REVEIW ARTICLE

DOMESTICATION OF WALLAPATTA (*Gyrinops walla* Gaertn.) AS A POTENTIAL EXPORT AGRICULTURAL CROP SPECIES

H.A.Sumanasena[1], K.D.N.Priyadarshani[2] and Saman Bowatta[3]

Summary

*Sri Lankan society was instigated to pay attention to wallapatta (*Gyrinops walla *Gaertn.) as a valuable plant species following confiscation of an illegal consignment of wallapatta wood pieces by the custom officers of Colombo Air Port recently. Poachers claimed wallapatta having agarwood resin in it. If this is true, wallapatta could be grown as a component species of mixed home garden along with other export agricultural crops and multipurpose tree species . This would help to commence* Gyrinops *derived agarwood industry and commercial plantaions of wallapatta as a new non-traditional export agricultural crop. Apart from that the proposed industry would help to alleviate rural poverty and generate employment opportunities also. Nevertheless, present knowledge on the potential of agarwood production from wallapatta is very meager and disorganized, especially in the local context. This review collates relevant information for the benefit of those who wish to embark on research and development programs of wallapatta as an alternative source of agarwood. Overall literature review indicated that a domestic cultivation program of wallapatta can be commenced in Sri Lanka very soon with adoption of already available research findings in other agarwood growing countries along with the support of some applied research with regards to nursery techniques and artificial infection techniques for agarwood formation in tree trunks. As wallapatta is a native species considered to be converted to a cash crop, further research under local conditions would be worthy.*

[1]*Central Research Station, Department of Export Agriculture, Matale, Sri Lanka.*

[2]*Intercropping and Betel Research Station, Department of Export Agriculture, Dampellessa, Narammala, Sri Lanka.*

[3]*AgResearch Limited, Grasslands Research Centre, Tennent Drive, Private Bag 11008, Palmerston North 4442, New Zealand.*

10-CM 18403

INTRODUCTION

Attention to wallapatta (*Gyrinops walla* Gaertn.) as a valuable plant species emerged in the local society following recurrent confiscations of an illegal consignments of wallapatta wood pieces by the customs officers as well as other law enforcement authorities of Sri Lanka in recent past.

Poachers claimed that wallapatta also contains agarwood resin and it seems to be the reason for indiscriminate tree fellings that were reported at a few places in wet and intermediate zone of Sri Lanka recently. No one in Sri Lanka knew wallapatta had this valuable property until recently (http://www.sundaytimes.lk/121209/news). In an independent development, Subasinghe *et al.*, (2012) claimed that wallapatta tree that is native to Sri Lanka has the capacity to produce agarwood type resins. In fact, bark of the wallapatta has been used traditionally for medicinal purposes specially for casting broken bones, where its common name of wallapatta must have been coined.

' Walla patta' which has been an indegenous product of Sabaragamuwa region is prepared by peeling the bark of the tree with subsequent immediate removal of the outer brown skin of it, while it is fresh, using a sharp table knife. Then it is made into stripes of 0.5cm wide. Then these patta stripes are hung beside the fireplace of the kitchen for few weeks until they get dried. these patta cords are used to tie casted broken bones covered with forest borne medicines (*mallum*) by Sabaragamuwa Region school of physicians.

Another important use of processed wallapatta cord is for wrapping the inflorecsence of the kithul palm *(Caryota urens)* following the treatment of unopened inflorescence in order to collect sap flow in Sinharaja peripheral areas. Similarly these cords are used for tying purposes in the preparation process of traditional '*kithul panimul*' with '*kola gotu*' (arecanaut leaf sheaths) in same region.

Traders have quoted prices for pure agarwood oil as high as USD (United States Dollars) 30, 000/kg, such oil only being made for orders. Grade-two oil costs approximately USD 15,000/kg, but generally oil prices are between USD 5000/kg and USD 10,000/kg. However, cheaper oils, adulterated perhaps with a mixture of sandalwood and sesame seed oil, can be bought for a few hundred dollars per kilogram (http://www.researchgate.net). Cosidering most of the facts, the Environment Minister of Sri Lanka suggested to promote cultivation of wallapatta among rural people enabling them to earn a high income (http://www.dailynews.lk/2012/12/15/news20.asp).

