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Feasibility Study on Small-Farm Production of Gums, Resins, Exudates, and Other Non-Wood Products

James W. Hanover
Department of Forestry
Michigan State University

August 1988

Winrock International (Forestry/Fuelwood Research and Development Project)

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INTRODUCTION

Past work with multipurpose tree species (MPTS) within the Forestry/Fuelwood Research and Development Project (F/FRED) has focused mainly on organization of research among cooperators, selection of fuelwood species priorities, socioeconomic research needs, germplasm availability, and experimental design (Taylor and Medema 1987). In 1987, USAID and Winrock International, through the F/FRED Project, decided to assess the potential for improving small-farm MPTS production via several biotechnology thrusts (F/FRED Project 1987) including the present study, which focuses on determining the feasibility of obtaining non-wood products from MPTS. These include gums, resins, exudates, extractives and other chemicals, in addition to the more typical uses of these species for fuelwood, timber, fodder, manure, and fruit. Indeed a study of MPTS uses for chemical production on small farms might conceivably result in identifying additional MPTS and considerably enhance small farmers' income. Against this broad background, the present study was undertaken.

Several approaches were used. Initially, these included a comprehensive literature search through libraries, letter inquiries to scientists in Asia, and interviews with Indian scientists currently studying at Michigan State University. Travels to India, Indonesia, and Malaysia early in 1988 included on-site interviews with scientists and administrators who had been briefed on this study's objectives. In July 1988, the author spent two additional weeks in Indonesia on a tree-improvement project during which time he acquired more literature and information on MPTS, agroforestry systems, and chemical extractives from trees. Upon completion of the above tasks, he began compiling, collating, and writing this report.

Tropical forests now provide a vast array of non-wood products that are produced both in natural forests or on plantations of selected tree species (Fig. 1). These products include essential oils, exudates, gums, latexes, resins, tannins, sterols, waxes, esters, acids, phenols, alcohols, edible fruits and oils, rattans, bamboos, flavorings, sweeteners, spices, balsams, pesticides and dyestuffs. Often on small family farms, there is little reliable data on the commercial value of these non-wood products because of the diffuse nature of their production. The often-used term minor forest products is inappropriate because, in the aggregate at least, these products constitute a valuable resource in world trade (OTA 1984). For example, in India the estimated worth of non-wood products is more than 20% of the total value of all industrial timber. The world trade in rattan is in excess of $1.5 billion and essential oils and spices exceed $1 billion (OTA 1984). It is quite likely that a systematic survey of non-wood forest products used by tropical forest dwellers would lead to increased use of these materials and enhance farmers' economic well-being.

Besides the monetary value of non-wood forest products in world trade, there are other less tangible benefits from these materials, including their role in family and social life in much of Southeast Asia. Gathering and processing forest products are often the only sources of employment and income for local people (Meulenhoft and Silitonga 1978).

Objectives

This study had two main objectives:

1) Survey and evaluate the present status and future potential of small-farm production of gums, resins, and exudates from MPTS in Asia.

2) Recommend research and development needed to help farmers improve their use of non-wood products from tropical trees.

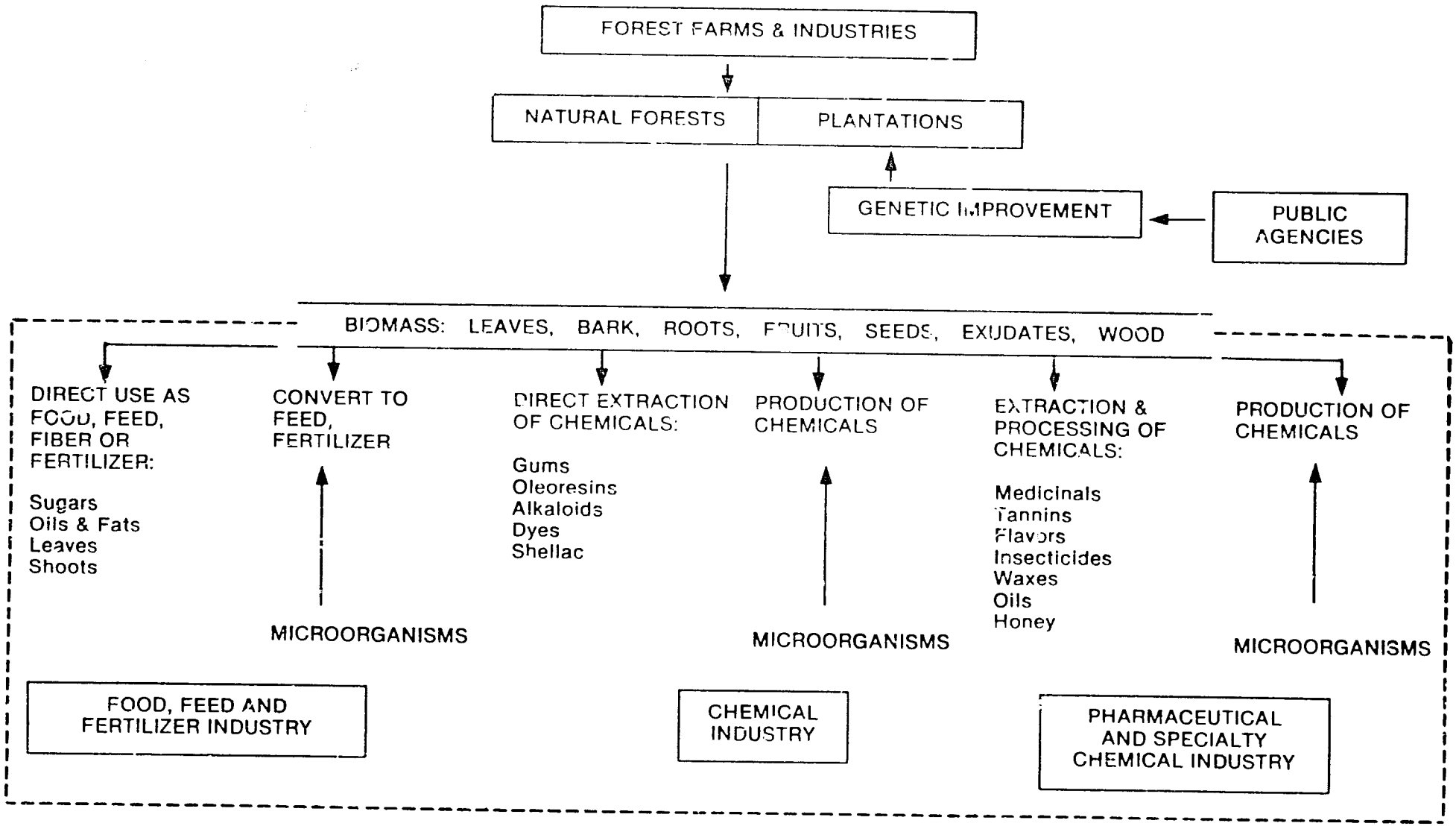

Fig. 1. Small-farm production of non-timber MPTS commodities.

Scope

Although gums, resins, and exudates are the primary products targeted for study, the scope was expanded slightly to include certain extractives, oils, dyes, pesticides, and specialty chemicals that also offer opportunities for increased utilization. Omitted from primary consideration are substances mainly used for medicine, food, or fodder. Within this framework there are still innumerable non-wood products of tropical forests that could be documented here. Many of these are referred to in the compilation of species and products (Tables 1, 2, and 3), but others of minor importance are omitted.

The scope of the present study is further defined by the tree species considered as sources of the above-mentioned chemicals. Three categories are included: priority MPTS (Table 1), additional MPTS important over narrower distribution ranges or under specific cultural situations (Table 2), and specialty trees (Table 3).

COMMODITIES FROM MPTS

Plant resins, gums, and exudates

According to Dell and McComb (1978), resins are non-volatile products of plants from which they exude naturally (surface resins) or that can be obtained by incision or infection (internal resins). They are insoluble in water but soluble in organic solvents. They are stable, inert, and amorphous, become sticky when heated, and are capable of being fused with no sharp melting points. They are mixtures of compounds, including flavonoids, terpenoids, and fatty substances.

