Production of Aromatic Plants in Asia - An Overview*

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Abstract

Aromatic plants are plants that possess aromatic compounds, most of which are essential oils which are volatile in room temperature. They have traditionally been used as raw materials for extraction of essential oils (which, in turn, are used in the flavor and fragrance industries), as well as the sources of spices, herbs, and other natural products such as traditional medicines, pharmaceuticals, cosmetics, botanical pesticides, insect repellents, herbal teas/drinks, etc.

Asia is well known throughout the world as 'the Land of Aromatic Plants' because it possesses favorable climatic conditions suitable for the growth and development of aromatic plants. Other names like 'the Land of Spices', 'the Land of Traditional Perfumes', also indicate the popularity of aromatic plants in Asia. Such plants have been used commercially as spices and as sources of raw material for essential-oil industry from the dawn of history.

Aromatic plants were originally collected from the wild. Due to overexploitation, many species have become extinct or scarce so that they have to be cultivated. The present paper provides information on the list of species of aromatic plants, either collected from the wild, or those cultivated in countries in Asia. It also discusses the cultivation of major aromatic plants, and the advantages of cultivation, the genetic improvement and the cultural improvement of aromatic plants.

Keywords: *Aromatic plants, essential oils, spices, herbs, flavor, fragrance.*

Introduction

What are Aromatic Plants?

Aromatic plants (AP) are plants that possess aromatic compounds, most of which are essential oils which are volatile in room temperature. These compounds are synthesized and stored in a special structure called gland which is located in different parts of plant such as leaves, flowers, fruits, seeds, barks and roots. These essential oils can be extracted by various physical and chemical processes such as steam distillation, maceration, expression, *enfleurage*, and solvent extraction. They are mainly used as flavors and fragrances. However, from ancient times, these plants have been used as raw materials for cosmetics, pharmaceuticals, botanical pesticides, etc.

Importance of Aromatic Plants

AP can be divided into four groups based on how they are utilized, viz.:

- *As raw materials for essential oil extraction:* This is the major use of AP and is the one dealt with in this paper.
- *As spices:* These are plants in which their non-leafy parts are used as a flavoring or seasoning.
- *As herbs:* These are plants in which their leafy or soft flowering parts are used as a flavoring or seasoning.

- *Miscellaneous group:* These are AP used in some ways other than the ones mentioned above, for example, as medicines, cosmetics, dyes, air fresheners, disinfectants, botanical pesticides, herbal drinks/teas, *pot pourri*, insect repellents, etc.

People have made extensive use of AP from time immemorial. The Egyptian, the Persian, and the Babylonian were known to grow and use AP in making perfumes and other scented waters from a distillation of rose petals and orange blossoms. Oriental people were also fond of AP. They were grown in the palace compounds and used as raw materials to make perfumes, scented water, and a dozen of other aromatic products.

The Impact of Industrialization

The techniques of essential-oil extraction from AP have been known for thousands of year. These essential oils have been used in home-made perfumes, scented water, traditional medicine, etc. These plants were normally grown in the backyard and collected for use whenever there was a need. With the advance of industrialization through large-scale production and modern facilities for processing and utilization, AP and their products have become very popular. However, as production costs become more and more expensive, it is necessary to come up with practical solution, i.e. the invention of synthetic compounds that are almost the same as natural materials. This has considerably reduced the use of natural flavor and fragrant materials.

Recent Popularity of Natural Flavor and Fragrance Derived from Aromatic Plants

Several factors have contributed to the recent popularity of natural flavors and fragrances derived from AP, viz.:

- ***Back-to-nature campaign:*** The growing dissatisfaction with synthetic chemical products in perfumery, food, cosmetic, and pharmaceutical industries has motivated many people to turn to natural flavors and fragrances obtained from AP.
- ***Health conscious:*** Certain synthetic flavor and fragrant compounds used in various industries have been known to cause certain health hazards. Thus, these industries were forced to use natural materials even at a much higher price.