In fact, agarwood, also known as '*gaharu*', is an important non-timber forest product (NTFP). As incense, perfume and medicine, it has been used for hundreds of years by many cultures throughout the world. Today, the

international trade in *gaharu* involves at least 18 countries and involves hundreds of tonnes worth millions of US dollars annually (Wyn and Anak, 2010). Indeed, due to the growth in the population and affluence of *gaharu*-consuming markets, the demand for '*gaharu*' has risen dramatically over the past 30 years.

However, the increase in demand appears to have led to diminishing supplies, leading to rising prices and concerns over the future supplies of the commodity. Furthermore, there are fears that the '*gaharu*' trade may drive some *gaharu*-producing species to extinction (Wyn and Anak, 2010).

If this species can be grown as a component species of mixed home garden along with other export agricultural crops and multipurpose tree species, *Gyrinops* derived products can be traded and made as a source of foreign exchange as a new non-traditional export agricultural crop. Apart from that the proposed industry would help to alleviate rural poverty and generate employment opportunities too.

Nevertheless, it is obvious that present knowledge on the potential of agarwood production from wallapatta is very meager and disorganized, especially in the local context. Therefore, the objective of making this review is to collate relevant information for the benefit of those who wish to embark on research and development programs on wallapatta as an alternative source of agarwood.

History of agarwood industry and legal aspect of wallapatta tree

Historically, agarwood has been used for medicinal, aromatic and religious purposes in Buddhist, Jewish, Christian, Muslim and Hindu societies. Trade in agarwood has been recorded for over 2000 years, with primary markets in the Middle East and East Asia being supplied from sources ranging from the north-east of the Indian sub-continent through continental South-east Asia and the Indo-Malaysian archipelago (Ding Hou, 1960). Moreover, it is used in the production of world's most expensive non-alcoholic perfumes produced in countries including France at present. This rise in levels of trade (and by implication of harvest) has given rise to concerns that demand may outstrip sustainable supply (Barden *et al.*, 2000).

Increasing demand for agarwood with economic growth in both the Middle East and North-east Asia consumer markets has caused populations of eight *Aquilaria* species to decline to the point where these species were compelled to be categorized as threatened according to 2006 IUCN Red List of Threatened Species (Wyn and Anak, 2010).

The Conservator General of Forests reiterated that under the provisions of the Forest Conservation Ordinance of Sri Lanka felling and export of wallapatta is illegal and banned (Anon, 2009). Nevertheless, wallapatta is not protected under the Fauna and Flora Protection Ordinance (Anon, 1993), of Sri Lanka but cannot be taken

out of the country without permission. Under the Forest Conservation Ordinance, any part of a tree growing in a forest is 'forest produce,' and cannot be felled, collected, transported, kept in possession or exported in any form without permission from Forest Department (Anon, 2009), However, if wallapatta is cultivated as a home garden tree species, there is no restriction to harvest and sell its resinous type agarwood.

In addition to the confusion regarding 'sandalwood' and '*gaharu* buaya'(true agarwood), a substantial amount of what is claimed to be true '*gaharu*' is not actually genuine. Normal *Aquilaria* wood or wood from other species is sometimes soaked in *gaharu* hydrosol and then sometimes also carved to look like high grade *gaharu*, and is often referred to as 'black magic wood' or 'BMW' in trade. In addition, so-called '*gaharu*' oil is often a petroleum-based synthetic. Furthermore, genuine *gaharu* oil is often diluted with cheaper oils (Wyn and Anak, 2010).

On this context, Sri Lanka would be entitled to claim and posses the patent rights for products derived from *G.walla* because walla (called after the plant's Sinhala name) was first recorded in Galle (http://www.sundaytimes.lk/121209/news).

Botany and ecology of wallapatta (*G. walla* Gaertn.) tree and related species

The species *G. walla* Gaertn. belongs to the domain of Eukarya, kingdom of Plantae, class of Magnolipsida, order of Malvales, family of Thymelaeaceae and genus of *Gyrinops* (http://www.theplantlist.org).