Other plant products related to resins include latex, essential oils, gums, waxes, and exudates composed of mixtures of these substances. Latex is a colloidal suspension or emulsion of water insoluble substances suspended in water varying in color from white to red to yellow. Essential oils are volatile terpenoids (C_5, C_{10}, and C_{15}) obtained by steam distillation of plant tissue and are completely incapable of mixing with water.

Fatty oils are non-terpenoid, non-volatile substances but, like essential oils, are liquid at room temperature. They are esters of fatty acids and glycerols and occur commonly in seed storage organs.

Gums are complex carbohydrates (polysaccharides) completely soluble in water and are secreted naturally or on incision or infection. Mucilage is chemically similar to gum and is obtained by macerating plant material in water. Some of the important uses of gums are as follows (NAS 1979):

- o used in adhesives on postage stamps
- o impart smoothness and stability to bakery products and lengthen shelf life
- o give body and smooth texture to confections
- o used as foam stabilizer in beer
- o provide smoothness to high-quality ice cream
- o used as purifier in wine and emulsifier in soft drinks, lotions, detergents, etc.
- o used in float-processing minerals

o impart luster to silk and sizing papers

o used as a medicine to treat inflammations and burns

Tannins and dyes

Condensed tannins are phenolic polymers that occur in a wide variety of trees, such as neem (*Azadirachta indica*). They play important roles in food quality and nutrition, toxicology, plant protection (insects and disease), wood adhesives, leather manufacture, and herbal medicine. For many of these uses, plant tannins cannot be replaced by synthetics. Many dyes are obtained from trees such as the orange-brown dye from *Acacia catechu*.

Essential oils

Essential oils are usually volative terpenoids obtained by distillation and often associated with resins. Important oils from trees include sandalwood oil from heartwood of *Santalum album*, cedarwood oil from *Cedrus deodora*, *C. atlantica*, *Juniperus* spp., rosewood oil from *Dalbergia sissoo*, eucalypt oil from many *Eucalyptus* species, and cosmetic oils, such as cajuput oil, lawang oil and patchouli.

Drying oils such as tung oil from seeds of *Aleurites* spp. and edible oils, such as Chinese tallow tree (*Sapium sebiferum*) seed oil, and oil palm (*Elaeis guineensis*) are also important in commerce.

Cosmetics, flavorings, and perfumes

Fragrance and flavor chemicals have immense commercial importance in world trade. Many of these substances are derived from trees (Tables 1, 2, and 3) and they generally fall into the chemical categories of essential oil derivatives or aromatic hydroxyaldehydes.

Insecticides

Probably the best example of a tree extractive that has insecticidal properties is that obtained from the neem tree. Extracts of neem seeds repel or kill a variety of insects, and commercial preparations are entering world markets (Larew 1988; Nagasampagi, personal communication).

Drugs and pharmaceuticals

Trees as sources of medicinal drugs or pharmaceutical chemicals are limited, although several reports are given (See Tables 1, 2, and 3). Such chemicals are usually quite complex in structure. Future research into tree chemistry may reveal additional opportunities in this category.

Fruits and other edible food

Many edible products available from tropical forest trees contribute significantly to staple diets. Foremost among them are bananas, bamboo shoots, oil palm, jack fruit from *Artocarpus* spp., and cashew nuts.

Shellac, honey, and silk

Some important commodities are derived from tropical tree species in which insects are an integral part of their production. Shellac, used in paints, varnishes, and printing ink, is a resin obtained as a result of lac insects (*Laccifer lacca*) inhabiting several host species, such as Japanese lacquer tree *(Rhus remicifera)*.

Many tropical trees are excellent sources of honey produced by bees, and much unexploited potential exists (Spencer 1988). Mulberry trees are intensively cultivated throughout Asia as an integral component in silk production. These tree-insect production systems and perhaps others offer substantial opportunities for expansion by small-farm enterprises in Asia.

Starch-sugar

The sago palm (*Metroxylon* spp.) is an important source of food starch in Southeast Asia, and the sap of other palms yields sugar that is converted to alcoholic drinks (Meulenhoff and Silitonga 1978).

Fertilizer and fodder

Throughout Asia, farmers commonly use tree leaves to feed livestock. Many examples are given in Tables 1, 2, and 3, including *Sesbania grandiflora, Azadirachta indica,, Acacia nilotica, Albizia procera, Robinia pseudoacacia Gleditsia triaconthos,* and others. Further development of these and other species for both feed and fertilizer could be promoted by applying modern research evaluation techniques.

Fiber

Rattan is a non-timber product of the tropical rain forest of increasing importance in world trade. It is a collective name for stems of climbing palms used to make distinctive furniture and plaid ware. There are over 300 species of rattan in three genera (*Calamus, Caemonorops,* and *Korthalsia*). Because of the concern that removal of tropical forests diminishes the rattan resource, its plantation culture is a subject of high research merit (Meulenhoff and Silitonga 1978).

The above categories of MPTS commodities provide an overview of the kinds of products now being gathered from tropical forests. A wide range of opportunities exists to further develop certain of these species/commodities through directed research. These specific opportunities are examined below.

PRESENT STATUS OF NON-WOOD PRODUCTS

A comprehensive examination of tree species from which important non-wood or non-timber products have been obtained by farmers is provided in Tables 1, 2, and 3. The information in these tables resulted from interviews, correspondence, and literature search.

Priority MPTS

The 11 species in this category resulted from F/FRED evaluations and other studies on tropical tree culture, especially in agroforestry systems.

Table 1. Priority MPTS that yield non-wood products.

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Acacia auriculiformis A. Cunn (akasia)	Indonesia, 0-800 m altitude, 1500-1800 mm rainfall, mean annual temp. 27-30 °C, wide site tolerance.	soga (dye) for batik, extracted from bark (6-14%), polysaccharide gum bark exudate of high viscosity, clear color, water soluble, 7% protein, tannin in bark	research needed on total chemical potential	Rudjiman 1981, Kasmudjo 1979, NAS 1979.
A. mangium (akasia, cassie)	S.E. Asia, Malaysia	bee honey	beekeeping	Suseno 1988.
A. nilotica (babul)	moist tropical, dry tropical	fuel, timber, tannin, gum, fodder, honey	gum is sweet and edible, home remedies from bark, tannin from pods and bark	NAS 1980, Little 1982.
Azadirachta indica (neem)	native to Burma and perhaps parts of India, Pakistan, Sri Lanka, Thailand, Peninsular Malaysia, and Indonesia; altitude to 1500 m; widely planted in dry tropical, moist tropical.	bark, leaf and seed (medicinal), insecticidal, fertilizer, fodder, timber; most parts except wood used in home remedies, bark has high tannin, neem oil or margosa oil from seeds used in soaps, disinfectants, drugs, cosmetics, seed cake used as fertilizer; leaves for fodder	research needed to further develop products from this versatile species	Larew 1988, Rego 1985, Little 1982.
Dalbergia sissoo (shisham, rosewood)	moist tropical, India, S.E. Asia	timber, furniture, plywood, fuel, fodder; some *Dalbergia* spp. (e.g., *D. retusa*) have potent insecticide secretion	research needed on wood properties and plantation culture, genetic improvement	Rego 1985, NAS 1979.
Eucalyptus camaldulensis (red gum)	Australia, throughout the world temperate and tropical climates with rainfall from 200-1100 mm	fuelwood, honey; wood is resistant to termites; leaf oils--cineole (pharmaceuticals), phellandrene (disintectants) or exudate from bark, and citronellal (perfume)	genetic variation in leaf oils should be studied to develop valuable strains	NAS 1980; Midgley, Eldridge, and Dorn 1987.

Table 1. Continued.