Aromatic Plants in Asia

The Land of Aromatic Plants

Tropical and sub-tropical Asia are rich in the number of species of AP due to their varied and suitable ecological conditions. The earliest known records related to AP were from Asia where the crops are indigenous. Asian people since prehistoric era had made use of AP in various traditional ways. In India, for example, old literature mentions numerous uses of essences obtained from plants in performing religious rite since prehistoric times. India is regarded as the traditional home of oriental perfumes (Sharma 1996). In China, Emperor Shen Nung, who lived around 2800 BC, held regular spice commodity market and practicing what he preached, consumed large quantities of spices everyday to strengthen his health and prolong his life. Throughout the long history of almost 5,000 years, the Chinese have continued to put faith in spices for medicinal purposes and for preserving and flavoring foods. At present, Chinese people have made use of more than 400 species of AP, not only from their flavor and fragrant properties, but also as medicines. China now produces more than 120 natural essential oils for domestic consumption as well as for export markets (Xiao 1996).

AP were versatile in various other Asian countries, particularly in Southeast Asia due to their abundance and tradition. Not only is Asia popular as the 'Land of Spices' and the 'Land of Herbs' (both of which are also AP), it is also quite popular as the 'Land of Traditional Perfumes and Cosmetics' as well as the 'Land of Traditional Medicines'. Various essential oils of commerce have been produced in Asia for more than a century.

List of Aromatic Plants in Asia

As AP have been utilized by Asian peoples since the dawn of history, it is very difficult to list all AP utilized in Asian countries. This is due to the fact that there are a large number of AP that either occur naturally in the wild or are being cultivated. Many species are very narrowly distributed and thus very little known outside the area of their occurrence. Some are used in one area but not in the other. Some are grown only for their domestic uses while others are cultivated on a large scale for their commercial exploitation. For convenience in describing them, the following system of grouping of AP is devised:

Naturally-occurring species: These are AP which occur naturally in the wild. Native people normally collect them for their own domestic uses. Some, however, are collected in a large quantity for industrial processing. They can be sub-divided into three categories on the basis of the quantity available and their potential.

(1) Available in small quantity: These are AP that are found scattering in the wild in small quantity. However, they are still collected for domestic uses. The list is given in Table 1.

(2) Available in large quantity: A few countries in Asia still maintain natural forests where AP are growing in pure stands (e.g. *Pinus* spp.), or scattered in large number such that native people can earn a good income by collecting them from the wild and sell them to local essential-oil factories. Examples can be cited of a few factories in Nepal which process pine resin from *Pinus roxburghii* for the production of turpentine and resin. About 4,000

Table 1. List of naturally-occurring AP in Asia available in small quantity for domestic uses*

Scientific name	Common name	Family	Parts used	Country
Acorus gramineus	Sweetflag	Araceae	Aerial parts	LAO, VIE
Aquilaria crassna	Eaglewood	Thymelaeaceae	Wood	THA, VIE
Cinnamomum iners	Thai cinnamon	Lauraceae	Bark	THA, VIE
C. loureirii	Vietnamese cassia	Lauraceae	Bark	VIE
C. tamala	Indian cinnamon	Lauraceae	Leaf	BGD
Elsholtzia blanda	-	Lamiaceae	Aerial parts	LAO, VIE
Homalomena aromatica	-	Araceae	Rhizome	LAO, VIE
Litsea cubeba	Cubeb	Araceae	Fruit	IND, VIE
Vetiveria zizanioides	Vetiver	Poaceae	Root	THA

** From Country Reports of the Asian Symposium on Industrial Utilization of Medicinal and Aromatic Plants (ASIUMAP), FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

Table 2. List of naturally-occurring AP in Asia available in large quantity for industry*

Scientific name	Common name	Family	Parts used	Country
Artemisia vulgaris	Mugwort	Asteriaceae	Aerial parts	NEP, VIE
Cinnamomum glaucescens	-	Lauraceae	Berry	NEP
Cymbopogon distans	-	Poaceae	Aerial parts	NEP
Gaulteria fragrantissima	Wintergreen	Ericaceae	Leaf	NEP
Juniperus indicus	Juniper	Cupressaceae	Berry	NEP
Nardostachys grandiflora	Spikenard	Valerianaceae	Rhizome	NEP
Pinus khasya	Pine	Pinaceae	Resin	THA
P. merkusii	Pine	Pinaceae	Resin	THA, VIE

P. roxburghii	Pine	Pinaceae	Resin	NEP
Parmelia nepalensis,	Lichens/Tree moss	Parmeliaceae	Whole plant	NEP
Usnea spp.,*Ramaliana* spp.	Lichens/Tree moss	Usneaceae	Whole plant	NEP
Rhododendron anthopagon	Rhododendron	Ericaceae	Twig	NEP
Zanthoxylum armatum	Zanthozylum	Rutaceae	Fruit	NEP

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

to 5,000 t of pine resin are produced annually (Rawal 1996). Similar situations can be found in Northern Thailand where a similar product is obtained from *Pinus khasya* and *P. merkusii*.