Gyrinops species occur in Sri Lanka, Lesser Sunda Islands, Sulawesi, Molluccas, Irian Jaya and Papua New Guinea (Ding Hou 1960, Compton and Zich 2002). *G. walla*, commonly known as wallapatta in Sinhala, grows freely in low country wet zone in Sri Lanka, with a small population also growing in India. Five stamens with short or absent filaments and shiny, glabrous, clear nerve leaves are present in *G. walla*. The fruit shape is oblong (Eurlings and Gravendeel, 2005). The taxonomic status of *Aquilaria* and *Gyrinops* as separate genera is doubted as they are only distinguished by the number of stamens. *Aquilaria* and *Gyrinops* belong to subfamily *Aquilarioideae* and are separated by the number of stamens only: eight to twelve in *Aquilaria* and five in *Gyrinops*. Taxonomic status of *Aquilaria* and *Gyrinops* by performing phylogenetic analyses, Eurlings and Gravendeel (2005) found that both genera are paraphyletic and suggested synonymizing both genera as the latter is the oldest name.

Two genera *Aquilaria* and *Gyrinops* are recorded as species that produce agarwood which is in high demand as a forest product of substantial economic value (Eurlings and Gravendeel, 2005). According to studies conducted by Ng *et al.*, (1997) only nine species of *Aquilaria* genus out of 15 recorded species were identified as species that produce agarwood. In addition, agarwood production has been revealed in 2 *Gyrinops spp*. namely *G. ledermanii* and *G. versteegii* by Compton and Zich (2002), although there are 8 recorded species in the genus *Gyrinops*.

Individuals of six *Aquilaria* spp. Of *Thymelaeaceae* (*A. beccariana*, *A. crassna*, *A. filaria*, *A. hirta*, *A. malaccensis* and *A. microcarpa*) cultivated in Indonesia were investigated to assess the reproductive phenology, pollination, seed production and germination by Soehartono and Newton (2001). Most of the selected trees flowered during the dry season, fruits requiring betw een 36 and 72 days to develop, depending on the species. The results indicate that *Aquilaria* spp. have high reproductive potential, but suggest that seed dispersal might be limited in natural forests. The implications of these results for the management of *Aquilaria* spp. have been discussed.

Botanically, agarwood-producing species are in a separate family (*Thymelaeaceae*) from what are considered to be the true sandalwoods *Santalum* spp. (*Santalaceae*) and red sandalwoods *Pterocarpus* spp. (*Leguminosae*). Nevertheless, attempts to standardize nomenclature (e.g. *CITES Notification No. 1998/19*) show that the confusion of '*gaharu*' with sandalwood is not confined to Malaysia, with one Indian vernacular name for *Aquilaria malaccensis* being '*Aggalichandanam*' and one Indian vernacular name listed for *Pterocarpuss antalinus* being '*Agaru*' (Wyn and Anak, 2010).

Agarwood, aloeswood, eaglewood and '*gaharu*' are all names for the resinous, fragrant and highly valuable heartwood produced primarily by *Aquilaria* species and *Gyrinops* in the family *Thymelaeaceae* (Wyn and Anak, 2010). At present, wallapatta (*G. walla*) mainly grows in forests and in some home gardens of the low country wet and intermediate zone areas of Sri Lanka (Figure 1).

Cultivation and propagation aspects

One of the first attempts to cultivate *Aquilaria* was undertaken in 1928 (Lok and Yahyda, 1996). However, natural mortality caused the original population density of this stock of 833/ha to decrease to 31/ha by 1995 (Lok *et al.*, 1999). Beginning in the late 1990s, Forest Research Institute of Malaysia (FRIM) collaborated with a New Zealand research company, Industrial Research Limited, and established trial planting plots with 2000 seedlings being offered for sale in 2006. Following FRIM's initiative, the Forestry Department of Peninsular Malaysia (FDPM) established numerous trial plantings of *Aquilaria* throughout the Peninsula. The Sabah Forestry Department has brought experts from the University of Minnesota who had previously successfully initiated cultivation projects in Vietnam, Thailand, Bhutan and Papua New Guinea. Furthermore, the Forest Department of Sarawak was also reported to have established a number of *Aquilaria* trial plots both *in situ* and *ex situ* (Wyn and Anak, 2010).