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Leucaena leucocephala (su-barbul)	India and tropics	gum from seed, wet-end additive in paper mills, fodder, fertilizer	boiling in water and centrifuging	Beri, Dobhal, and Ayyar 1982; NAS 1980.
Melia azedarach (Chinaberry)	Asia, Middle East, and India; widely cultivated	some insecticidal properties (azadirachtin), fodder	not an important chemical species, lack of research?	Little 1982, NAS 1983.
Prosopis cineraria (jand)	dry and arid regions of India	fat and protein from seed; may be used for human consumption, oil for cooking and torofine for food	seeds dehusked, fat (7.6%) extracted with petroleum ether	NAS 1979.
P. juliflora (Swartz) D.C. (mesquite)	wastelands of S.E. Asia, extremely hardy, all soils, coppices readily	fuelwood, tannin, honey; pods are fed to livestock	not an important chemical species, lack of research?	Jambulingam and Fernandes 1987, Little 1982.
Robinia pseudoacacia (black locust)	throughout world, temperate and mediterranean zones	fuelwood, fodder, heartwood chemicals for wood preservative	research needed for chemicals utilization	Smith et al. (in press).

Perhaps the most exemplary species in terms of providing products for farm and other uses is the neem tree (*Azadirachta indica*). This species is widely adapted, easily cultured, and contains useful substances from most of its parts. The bark is high in tannins for adhesives and medicinals; the seeds and leaves contain azadirachtin, a promising new insect repellent, as well as neem or margosa oil used i soaps, cosmetics, etc.; both leaves and seeds are also used for fertilizer and fodder. The insecticide azadirachtin deserves intensive research because it is a systemic repellent against many important insect pests. Dr. B.A. Nagasampagi of the National Chemical Laboratory in Puna, India, has a fine research team working on the development of the neem insecticide. Fig. 2 illustrates the general procedure by which neem or most other biologically active compounds from plants are analyzed to determine their effectiveness. The neem insecticide is now being marketed commercially in India and the United States.

Acacia mangium, or akacia, in contrast to neem, is a straight-stemmed, rapidly-growing plantation tree used mainly for lumber, veneer, furniture, or pulp. It is also excellent for erosion control. However, little information is available about its chemistry or products obtainable from its parts. It is a source of bee honey and may be further developed for this purpose by farmers as planting increases.

Many of the priority MPTS are used as fodder for animals (*Acacia nilotica, Dalbergia sissoo, Leucaen leucocephala, Prosopis* spp., and *Robinia pseudoacacia*), and this practice will continue. Several species produce useful gums, especially Acacia and Leucaena. Further research into sources of gums should reveal other species capable of providing these important food additives.

Acacia spp., neem, Prosopis spp. and many other MPTS give high yields of tannin from their bark. Research and development of tannin as an adhesive is particularly active and fruitful in Southeast Asia and should be increased.

Dalbergia sissoo or rosewood is a beautiful wood for many purposes and rosewood oil from the wood is valuable. Research is needed to further characterize its chemistry and products and establish the species in plantations because the resource is decreasing at an alarming rate.

Both *Prosopis cineraria* and *P. juliflora* have high potential as sources of chemical products, including protein from seed, cooking and other oils, tannins, honey, and other foods for human consumption.

Robinia pseudoacacia is a remarkably versatile MPTS that is gaining popularity as it is tested throughout the world. It has a wide array of uses that could be further expanded with increased knowledge about its heartwood, leaf and other chemical constituents.

The high-priority MPTS should also be priority research for development of gums, resins, extractives and other chemicals. New products from these species will have wide economic impact on the farmers who cultivate them.

Additional MPTS

Table 2 includes over 100 additional species for which farmers may play a key role in harvesting or processing that are currently useful sources of chemical or related substances.

There are numerous sources of resinous products available from tropical forest species. The most notable and worthy of research emphasis are the Dipterocarps (*Diptocarpus kerri*), which produce resins rich in essential oils (Gianno 1986); *Shorea pinanga* or illipe, yields a useful resin called damar batu; *Aquilaria* spp. (karas tree) has valuable resins in roots and branches called gharuwood; *Pinus merkusii* is prized and cultivated for its resin from which essential oils are distilled.

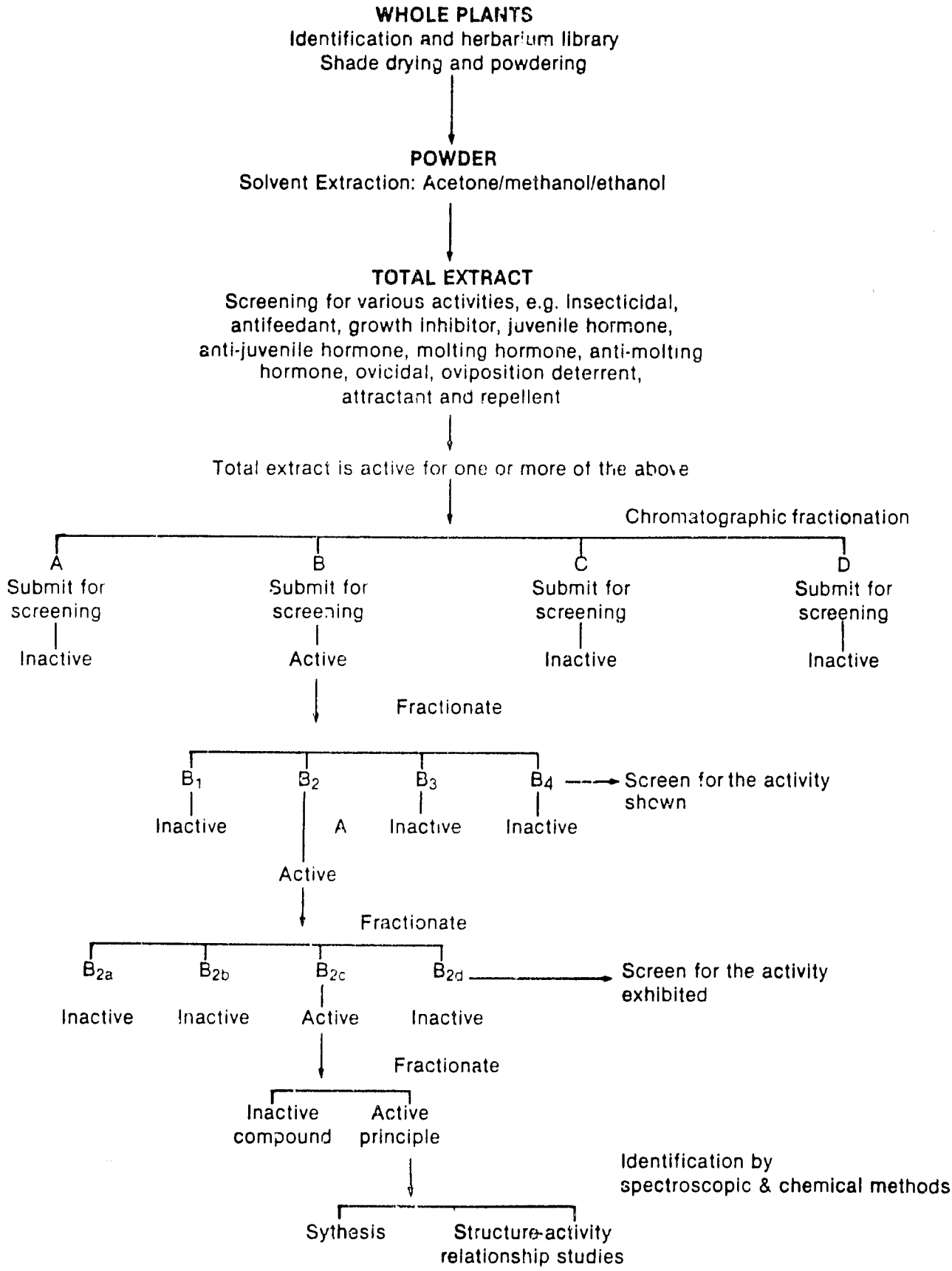

Fig. 2. Methodology for screening plant extracts for insect control activity.
Source: Nagasmpagi, 1988.