Commercial utilization of naturally-occurring AP is facing a number of constraints particularly the lack of raw materials to feed the factories. The other problem is the lack of manufacturers. With the establishment of a state enterprise in 1991 in Nepal, known as the Herbs Production and Processing Company Limited (HPPCL), such commercial utilization of naturally-occurring AP has taken a strong foothold in essential-oil industry in Nepal (Rawal 1996).

The list of naturally-occurring AP that are collected for processing is shown in Table 2.

(3) Potential naturally-occurring species: Taking advantage of the abundant naturally-growing AP in certain countries with suitable ecological conditions, e.g. in Bhutan, Lao PDR, and Nepal, attempts have been made to explore the possibility of industrial utilization of certain species in the future. The species that have been selected, through processing and marketing studies, are shown in Table 3.

Cultivated species: These are those which are grown in cultivation. They are either selected from promising varieties or clones from the wild, or have been improved through breeding, or introduced from other countries. This group can also be sub-divided into Three sub-groups on the basis of their scale of cultivation and their potential for cultivation.

(1) Small-scale cultivation: They are normally cultivated in backyard gardens or in mixed, subsistence cropping practice for domestic uses or processing in cottage industry. The list of AP that are grown on a small scale is given in Table 4.

Table 3. List of potential naturally-grown AP in Asia*

Scientific name	Common name	Family	Part used	Country
Abies densa	Silver fir	Pinaceae	Wood	BHU
Acorus calamus	Sweet flag	Araceae	Rhizome	BHU
Acorus gramineus	-	Araceae	Rhizome	LAO
Adenosma indicum	-	Scrophulariaceae	Aerial parts	LAO, VIE
Amomum sp.	Cardamom	Zingiberaceae	Fruit	LAO, VIE
Artemisia vulgaris	Mugwort	Asteriaceae	Aerial parts	BHU, VIE
Blumea balsamifera	-	Asteriaceae	Leaf	LAO, VIE
Chenopodium ambrosioides		Chenopodiaceae	Aerial parts	LAO
Cinnamomum camphora	Camphor	Lauraceae	Wood	LAO
C. cassia	Cassia	Lauraceae	Bark, leaf	LAO, VIE
C. obtusifolium	-	Lauraceae	Bark, leaf	LAO, VIE
Cunninghamia sinensis	-	Pinaceae	Saw dust	LAO

Elscholtzia cristata	-	Lamiaceae	Aerial parts	LAO, VIE
Eucalyptus globulus	Eucalypt	Myrtaceae	Leaf	LAO, VIE
Homalomena occulta	-	Araceae	Rhizome	LAO, VIE
Hyptis suaveolens	-	Lamiaceae	Herb	LAO, VIE
Litsea cubeba	Cubeb	Lauraceae	Fruit	LAO, VIE
Zanthoxylum armatum	-	Rutaceae	Fruit	LAO, VIE

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

Table 4. List of AP cultivated on a small-scale in Asia*

Scientific name	Common name	Family	Parts used	Country
Citrus hystrix	Leech lime	Rutaceae	Fruit peel	THA
Jasminum sambac	Arabian jasmine	Oleaceae	Flower	IND, PHI
Lavandula angustifolia	Lavender	Lamiaceae	Flower	IND
L. officinale	Lavender	Lamiaceae	Flower	IND
Lonicera japonica	Honeysuckle	Caprifoliaceae	Flower	CPR
Michelia alba	'Champi'	Annonaceae	Flower	CPR, THA
Ocimum gratissimum	Lemon basil	Lamiaceae	Aerial parts	IND, VIE
O. tenuiflorum	Holy basil	Lamiaceae	Aerial parts	THA, VIE
Pelargonium capitatum	Alta of rose geranium	Geraniaceae	Leaf	IND
P. crispum	Curly-leaved geranium	Geraniaceae	Leaf	IND
P. fragrans	Nutmeg-scented geranium	Geraniaceae	Leaf	IND
P.graveolens	Pot geranium	Geraniaceae	Leaf	IND
P.macrorrhizum	Scented geranium	Geraniaceae	Twig	IND
P.pratense	Scented geranium	Geraniaceae	Twig	IND
Rosa damascena	Damask rose	Rosaceae	Flowers	IRA, IND
Zingiber purpureum	'Phlai'	Zingiberaceae	Rhizomes	THA

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

(2) Large-scale cultivation: These are cultivated for industrial processing (Table 5).