In Vietnam, agarwood is collected from heartwood of *A. crassna* (*Thymelaeaceae*) and cultivation of agarwood by PhuQuoc islanders is increasing every year. Local plantations are based on seeds, seedlings and young *Aquilaria*

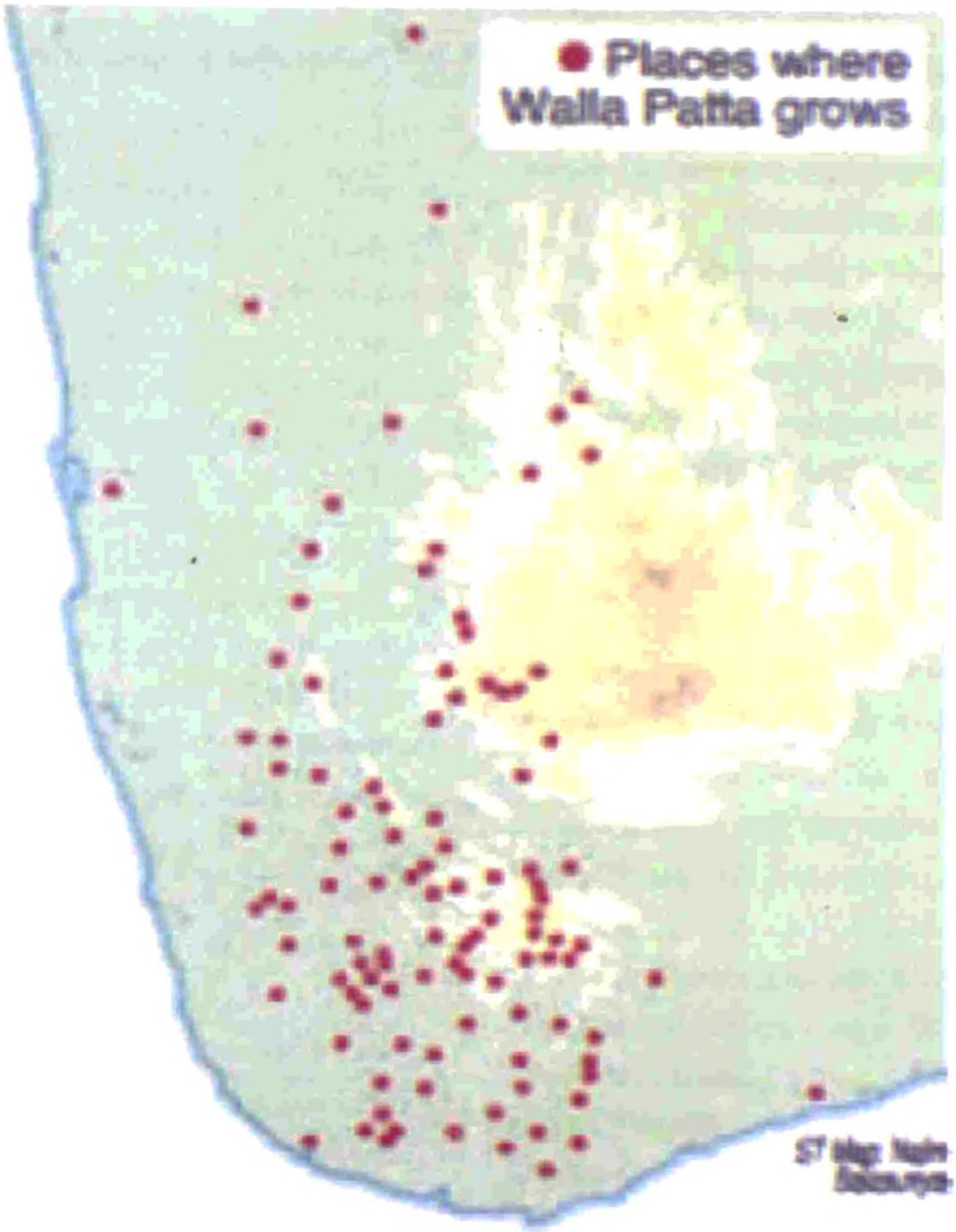

Figure 1: Walla patta (*G. walla*) distribution in Sri Lanka (http://www.sundaytimes.lk/121209/news/lankas-perfume-goldmine-23702.html)

trees, which grow together with other crops, for a future profit. The promotion and development of agarwood plantations would be an initiative to preserve natural *Aquilaria* trees, as well as to supply the high demand for agarwood in world market (Nakashima *et al.*, 2005).

Pimol Tiengtum (1995) reported that shoot tips and lateral buds from 2 species of agarwood trees (*A. crassna* and *A. malaccensis*) were cultured on Woody Plant Medium (WPM) and modified MS medium. The highest rooting percentage was 65 % in medium containing 0.5 mg/L IBA. Shoots of *A. malaccensis* failed to root. The survival rate of *A. crassna* plantlets was 90 % when transplanted in the nursery.