Table 2. Additional MPTS Important within Specific Distribution Ranges and Cultures.

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Acacia catechu (akasia, cassie, khair)	S.E. Asia, Malaysia, much of India except very humid regions; dry tropical, moist subtropical; drought and frost tolerant	gum Arabic, fodder, timber, fuel, soil conservation; leaves for fodder; heartwood extract obtained by hot water extraction, called katha or cutch which is high in catechin used as medicine, dyeing agent	high potential for chemicals	Suseno 1988
A. dealbata (silver waitle)	temperate	fuel, gum, tannin, fodder		Rego 1985.
A. decurrens (green wattle, akasia, cassie)	tropical and subtropical countries	fuel, tannin, fodder		Rego 1985.
A. farnesiana (pissi babul)	dry tropical	fuel, tannin, fodder, gum, soil conservation		Rego 1985.
A. leucophloea (pilang, cassie)	S.E. Asia, Malaysia	tannin		Suseno 1988.
A. melanoxylon (Australian black wood)	temperate	fuel, timber, tannin, fodder		Rego 1985.
A. modesta (phelai)	dry subtropical, dry tropical	fuel, timber, gum, tannin, soil conservation, fodder		Rego 1985.
A. senegal (khor)	Hot, dry and barren regions of Africa and Middle East Asia; suited to rocky hills, dry sandy flats or dunes with annual rainfall between 200-350mm	fuel, fodder, tannin, soil conservation; gum as main product; medicine	trees are tapped and the gum tears picked	NAS 1979, Rego 1985.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
A. tortilis (umbrella thorn, Israeli babool)	Africa (semi-arid), Middle East, India; very drought tolerant; dry rocky, sandy sites; 0°C to 5°C	pods (8-10cm), foliage, wood dense, fuel, fodder, timber, fence posts, implements, firewood, charcoal, soil stabilization	plantation culture, 10 year rotation; coppices easily, harvest pods or leaves and feed directly; best of 228 multipurpose tree species tested in Rajasthan, India; pods are main sustenance for E. Africa wildlife	NAS 1979.
Aegle marmelos (bel)	wet tropical, moist tropical	fuel, fruit, gum, bark and fruit (medicinal)		Rego 1985.
Aesculus indica (horse chestnut)	temperate, subtropical	timber, fodder, fruit, ornamental		Rego 1985.
Agathis sp. (damar)	S.E. Asia, Malaysia	copal	a valuable resin exudate	Suseno 1988.
Ailanthus excelsa (maharukh)	dry tropical, moist tropical	timber, packing cases, boards, bark (medicinal), fishing floats		Rego 1985.
Albizia lebbeck (siris)	dry tropical, moist tropical	timber, fodder, fuel, medicinal		Rego 1985.
A. procera (safed siris)	dry subtropical, moist tropical, wet subtropical, wet tropical	fuel, fodder, timber		Rego 1985.
Aleuritas moliucana (kemiri)	S.E. Asia, Malaysia	oil	distillation of seed	Suseno 1988.
Alpinia galanga, A. mallacencis, A. nutans (lengkuas)	S.E. Asia, Malaysia	food spices, alpinia oil, rhizome, distillation of rhizome, traditional medicine		Suseno 1988.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Amomum kepulaga, *A. cardamonum*, *Elletaria cardamonum* (Kapulaga)	S.E. Asia, Malaysia	seed for cosmetic and medicine, Cardamon oil	distillation of seed, intensive tumpangsari system	Suseno 1988.
Anacardium occidentale L. (jambu mete, cashew nut)	throughout topic and subtropic region; 0-1000 m alt.; 500-4000 mm rainfall; wide site tolerance	cashew nut: kernel, cashew apple, shell liquid, gum, tannin, leaves, nut eaten, apple is processed for drinks, high in vitamin C, leather preparation or glue, vegetable, fuel	2-3 kg per tree harvested annually, up to 15 kg per tree per year; excellent for soil conservation, provides valuable yields, suitable for taungya system	Rudjiman 1981, Venkataraman 1977.
Anogeissus latifolia (axelwood, bakli)	Ranges from Africa to Arabia, India and S.E. Asia: dominant species in dry deciduous monsoon forests; dry subtropical, moist subtropical, moist tropical	poles, rafters, fuel, fodder, gum (light yellow or brownish gum known as gum gatty or Indian gum, exuding from the bark serving in pharmaceuticals and calico printing); used on host plant for tassar silkworm rearing		Rego 1985, Little 1982.
A. pendula (kardhai)	dry tropical	fuel, fodder		Rego 1985.
Aquilaria spp., (karas tree)	Malaysia	aromatic; resin permeated wood roots and branches; possibly pathological; incense	felled trees may yield thousands of dollars of wood per tree	Gianno and Kochummen 1981.
Arenga spp. (pohonaren, sago palm)	S.E. Asia, Malaysia	Aren sugar, roofing	dried leaf: swamp forest species *Metroxylon sagu* yields starch from stem	Suseno 1988, Wee and Rao 1982.
Artocarpus communis (bread fruit)	moist tropical, esp. Indonesia	timber, fruit, fodder	fruit production by single tree can be 450 kg per year; high carbohydrate; profitable for farmer	Rego 1985, Suseno 1988.
A. integra (nangka)	S.E. Asia, Malaysia	unripened fruit, vegetables, fodder	fruit production by single tree can be 400 kg per year, high carbohydrate; profitable for farmer	Suseno 1988.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process Operation Remarks	References
Avicenia spp., (api-api)	S.E. Asia, Malaysia	tannin, first quality for charcoal		Suseno 1988.
Bauhinia purpurea (khairwal)	moist tropical	gum, fodder, fuel		Rego 1985.
B. racemosa (jhinjhora)	subtropical, tropical	tannin, fibre, gum		Rego 1985.
B. variegata (kachnar)	moist tropical, subtropical, tropical	cherry gum, bark (dye and medicinal), fodder, flower buds eaten		Rego 1985.
Betula cylindrostachys (birch)	subtropical, temperate	essential oils, fuel, timber, charcoal		Rego 1985.
Borassus flabellifer (L. palmyrah palm)	Tamill Nadu, India; plains, croplands, paddy fields, soil sandy to clay	nera (a sugary exudate from cut end of flowering spathe); palm sugar, candy, handicrafts from leaves	tapping of tree at 10-12 m in height; exported to 40 countries; good source of income to farmers	Jambulingam and Fernandes 1987.
Boswellia serrata (salai)	most parts of India	Salai gum, sizing of paper	tapping tree yields oleo-gum resin which can be distilled (steam) with ether, benzene, etc. to separate essential oil, polysacharides and resin	Sharma, Bhandari and Shrivastra 1985.
Bruguera spp. (tancang)	S.E. Asia, Malaysia	tannin, first quality for charcoal		Suseno 1988.
Calliandra calothyrsus Meissn. (kaliandia merah)	Introduced to Java from Central Amer.; 150-1800m alt.; min. 1500mm rainfall; shade tolerant; prefers fertile soils	leaves—22% protein, flowers, nectar, seeds, shellac, fodder, honey, vegetable, wood coating, novelties	good soil protection, deep roots, high litter production, rapid growth, nitrogen fixation, shrub up to 10m, evergreen canopy	Rudjiman 1981.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Canangium odorata (kenanga)	S.E. Asia, Malaysia	Java cananga oil, Yilang-yilang oil is a blood pressure regulator, sedative, antiseptic	distillation of flower	Suseno 1988.
Cassia fistula (amaltas)	moist tropical	medicinal (bark, fruit and leaves), timber, tannin (root and bark)		Rego 1985.
Celtis australis (kharik)	temperate, subtropical	timber, fuel, fodder, sports goods, fruit (edible and medicinal), utensils		Rego 1985.
Ceratonia siliqua L. (carob)	Dry climate characterized by hot, dry summers and cool, wet winters; wide variety of soils	seed contains sugar sometimes sold as candy; can be converted to syrup and fermented to a wine or liquor, gum and fodder, feed, food, forestation and soil conservation		NAS 1979.
Cinchona ledgeriana Moens (yellow bark, ledger bark)	India, Asia	high concentrations of alkaloid quinine, quinidine (5-14%) on bark of stem and roots, anti malaria (quinine) and cardiac depressant (quinidine)	fast growing tree, up to 20 ft. tall, coppices; stumps grubbed out to obtain root bark	Staba 1988.
Cinnamomum burmani (kayu manis)	S.E. Asia, Malaysia	bark for cooking, cinnamon bark oil; cinnamon leaf oil, cosmetic and medicine	distillation of dried bark; distillation of leaf	Suseno 1988.
C. camphora (camphor, kapur)	moist tropical	camphor oil, medicinal		Rego 1985.
C. cecidodaphne (gundroi)	subtropical, temperate	cabinet making, planks, construction work, essential oil		Rego 1985.
C. culilawan (kayu teja, kulilawan)	S.E. Asia, Malaysia	Lawang oil	distillation of dried bark	Suseno 1988.
Cupressus torulosa (Himalyan cypress)	temperate, subtropical	timber, furniture, leaves (oil)		Rego 1985.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process Operation Remarks	References
Curcuma longa (Zingiberaceae) (kunar, kunyit)	S.E. Asia, Malaysia	traditional medicine, curcuma oil	fresh and dried powder, distillation of rhizome	Suseno 1988.