(3) Potential cultivated species: These are AP that have been subjected to extensive yield trials at the research stations They are normally introduced crops that have been grown commercially elsewhere. Some, however, are native species that have been found to be promising after investigation with respects to adaptation to cultivation, having high yield of essential oils, with a simple processing technique, and with assured markets. They are shown in Table 6.

Countries of Production of Major AP

Although by definition, AP are plants which possess aromatic compounds, those that are

grown commercially are mainly for the purpose of extraction of essential oils. Of course, many are also grown as herbs, spices or for other purposes. Few countries in Asia produced essential oils on an industrial basis. These are China, India, Indonesia, Nepal, Sri Lanka and Thailand. Major AP that are grown for essential-oil extraction in these countries are shown in Table 7.

Collecting Naturally-Occurring AP

The Present Status

Although Asia abounds with a large number of AP, a majority of which still occur naturally in the wild, the extent to which they are being collected at present is quite small due to the change in habitat. However, a few countries, viz. Nepal, Bhutan, and Lao PDR, still collect AP from the wild.

Table 5. List of AP cultivated on a large-scale for industrial processing in Asia*

Scientific name	Common name	Family	Parts used	Country
Acorus calamus	Sweetflag	Araceae	Rhizome	CHN
Amomum globosum	Chinese cardamom	Zingiberaceae	Fruit	CHN
Artemisia vulgaris	Wormwood, mugwort	Asteriaceae	Aerial parts	CHN
Cananga odorata	Cananga, Ylang Ylang	Annonaceae	Flower	INS, PHI
Chrysanthemum morifolium	Chrysanthenum	Coppositae	Flower	CHN, THA
Cinnamomum burmanii	Indonesian cassia	Lauraceae	Bark	INS,
Cinnamomum cassia	Chinese cassia	Lauraceae	Bark	CHN, VIE
Cinnamomum camphora	Camphor	Lauraceae	Bark	CHN
Cinnamomum loureirii	Vietnamese cassia	Lauraceae	Bark	VIE
Cinnamomum verum	Cinnamon	Lauraceae	Bark	IND,INS, SRL
Cinnamomum tamala	Indian cassia	Lauraceae	Bark	IND, NEP
Curcuma domestica	Turmeric	Zingiberaceae	Rhizome	INS, VIE
Cymbopogon citratus	Lemongrass (W.Indian)	Graminae	Leaf	THA,IND, SRL
Cymbopogon flexuosus	Lemongrass (E. Indian)	Graminae	Leaf	THA,IND, SRL
Cymbopogon martinii var. *motia*	Palmarosa	Graminae	Leaf	IND, NEP, VIE
Cymbopogon nardus	Citronella (Ceylon)	Graminae	Leaf	IND, SRL, VIE
Cymbopogon winterianus	Citronella (Java)	Graminae	Leaf	IND, INS
Elettaria cardamomum	Cardamom	Zingiberaceae	Fruit	IND, SRL
Eucalyptus globulus	Eucalypt	Myrtaceae	Leaf	IND, INS, VIE
Glycyrrhiza glabra	Licorice	Fabaceaee	Stem	CPR
Glycerrhiza urens	Licorice	Fabaceae	Stem	CPR
Illicium verum	Star anise	Magnoliaceae	Fruit	CPR
Jasminum officinale	Jasmine	Oleaceae	Flower	IND
Matricaria chamomilla	German chamomile	Asteriaceae	Flower	NEP
Mentha arvensis .	Japanese mint	Lamiaceae	Aerial parts	IND, PAK THA