Van Minh (2005) micro-propagated *A. crassna* (agarwood), a Vietnamese forest tree, using shoot explants from 20-year old trees known to produce the valuable exudate 'tok'. Either shoot tips or internodes could be used for the initial explants but in subcultures, best results were obtained from internodes. Plants transferred to the field grew to 2m after 18 months and had normal morphology. He *et al.*, (2005) also established an efficient plant regeneration system via organogenesis from shoots developed from seedlings of *A. agallocha*. All plantlets that survived acclimatization grew well in the pots.

The percentage variation in root colonization and number of arbuscular mycorrhizae (AM) propagules in the rhizosphere soil samples were observed from root and rhizosphere soil samples of agarwood plants that were collected from various plantations of Jorhat District of the Brahmaputra Valley in Asam India (Tamuli and Boruah, 2002). Moreover, genus *Glomus* was found to be dominant and among the *Glomus* spp., *G. fasciculatum* is the most dominant followed by *G. aggregatum*. Turjaman *et al.*, (2006) also found that AM fungi can accelerate the establishment of the planting stocks of *Dyerapolyphylla* and *A. filaria*, thereby promoting their conservation ecologically and sustaining the production of these NTFPs economically. Preliminary experiments on feasibility of vegetative propagation of wallapatta have been already commenced at the Intercropping and Betel Research Station, Narammala, Sri Lanka.

Pre-harvest manipulation for inducement of beneficial resin production

Agarwood is known as the result of natural infection, found as irregular patches in trunks of the standing tree of *A. agallocha* Roxb., which are of great economic importance. Two new fungi records, *viz.*, *Fusarium oxysporum* Schlect. and *Chaetonium globosum* Kunze. were isolated for the first time from the diseased wood of *A. agallocha by* Tamuli *et al.*, (2000).These two fungi colonized wood blocks of *A. agallocha*, when these were inoculated artificially.

Subeham *et al.*, (2005) reported that each area surveyed in Indonesia has a different classification and price of each grade, according to their experience by observing the darkness, smell, oil and density of agarwood. *Fusarium laseritum* is the faster fungus infecting *Aquilaria* sp. tree and can be isolated and inoculated easily into medium. Thus, this fungus is inoculated into holes in the trunk. One year after inoculation, obtained agarwood is of the lowest grade. However, Subeham *et al.*, (2005) did not explain the practical aspects of tree inoculation and reason could be either the scope of their study was socio-economic, or they did not want to divulge a traditional inoculation technique that must have been perfected and adopted by a traditional agarwood producing community. This indicates us the requirement to carry out our own applied research on artificial stimulation aspects for *G. Walla*.

Pojangaroon and Kaewrak (2005) determined the efficacy of mechanical methods of stimulating agarwood formation in *A. crassna* trees in Thailand. The most suitable method for inducing formation of agarwood was through the use of 1.27 cm wide screws which gave the widest dis-colouration ring and pale specific aromatic kritsana scent by burning. Wood samples gave very low essential oil yield.

In another study, Yagura *et al.*, (2005) reported that three novel diepoxy-tetrahydrochromones, oxidoagarochromones A(1), B(2) and C(3) were isolated from agarwood artificially produced by intentional wounding of *A. crassna*. Inductive production of these three compounds was also confirmed at the early stage of wounding in *A. sinensis* and *A. crassna*.

These diepoxytetrahydrochromones would play an important role in the understanding the biosynthesis of chromone derivatives in agarwood.

Tabata *et al.*, (2003) reported findings of a structural survey that was done to investigate the pattern and variation of resin deposition in agarwood, and to know its standard features. The stems of each *G. versteeghii* and *Aquilaria* were inoculated with *Fusarium*. The results showed that there were many types of colour and shape of resin on agarwood, but many have some injured parts. Resin deposition occurs around the drilled site, above the term of treatment or differences of wood species and fungi. Resin deposition also occurred not only in fungi-inoculated but also in control trees.

According to Jalaluddin (1977) a fungus known as *Cytosphaera manganiferae* Died. was isolated for the first time from the diseased tissues of standing trees of *A. agallocha* Roxb. and irregular patches of diseased wood, a result of natural infection, were found in the trunks of standing *A. agallocha* trees, which are of great economic importance. A fragrant perfume known in Bangladesh as 'attar' is obtained from the diseased wood by steam distillation.