C. xanthorhiza (Zingiberaceae) (temulawak)	S.E. Asia, Malaysia	medicine, beverages	distillation of rhizome	Suseno 1988.
Cymbopogon citratus (sereh lemon, bumbu)	S.E. Asia, Malaysia	spices, beverages, lemongrass oil	distillation of leaf	Suseno 1988.
C. nardus (sereh, sereh wintergrass)	S.E. Asia, Malaysia	spices, beverages, Java citronella oil	distillation of leaf after dried 1-4 days	Suseno 1988.
Derris indica, *Pongamia pinnata* (kasanj)	Native to Indian subcontinent, now widely introduced throughout the world's humid lowland tropics, including Philippines, Malaysia, Australia	oil from seed for lubricant, fuel in kersosene lamp, leather dressing, manufacture of soap, varnish and paints, and medicine; pressecake after seed oil is extracted has insecticidal and pesticidal properties, poultry feed and fertilizer		Little 1982.
Diospyro peregrina (kala tendu)	moist tropical	gum, tannin (dyeing, tanning and medicine), seed (medicinal oil); constructional wood		Rego 1985.
Dipterocarpus kerri (keruing gondol)	Malaysia	oleoresin from wood - keruing oil, Gurjun balsam essential oil, perfume like patchouli oil	tapped and collected weekly	Gianno and Kochummen 1981.
Dryobalanop spp. (kamper)	S.E. Asia, Malaysia	camphor		Suseno 1988.
Emblica officinalis (amla)	wild and cultivated throughout much of tropical Asia, including central and southern India, Sri Lanka, Burma, Malaysia, S. China	fruit contains vitamin C (ascorbic acid) in high quantity; bark used in taminga dying, hair dyes; fodder, tannin, timber, fuel; very sour fruits eaten fresh, dried, preserved; bark sometimes used in medicine		Little 1982.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Eucalyptus citriodora (lemon scented spotted gum)	subtropical, moist tropical	fuel, oil (medicinal)		Rego 1985.
E. globulus (blue gum)	temperate	timber, paper, essential oil		Rego 1985.
E. tereticornis (mysore gum)	dry tropical, moist tropical	timber, paper, essential oil, fuel, plywood		Rego 1985.
E. urophylla *E. alba* (ampupu, hue)	S.E. Asia, Malaysia	bee honey, Eucalyptus oil	bee keeping, distillation of leaf	Suseno 1988.
Eugenia caryophillata (cengkeh)	S.E. Asia, Malaysia	clove oil, clove stem oil, clove leaf oil	dried flower distillation, leaf distillation	Suseno 1988.
Fraxinus excelsa (European ash)	temperate	timber, furniture, axe handles, gum, carriages, boat buildings, sports goods		Rego 1985.
Garuga pinnata (Kharpat)	moist tropical	timber, furniture, bark (tannin), fodder		Rego 1985.
Gaultheria punctata (gandapura)	S.E. Asia, Malaysia	Gaultheria oil (minyak gandapura medicine)	leaf distillate	Suseno 1988.
Gmelina arborea (gambar)	moist tropical	timber, printing block, musical instruments, cart axles, fuel, medicinal		Rego 1985.
Gnetum gnemon L (melinjo)	S.E. Asia, Malaysia	chip, vegetable	fruit eaten	Suseno 1988.
Grevillea robusta (silver oak)	subtropical	gum, resin, timber, fuel, ornamental		Rego 1985.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process Operation Remarks	References
Hardwickia binata (anjan)	dry tropical	timber, posts and beams, fibres for ropes, oleoresins		Rego 1985.
Holoptelia integrifolia (kanju)	dry tropical, moist tropical	fuel, charcoal, brush back, light furniture, cabinets, plywood, fodder		Rego 1985.
Juglens regia (walnut)	temperate	timber, gunstocks, fruits		Rego 1985.
Kaempferia galanga (Zingiberaceae) (Kencur)	S.E. Asia, Malaysia	traditional medicine, spices, beverages, atsiri oil		Suseno 1988.
Lagerstroemia speciosa (jarul)	moist tropical	timber, medicinal, fodder, furniture, poles, sleepers		Rego 1985.
Madhuca longifolia (mahua)	dry tropical	timber, fuel, fruits and flowers edible, oil		Rego 1985.
Mangifera indica (mango)	dry tropical, moist tropical, wet tropical	edible fruits, fatty oils, plywood, shoe heels		Rego 1985.
Massoi aromatica (mesoyi, masoi)	S.E. Asia, Malaysia	oil for cosmetics and perfume	distillation of powder bark	Suseno 1988.
Mellaleuca leucadendron (kayu putih)	S.E. Asia, Malaysia	cajuput oil; fuelwood	distillation of leaf; a very valuable oil	Suseno 1988.
Mesua ferrea, (nahor)	moist subtropical, moist tropical, wet tropical, wet subtropical	box planks, fuel, paper pulp, medicinal		Rego 1985.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Michelia alba (cempaka putih)	S.E. Asia, Malaysia	champaca oil, champaca leaf oil	distillation of flower and leaf	Suseno 1988.
M. champaca (champa, Cempaka kuning)	moist tropical, wet tropical, S.E. Asia, Malaysia	timber, fuel, fatty oil, champaca oil, champaca leaf oil, resin	distillation of flower	Rego 1985, Suseno 1988.
Morus spp. (murbei)	S.E. Asia, Malaysia	leaf silk	silk worm rearing	Suseno 1988.
Myristica fragrans, (East Indian nutmeg) (pala)	S.E. Asia, Malaysia	spices, candied fruit (sweets), nutmeg oil, mace oil, nutmeg contrete	drying of nutmeg and foel; distillation of nutmeg and foel;	Suseno 1988.
Pallaquium spp. (perca)	S.E. Asia, Malaysia	gum		Suseno 1988.
Persea americana (alpikat, avicado)	S.E. Asia, Malaysia	fruit, avocado oil	distillation of seed	Suseno 1988.
Phelophorum spp. (soga)	S.E. Asia, Malaysia	tannin		Suseno 1988.
Pinus elliotti (slash pine)	subtropical, tropical	timber, resin, pulpwood		Rego 1985.
P. insularis (khasi pine)	subtropical	timber, resin, pulpwood		Rego 1985.
P. merkusii (tusam)	S.E. Asia, Indonesia, Malaysia, Philippines; 50-2000 m alt.; 1200-2200 mm rainfall; 0°-28°C; wide site tolerance	oleoresin by tapping, turpentine (24% of resin tapped from tree), solvent; pine needle oil	tapping of resin, distillation	Rudjiman 1981, Meulenhoff and Silitonga 1978.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products Uses	Process/Operation Remarks	References
Piper betle (sirih, suruh)	S.E. Asia, Malaysia	traditional medicine, betle vine oil for medicine	fresh leaf, distillation of leaf	Suseno 1988.
P. nigrum (lada, peper)	S.E. Asia, Malaysia	traditional medicine, peper oil	fruit powder, distillation of dried fruit	Suseno 1988.
Pithecellobium dulce (jangh, jalebi)	tropical	packing cases, fuel, fodder, edible fruits, fatty oil		Rego 1985.
Pittosporum resiniferum	Philippines; 30 m tall	fruit, walnut size, rich in light oil, fuel, torch light	pinene (38%) and myrcene (40%), yields 6-18 kg/yr per tree, grown in plantations, harvest oil projected at 6-10 bbl/ac/yr, early development stage	Noble 1978, Nemethy and Calvin 1982.
Pogostemon cablin (nilam, dhilem)	S.E. Asia, Malaysia	patchouli oil	distillation of leaf; a valuable oil in commerce	Suseno 1988.
Pongamia pinnata (karanj)	dry tropical	seeds—fatty oil, furniture, turnery articles, fuel, fodder, medicinal		Rego 1985.
Prosopis chilensis (kikkar)	dry tropical	fuel, fodder, small timber, soil conservation		Rego 1985.
P. cineraria (jand, shami)	Southwestern Asia; dry, tropical	pods for fodder, high protein food additive	not an important chemical species—lack of research?	Little 1982.
Pterocarpus indicus (tangsana, sono kembang)	S.E. Asia, Malaysia	fancy wood, luxury wood, oil, fodder	distillation of flower	Suseno 1988.
P. marsupium (bijasal)	moist tropical	gum, kino (medicinal), railway carriages firewood, fodder constructional purposes		Rego 1985.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
P. santalina (cendana merah, red sandalwood)	S.E. Asia, Malaysia	sandalwood oil, fodder	distillation of wood	Suseno 1988.
Pterocymbium tinctorium	tropical, islands region	carving, dye, medicinal, fuel, fodder, musical instruments		Rego 1985.
Quercus lineata (Indian oak)	temperate	fuel, bark and leaves—tannin		Rego 1985.
Santalum album L. (cendana, sandalwood)	S.E. Asia, Malaysia, dry tropical	sandalwood oil, wood handcraft, medicinal, perfumery, fodder	distillation of root and wood gives valuable oil; research needed for extensive plantation culture and utilization	Suseno 1988, Rego 1985.
Sesbania grandiflora (agali)	S.E. Asia, humid tropical, to 800 m elevation, wide range of soils	fuelwood, bark tannin, ornamental; foliage for green manure; leaves, pods used for vegetables, fodder		Little 1982.
Schleichera oleosa (kesambi, kosambi)	S.E. Asia, Malaysia	vegetable, first quality of charcoal, lac, mecassar oil	excretion of Laceiferlaca in branching, fruit eaten and distillation	Suseno 1988.
Stenoptera spp. (tengkawang)	S.E. Asia, Malaysia	cosmetic oil	fruit preserve	Suseno 1988.
Sterculia urens (Karaya)	dry tropical	gum karaya, timber, toys, match boxes and splints, fuel, seed (edible)		Rego 1985.
Stereospermum suavelens (paral)	moist subtropical	timber, carriages, wagons, furniture, fuel, charcoal, medicinal		Rego 1985.
Styrax benzoid (kemonyan)	S.E. Asia, Malaysia	styrax gum		Suseno 1988.

Table 2. Continued

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Syzygium cumini (jamun)	moist tropical	fruit (edible and medicinal), timber, plywood, fuel, fodder, match wood		Rego 1985
Tamarindus indica (imli, tamarind tree)	Tamil Nadu, India, dry tropical, wide variety of soil types	fruit pulp (sauces and chutney), medicinal, fodder, timber, fuel, charcoal, gum for textile sizing, paper and jute products	edible pulp is extracted from pods; seed ground to produce a pectin-like gum	Rego 1985, NAS 1979.
Terminalia alata (laurel)	tropical	telegraphic and electric poles, constructional purposes, agricultural implements, tool handles, railway wagons, pulp, fodder		Rego 1985.
T. bellirica (bahera)	moist tropical	timber, pulp, plywood, fruit, medicinal, fodder		Rego 1985.
T. catappa (Indian almond)	tropical	timber, mine-props, plywood, bark (tannin and oxalic acid), fodder, leaves for tasar silk worm, seed, oil		Rego 1985, Little 1982.
T. chebula (harra)	moist tropical, tropical	fruits, medicinal, timber		Rego 1985.
T. crenulata (laurel)	moist tropical, dry tropical, wet subtropical	timber, fodder, bark (oxalic acid)		Rego 1985.
T. myriocarpa (hollock)	moist tropical	jute mill rollers, fuel, fodder		Rego 1985.
Trewia nudiflora (gutel)	tropical	timber, plywood, fuel, medicinal		Rego 1985.
Zingiber officinale (Zingiberaceae) (jahe)	S.E. Asia, Malaysia	preserved ginger, ginger ale, ginger oil		Suseno 1988.
Ziziphus mauritiana (ber)	dry tropical, moist tropical	fruits, fuel, tannin, medicinal, fodder		Rego 1985.

Many species yield important commercial oils, including *Santalum album* (sandalwood), *Dalbergia sissoo* (rosewood oil), *Pittosporum resiniferum*, *Canangium odorata* (yilang-yilang oil from distillation of flowers), *Cinnamomum burmani* (cinnamon bark oil), *Eucalyptus uraphylla* (leaf oils), *Mellaleuca leucadendon* (cajuput oil), *Myristica fragrans* (nutmeg oil), *Pogostemon cablin* (patchouli oil), and many others, including *Pinus roxburghii*, *P. elliotti*, and *P. khesyaand*. Several institutes are actively researching the oil species to determine compositions and yields (Ibrahim 1988a, 1988b). However, considerably more emphasis is needed on resin and oil-bearing species because they offer good income potential for small farmers. Research is also required to improve methods of stimulating resin production, more efficient collection systems, and localized processing. Further, the opportunities for plantation culture of aromatic plants, such as *Aleuritas* (tung oil), *Shorea* spp. (fruit, fat, and resin), camphorwood, sandalwood, rosewood, and others are substantial as is evidenced by results in mainland China.

Many MPTS have edible parts that can contribute significantly to staple diets. These include bananas, durian, mangoes, illipe nuts, walnuts, breadfruit, bamboo shoots and other tree shoots or leaves, and starch from sago palm.

Individual species yield various products, such as dyes, tannins, gums (*Acacia catechu*, *Astragolus* spp.), medicinals, shellacs, perfumes, sugars, and animal feeds that research could help develop further.

Specialty MPTS

This category of MPTS includes some unique species for testing in terms of producing non-wood products on plantations. *Shorea pinanga* (illipe or red meranti) is a good example of a MPTS that plays an important role in the economic well-being of farmers practicing agroforestry. The illipe nut provides substantial income to farmers because it contains flavoring substances, perfume components, and is edible. Serious consideration should be given to the continued introduction of special-purpose exotic species into Southeast Asia. The jojoba tree (*Simmondsia chinensis*) is a dry-site species that yields a valuable wax and oil, as well as other products (Table 3). It could provide farmers income if preliminary research shows feasibility (Yermanos 1979). Chinese tallow tree (*Sapium sebiferum*) is a seed oil tree that lends itself to intensive culture on small farms. Its attributes and potentials are well described by Cowles and Scheld (1987). *Gleditsia triacanthos* (honeylocust) is capable of producing large quantities of pods that are rich in sugar and protein. The pods may be fed to livestock but research into their chemistry may reveal other uses of this drought-hardy tree. Rattan (*Calamus caesius*), although a woody vine, grows intimately with forest trees and is widely used for its fiber throughout the world. The chemistry of rattan is little known so additional research along these lines would be justified. The Empress tree, or *Paulownia*, is popular in South China because of its extremely rapid growth, fine wood, and other uses. Research on its chemistry and cultural requirements in other parts of Asia should be undertaken. Finally, the rubber tree (*Hevea brasiliensis*) is perhaps one of the most highly researched and intensively cultured species in Asia. Yet other facets of its cultivation, especially as a source of bee honey, deserve increased attention from researchers.