Incomplete or partially diseased wood is employed in the preparation of a joss-stick locally known as 'agarbatee' which gives out fragrant fumes on burning. The fungus colonized wood blocks of *A. agallocha* when these were inoculated artificially. Jalaluddin (1977) suggested that there is a possibility of commercial exploitation for the production of diseased wood by artificial infection.

According to GC/MS (Gas Chromatography/Mass Spectrometry) analysis results marked differences in the oil compositions among the treatments with regards to their quality were observed between compositions of oils obtained from healthy, naturally infected and artificially screwed wounds of eaglewood (*Aquilaria agallocha* Roxb.) (Bhuiyan *et al.*, 2004).

Subasinghe *et al.*, (2012), extracted resins from Wallapatta trees *(G. walla)* using a pruning saw and a chisel and samples were analyzed using Gas Chromatography. They summarized that the resin of *G. walla* contains several aroma principles commonly found in agarwood. Subasinghe *et al.*, (2012) concluded that their findings give promising results for the first time on the resin formed in *G. walla* and its capacity to produce agarwood type resins. The above information indicated that studies are necessary to implement the harvesting of the resins from *G. walla* at commercial scale.

Concluding remarks and recommendations

The above review of literature confirmed that wallapatta also belongs to the family of agarwood resin producing trees. Commercial *Aquilaria* cultivations and mixed cropping practices have already been commenced in few countries such as Vietnam, Thailand and Indonesia as a source of agarwood.

Wallapatta is being already declared as a species belongs to endangered genus *Gyrinops* by the IUCN and therefore, following conditions should be observed in any endeavourer in domestication of wallapatta as a home garden crop in Sri Lanka.

Government and non-government stake holders should support initiatives for the establishment of wallapatta base agarwood plantations, but bear in mind the need to strictly protect representative wild populations as seed sources to preserve genetic diversity. Department of Export Agriculture appears to have the mandatory rights to initiate and conduct research, development and commercial cultivation program for wallapatta base agarwood industry in Sri Lanka. In addition, such cultivations should be registered with relevant line agencies in order to monitor production output and enable the distinction of cultivated or non-wild sources for free trade flow. This should extend to oil distillation and other associated agarwood processing activities, too.

Overall literature review indicated that there would be a potential to develop local wallapatta as a supplementary species for production of agarwood related commercial products. Hence, a domestic cultivation program of wallapatta can be commenced in Sri Lanka very soon with adoption of already available research findings in other agarwood growing countries along with few applied research activities with regards to nursery techniques and artificial stimulation techniques for agarwood formation in tree trunks. As wallapatta is a native species to be converted to a cash crop, further research under local conditions would be worthy.

LIST OF REFERENCES

Anon, (2009): Forest Ordinance of Sri Lanka, ActNo. 65 of 2009, Parliament of the Democratic Socialist Republic of Sri Lanka.

Barden A., Awang A., Mulliken T. and Song M. (2000): Heart of the matter. Agarwood use and trade and CITES implementation for *A. malaccensis*. TRAFFIC International, Cambridge, UK.

Bhuiyan, N.I.,Begum J. and Bhuiyan N.H. (2004): Analysis of essential oil of eaglewood tree (*Aquilaria agallocha* Roxb.) by gas chromatography mass spectrometry. *Bangladesh Journal of Pharmacol* 4: 24-28.

Compton, J. G. S. and Zich F.A. (2002): *Gyrinops ledermannii* (*Thymelaeceae*) being an agarwood producing species prompts call for further examination of taxonomic implications in the generic delimitation between *Aquilaria* and *Gyrinops*. *Flora Malesiana Bulletin* 13(1): 61-65.

Ding Hou (1960): Wolters-Noordhoff publishing, Groningen, The Netherland. Thymelaeceae. In: Van Steenis C.G.G.J. (eds.) *Flora Malesiana* 1(6):1-48.

Eurlings, M.C.M. and Gravendeel B. (2005):TrnL-trnF sequence data imply paraphyly of *Aquilaria* and *Gyrinops*(*Thymelaeaceae*) and provide new perspectives for agarwood identification. *Plant Systematics and Evolution* 254 (1-2): 1-12.

He M.L., Qi S.Y and Hu L.J.(2005): Rapid in vitro propagation of medicinally important *Aquilaria agallocha*. *Journal of Zhejiang University Science* 6B (8): 849-852.