There is certainly a wide range of opportunities for developing new chemical resources from MPTS and for making already important species even more useful to farmers.

CONSTRAINTS AND OPPORTUNITIES

As suggested in Fig. 1, the utilization of non-wood products from tropical species may begin with trees growing either in natural stands or cultured in plantations. Plantations may be large-scale or on

Table 3. Specialty MPTS.

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Calamus caesius (blume, rattan, rotan sega)	woody vine growing throughout tropical rain forests, up to 150 m in length	cone, fiber, extensively for rope, house construction, baskets, sleeping mats, chemistry unknown		Weinstock 1984.
Gledisia triacanthos (honey, locust)	N.E. America but adapts to wide range of conditions; drought hardy, subtropical; grows to 45 m but yields pods in 3-4 years	pods (up to 5 cm x 45 cm), rich in sugar and protein; 450 kg. dry pods/tree/year max.; livestock feed, shade, ornamental, fuel, lumber	harvest pods for fodder, grind or rush; excellent for two-story agriculture due to translucent crown; legume but does not fix nitrogen	NAS 1979, Gold and Hanover 1987.
Hevea brasiliensis Muell. (rubber)	S.E. Asia, tropics	tapped for latex to make rubber; provides substantial income for farmers; extensively cultivated and researched; excellent source for bee honey, seasonal		Nair 1987.
Paulownia spp. (Paulownia, Empress tree)	S. China, subtropical; extremely rapid growth, coppices	intercropped with other species; leaves used for fodder; sawdust for mushroom culture	research needed on chemistry	Vondra 1988.
Rhizophora macronata (mangrove)	Malaysia	tannin from bark (15% of tree), high potential as adhesive	gather, grind, extract bark with water; bark presently wasted	FRIM 1987
Sapium sebiferum: (Chinese tallow tree)	Central S. China, semi-tropical; widely planted in Asia and S. America	white seed coat contains a hard, edible tallow used in soaps, candles; kernal oil is a good drying oil similar to tung or linseed	extensive trials needed to introduce to cultivation	NAS 1983, Cowles and Scheld 1987.

Table 3. Continued.

Scientific Name (Common Names)	Region Cultivated/Characteristics	Products/ Uses	Process/Operation Remarks	References
Shorea pinanga (red meranti, illipe)	S.E. Asia, Sarawak; widely cultivated	nut, flavor, perfume, fat from nut used in chocolate industry; provides substantial income for poor	farmers extract from nut; seasonal fruiting, sporadic	Muelenhoff and Silitonga 1978.
Simmondsia chinensis (jojoba)	Sonoran Desert of Mexico and U.S.; drought resistant, tolerates temp. to 40° C; a bush to 5 in height; long-lived (100 + years)	liquid wax, polishing wax; cosmetics; cooking oil; lubricant; animal feed and feed supplement, browse obtained from seed and leaves; 14-18 kg seeds/ tree, 400 kg/ha	oil requires little or no refining, 45% yield, is equivalent to whole sperm oil; stores long-term	Yermanos 1979.

individual farms, often in an agroforestry system. Although some problems associated with developing a MPTS product are unique to a particular cultural system, many are common to both.

Perhaps the greatest challenge in having farmers adopt any new system is being able to educate and demonstrate to them the benefits and implementation of change. As seen in Tables 1-3 and the discussion above, there are innumerable MPTS uses for gums, resins, and exudates based on a long history of traditional practices. Therefore, new products and procedures must be carefully introduced and adopted by farmers with their own modifications to ensure long-term success. Well-designed experiments followed by well-developed demonstrations will be keys to implementing new or better ways of culturing and utilizing MPTS.

Although our present knowledge base for non-wood products is substantial, the potential for increased utilization of MPTS for chemicals, etc. is enormous. There are several reasons for this. First, there are thousands of species available for exploring new uses. Second, only recently have powerful analytical methods been available to screen rapidly for chemicals in plants. For example, analyses that used to take a lifetime can now be done in days or weeks with gas or liquid chromatography. Third, the world demand for many tropical species products is large and values are often high in the world markets. Fourth, there is genuine worldwide concern for the well-being of tropical forests and the people who live in and derive their livelihood from them. This consideration, along with economics, is probably the driving force that will ensure that chemicals become an even more important commodity obtainable from MPTS.

The nine points listed below constitute general recommendations for future research to help expand use of non-wood products from MPTS:

1. find new species as sources of useful products,
2. develop new or better uses for existing MPTS,
3. preserve the genetic diversity currently available in tropical ecosystems,
4. improve species selection through tree improvement procedures,
5. improve methods of collection and harvesting the products,
6. develop methods for sustained production,
7. develop markets,
8. process products at local levels to the fullest extent possible, and
9. carefully integrate new developments into existing social systems.

SPECIFIC RECOMMENDATIONS

Traditional harvesting or collection of non-wood products from tropical forests and their utilization both locally and in world markets has considerable potential for expansion. A key requirement for assisting such expansion is carefully planned and executed research projects to open new opportunities that can eventually be adopted by farmers. The following 12 recommendations are designed to guide

research planning by Winrock International in small-farm production of non-wood products, especially gums, resins, and exudates.

1. An international workshop on developing non-wood products from tropical forests should be held in 1989 or 1990 at an appropriate location in Southeast Asia. The purpose of this workshop would be to bring together experts in the biological, technical, economic, and social sciences who could develop a "state-of-the-art" document. This workshop would serve to focus wide attention and stimulate further research on the vast potential of non-wood products for future development in tropical forests.

2. Establishment of a formal cooperative center or institute in Southeast Asia would act as an information clearinghouse and research and coordination facility for non-wood forest products. Dr. Salleh Mohd. Nor (1988), Director General, Forest Research Institute Malaysia, has also proposed that a similar institute be located at Kuala Lumpur. Such an organization would provide the international focus, knowledge base, long-term continuity, and planning and coordination opportunities that are desperately needed to bring the presently dispersed non-wood products industries into their deservedly leading economic role in the tropics.

3. Selected high-priority MPTS widely grown by small farmers should be screened for new chemical substances. Emphasis should be given to the following species:

   Acacia auriculiformis
   A. mangium
   A. nilotica
   Azadirachta indica
   Eucalyptus camaldulensis
   Robinia pseudoacacia

   Systematic chemical characterizations aimed at revealing chemicals that can be collected by farmers are needed for these species. Although neem or *Azadirachta indica* is probably the furthest along in terms of profiling its chemistry and product development, much remains to be done even on that remarkable species. The others listed are also high priority for chemical screening.

4. Analysis of the primary species from which oleoresins are obtained by farmers is needed. Species such as *Pinus merkusii* and *Dipterocarpus kerri* should be emphasized and studied from the following standpoints:

   - genetic variation in resin yield and composition, especially as composition affects quality of resin,
   - improved techniques for tapping of trees to increase yields and efficiency of operations,
   - investigation of the use of the stimulant paraquat for increasing yield per tree, and
   - optimized marketing and processing of farmer-gathered materials to increase returns to local economies.

5. The following specialized species-products systems should be carefully evaluated by economists and sociologists and possibly targeted for demonstration and development:

- o Beekeeping and honey production. This is a lucrative enterprise for small farmers that involves species such as rubber tree, acacias, *Eucalyptus* spp., and *Robinia pseudoacacia*.

- o Sericulture. Cultures of *Morus* spp. and silkworms to produce silk are highly amenable to further development in Southeast Asia.

- c Production of valuable shellac and lacquers. These are derived from culturing *Agathus lorantifolia* and the insect *Laccifer lacca* to produce the intermediate substance copal.