Jalaluddin M. (1977): A useful pathological condition of wood. *Economic Botany* 31: 222-224.

Lok E.H. and Yahyda A.Z. (1996): The growth and performance of plantation grown *Aquilaria malaccensis* in Peninsula Malaya. *Journal of Tropical Forest Science* 8: 573-575.

Lok E.H., Chang Y. andAziah M.Y. (1999): Early survival and growth in field trials of *Aquilaria malaccensis* (Karas) and *Azadirachta excels* (Sentang). *Journal of Tropical Forest Science* 11(4): 852-854.

Nakashima E.M.N., Nguyen M.T., Nguyen M.T., Le Tran Q. and Kadota S. (2005): Field survey of agarwood cultivation at PhuQuoc Island in Vietnam. *Journal of Traditional Medicine* 22:296-300.

Ng L.T., Chang Y.S. and Azizol L.K. (1997): A review on agar (gaharu) producing *Aquilaria* species. *Journal of Tropical Forest Products* 2(2):_272-285.

Pimol Tiengtum (1995): In vitro culture of agarwood trees (*Aquilaria* spp.) Kanpholiang kritsananaisaphap plot chua. Summary, (Unpublished postgraduate report) Graduate School. Kasetsart University, Bangkok (Thailand).

Pojanagaroon S. and Kaewrak C. (2005): Mechanical Methods to Stimulate Aloeswood Formation in *Aquliaria crassna* Pierre ex H.Lec (Kritsana) trees. *Acta Horticulturae (ISHS)* 676: 161-166.

Soehartono, T. and Newton, A. C.(2001): Reproductive ecology of *Aquilaria* spp. in Indonesia. *Forest Ecology and Management* 152(1-3): 59-71.

Subasinghe S.M.C.U.P., Hettiarachchi D.S. and Rathnamala E. (2012): Agarwood-type resin from *Gyrinops walla* Gaertn: A New Discovery. *Journal of Tropical Forestry and Environment* 2 (2): 43-48.

Subeham, Junya U., Fujino H., Attamimi F. andKadota S. (2005): A field survey of agarwood in Indonesia. *Journal of Traditional Medicines* 22(4): 244-251

Tabata,Y., Widjaja E., Mulyaningsih T., Parman I., Wiriadinata H., Mandang Y.I. andItohT.(2003): Structural survey and artificial induction of aloeswood. *Wood Research* 90: 11–12.

Tamuli P. and Boruah P. (2002): Vesicular-abuscular mycorrhizal (VAM) association of agarwood tree in Jorhat District of the Brahmatputra Valley. *Indian Forester* 128(9): 991-994.

Tamuli P., Boruah P., Nath S.C., and Samanta R. (2000): Fungi from diseased agarwood tree (*Aquilaria agallocha* Roxb.): two new records. ed. Ram Parkash. *Advances in Forestry Research* XXII:182-189.

Turjaman M., Tamai Y., Santoso E., Osaki M. and Tawaraya K. (2006): Arbuscular mycorrhizal fungi increased early growth of two non-timber forest product species *Dyera polyphylla* and *Aquilaria filaria* under green house conditions. *Mycorrhiza* 16(7): 459-64.

Van Minh T. (2005): Application of tissue culture techniques in woody species conservation improvement and development in Vietnam: Agarwood (*Aquilaria crassna* Pierre ex.LeComte) via shoot-tip culture. *Acta Horticulturae (ISHS)* 692:37-42.

Wyn, L.T. and Anak N.A. (2010): Wood for the trees: A review of the agarwood (*Gaharu*) trade in Malaysia, Published by TRAFFIC Southeast Asia, Petaling Jaya, Selangor, Malaysia,© 2010 The CITES Secretariat.

Yagura T., Shibayama N., Ito M., Kiuchi F. and Honda G. (2005): Three novel diepoxytetrahydrochromones from agarwood artificially wounded by intentional wounding. *Tetrahedron Letters* 46(25): 4395-4398.

National Digitization Project

National Science Foundation

Institute : National Science Foundation

1. Place of Scanning : Sanje (Private) Ltd, Hokandara
2. Date Scanned : 02/06/2017
3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara
4. Scanning Officer

Name : Angelo Melvin Luwis

Signature : A. M. Luwis

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : Information Officer

Name : Renuka Sugathadasa

Signature : R. P. Sugathadasa

Date : 02/06/2017

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"