6. Tannins derived from gathered bark of several species, including the neem tree, other acacias, and mangroves, are excellent binders and adhesives that could enter world trade in a significant way. Current research should be expanded and results implemented by economists, extension specialists, and sociologists.

7. The remarkable illipe nut from *Shorea pinange* or *S. macrophylla* yields useful substances that should be characterized and marketed. The seed fat is especially valuable as a cocoa butter replacement in chocolate.

8. Versatile rattans deserve strong research emphasis because they already have proven roles in world markets that can be substantially increased with more research. For example, plantation culture of rattan should be developed as the natural forests are removed. There is a great demand for disposable chopsticks, made from rattan, and rattan furniture is prized around the world.

9. Tissue culture research should be conducted to develop methodology for selected species including rattans, rubber tree, *Pinus merkusii*, and bamboo. This is necessary to accelerate genetic improvement programs for these valuable species and to ensure preservation of genetic diversity as mature forests are depleted.

10. Several highly promising new exotic tree species should be researched for possible use in Southeast Asia, including the Chinese tallow tree, jojoba, *Paulownia*, and honeylocust. These species offer unique opportunities for small-farm income or on-farm use for feed or fertilizer if their culture can be established.

11. Social-science studies of non-wood forest products at the village level should focus on their use, management, and ecology in a holistic framework. These would include methods of collecting, managing, and propagating forest resources and would integrate ethnological, economic and ecological data about people and forests (Padoch and Peters 1988).

12. Tree improvement programs should be initiated for all major species involved in plantation culture from which chemicals may be derived. These programs encourage farmers to tend trees intensively as crops, enable improved crop outputs or quality, and invariably show high benefit/cost ratios when carefully undertaken. Such programs are critical to increased utilization of the priority MPTS and other high-priority species.

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Appendices

SELECTED LIST OF INTERVIEWEES

INDIA

National Chemical Laboratory, Pune:

Dr. A.C. Mascarenhas, Head
Biological Sciences Division

Dr. John Barnabas, Head
Biochemical Science Division

Dr. N.R. Ayyangar, Head
Organic Chemistry Division

Dr. Nagasampagi, Head
Natural Products Division

Many (10-15) other scientists provided useful information at the NCL in Pune.

New Delhi:

Dr. Ravinder Sehgal
Department of Tree Improvement and Genetic Research
University of Horticulture and Forestry
Solan, 173230 India

Indian delegation to M.S.U.:

Mr. K.S. Bangarwa
Haryana Agricultural University
Hisar, Haryana

Dr. K.S. Bhatia
C.S. Azad University of Agriculture and Technology
Kanpur, Uttar Pradesh

Dr. Ranjit Singh Dhanda
Punjab Agricultural University
Hoshiarpur, Punjab

Dr. Mukund Purshottam Diwakar
Konkan Krishi Vidyapeeth Agricultural University
Dapoli, Maharashtra

Mr. M. Saleem
Sher-e-Kashmire University of Agricultural Sciences and Technology
Srinagar, Kashmir

Dr. N.K. Verma
Birsa Agricultural University
Ranchi, Bihar

INDONESIA

Jakarta

Dr. Setyono Sastrosumarto, Director General
Agency for Forestry Research and Development

Johannes A. Hoesada, Secretary to Dr. Setyono
Agency for Forestry Research and Development

Lukito Darvadi, Project Manager
Perum Perhutani

Bogor

Dr. Nana Supriana, Director
Forestry Products Institute
North Sumatera

Mr. Ombo Sayapradfa, Head
Forest Research Institute

Bengkulu

Dr. Soekotjo, President
University of Bengkulu
Jalan Kantz Lima

Yogyakarta

Oemi Hani'in Suseno, Professor
University Gadfah Mada

MALAYSIA

Forest Research Institute

Dr. Abdul Razak Bin Moh. Ali, Assistant Director
Chemistry

Dr. J. Ibrahim, Phytochemist (resins)

Dr. Azrah Mohd. Yusoff, Tissue Culture

Dr. Salleh Mohd. Nor, Director General

Dr. Mohd. Nor Mohd. Yusuf, Research Officer
Wood Chemistry

Mr. Francis Ng, Assistant Director
Wood Preservation

Universiti Pertanian Malaysia

Jalaluddin Harun, Lecturer
Wood Chemistry and Preservation

Dr. Kamas Awang, Dean
School of Forestry

Rubber Research Institute of Malaysia

Director, Biology Research
Tissue Culture

THAILAND

Bangkok

A. Colin McClung
Winrock International

Gerard Rinhon
Winrock International

臺灣省林業試驗所

TAIWAN FORESTRY RESEARCH INSTITUTE

BOTANICAL GARDEN, 53 NAN-HAI ROAD, TAIPEI

TAIWAN, REPUBLIC OF CHINA

Mar 12, 1988

Dr. James W Hanover
Department of Forestry
Michigan State University
East Lansing, Michigan 48824-1222
USA

Dear Dr Hanover

Your letter of Feb 3 to the Director of TFRI was received and was handed to me. In recent year forest by-product is one of the aspects received a lot of attention in this island. So far a limited results in several crops are available for the public. Enclosed please find a list of publication which may interest you. Since most of them were written in Chinese, I am afraid that they won't he very much help to you. If you need them I will be happy to send it to you.

At the end of August last year, I visited and talked to you in your lab. The several publications obtained from you are helpful to many of us. By the way I would like to get an invoice for the publication rel-ated to the genetic manipulation of woody plants, which is the topic of a conference held in E Lansing last year.

If anything I can do for you please don't hesitate write to me.

Sincerely,

Tsan-Piao Lin

Tsan-Piao Lin

Cheng TY, JC Yang, PY Tu, HL Liu, JL Wang 1980 Morphological variation and taxonomical study of oil tea camellia in Taiwan. Proceeding of the Annual meeting of Agricultural Associations, ROC. P. 43-61.

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Shieh JC, SG Hwang & S Cheng 1987 Effect of the essential oil of Cunninghamia lanceolata on the mycelial growth of Lentinus edodes. Quarterly Journal of Chinese Forestry 20(1):77-83.

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Wang JN 1985 Extractions, Analyses and yield-comparisons of berberine from nature species Phellodendron Wilsonii Hay et Kaneh in Taiwan. TFRI, Bull No.457 pp.10.

Multipurpose Tree Species Network Research Series

Papers

no. 1. Feasibility Study on Tissue Culture for Multipurpose Tree Species. Paiboolya Gavinlertvatana, A. Colin Matheson, and Eng Peng Sim. 1987.

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Reports

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The Forestry/Fuelwood Research and Development (F/FRED) Project is designed to help scientists address the needs of small-scale farmers in the developing world for fuelwood and other tree products. It provides a network through which scientists exchange research plans, methods, and results on the production and use of trees that meet the household needs of small farmers. These trees, in project terms, are multipurpose tree species (MPTS).

F/FRED is being carried out by the Winrock International Institute for Agricultural Development. Winrock was established in 1985 through the merging of the Agricultural Development Council (A.D.C.), the International Agricultural Development Services (IADS), and the Winrock International Livestock Research and Training Center. Winrock's mission is to improve agriculture for the benefit of people—to help increase the productivity, improve the nutrition, and advance the well-being of men, women, and children throughout the world. Winrock's main areas of emphasis are human resources, renewable resources, food policy, animal agriculture and farming systems, and agricultural research and extension.

F/FRED Project Management Office
Winrock International
1611 N. Kent St., Suite 600
Arlington, VA 22209
USA
tel: (703) 525-9430
tx: 248589 WIDC

F/FRED Global Research Unit
University of Hawaii
P.O. Box 186
Paia, HI 96779
USA
tel: (808) 579-8481
tx: 4900008339 DBS UI

F/FRED Coordinating Unit
Faculty of Forestry
Kasetsart University
P.O. 1038
Kasetsart Post Office
Bangkok 10903, Thailand
tel: 66-2/579-1977
66-2/561-1041
tx: 4900008037 MPT UI