Mentha citrata	Bergamot mint	Lamiaceae	Aerial parts	IND
Mentha piperita	Peppermint	Lamiaceae	Aerial parts	IND
Mentha spicata	Spearmint	Lamiaceae	Aerial parts	IND
Myristica fragrans	Nutmeg/Mace	Myristicaceae	Seed/aril	INS, SRL
Ocimum basilicum	Basil	Lamiaceae	Aerial parts	IND, THA
Pimpinella anisum	Anise	Umbelliferae	Seed	IND
Pinus caribaea	Turpentine	Pinaceae	Resin	NEP
Piper nigrum	Black pepper	Piperaceae	Berry	IND, INS, SRL,VIE
Pogostemon cablin	Patchouli	Lamiaceae	Aerial parts	INS
Syzygium aromaticum	Cloves	Myrtaceae	Flower bud	INS
Tagetes minuta	Marigold	Asteriaceae	Flower	NEP
Trigonella foenum-graecum	Fenugreek	Fabaceae	Seed	IND, PAK
Vanilla planifolium	Vanilla	Orchidaceae	Pod	INS, SRL
Vetiveria zizanioides	Vetiver	Poaceae	Root	IND, INS
Zingiber officinalis	Ginger	Zingiberaceae	Rhizome	THA, VIE

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

Table 6. List of potential cultivated species of AP in Asia*

Scientific name	Common name	Family	Parts used	Country
Abelmoschus moschata	Musk heart	Malvaceae		BHU
Artemisia annua	Worm wood	Asteriaceae	Aerial parts	BHU, VIE
Bursera delphechiana	Linaloe	Berseraceae	-	BHU
Cymopogon flexuosus	Lemongrass	Poaceae	Aerial parts	BHU
Cymbopogon martinii var. *motia*	Palmarosa	Poaceae	Aerial parts	BHU
Cymbopogon winterianus	Java citronella	Poaceae	Aerial parts	BHU
Melissa officinalis	Lemon balm	Lamiaceae	Aerial parts	BHU
*Mentha piperita **	Pepper mint	Lamiaceae	Aerial parts	BHU
*Ocimum basilicum **	Basil	Lamiaceae	Aerial parts	BHU,LAO,THA
Ocimum gratissimum	Lemon basil	Lamiaceae	Aerial parts	LAO, VIE
Vetiver zinanoides	Vetiver	Poaceae	Root	BHU, INS, VIE

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*

Objectives of Collecting

For household uses: In certain remote areas where AP are growing in the wild, native peoples sometimes collect them for their household uses, e.g. to make home-made products like perfume, shampoo, cosmetic, and flavoring and seasoning materials for their food. However, as development is approaching these remote areas, such practice is in the process of declining

For industrial extraction of essential oil: Rural people in certain countries still collect AP in a large quantity as a source of additional income. Processing of collected materials has been facilitated by the establishment of distillation units by the local people. However, as pointed out by Rawal (1996) in the case of Nepal, these collectors have not been able to obtain benefits fully because of exploitation by middlemen.

Advantages of Collecting

There are several advantages to collect-ing naturally-occurring AP, particularly where they still occur in abundance.

Generating income of native people: As pointed out by Rawal (1996), collecting naturally-occurring AP has supplemented the meager income of subsistence agriculture in the hilly and mountainous regions of the Himalayas. The same situation can be envisaged in other countries having similar condition as that of Nepal.

Providing raw material at low cost: As plant materials are growing naturally, there is no cost of production. It is anticipated that collecting in such remote areas would not be too costly. Thus, the price of these raw materials available for sale to the factories, even when transportation cost is added to them, would still be low.

Table 7. Asian countries which produce major AP*

Species	Country						
	CHN	IND	INS	NEP	SRL	THA	Others
Canango odorata			•				o PHI
Cinnamomum burmanii			•				
Cinnamomum camphora	•						
Cinnamomum cassia	•						
Cinnamomum tamala		o		o			
Cinnamomum verum		o			•		
Curcuma domestica	o	•	o	o	o	o	o PAK
Cymbopogon citratus		•					
Cymbopogon flexuosus		•					o BHU
Cymbopogon martinii		•		o			
Cymbopogon winterianus			•				
Elettaria cardamomum		•			•		
Mentha arvensis	•	•		o		o	o PAK, VIE
Myristica fragrans		o	•		o		
Ocimum basilicum		•					
Pimpinella anisum		•					
Piper nigrum		•	•			o	
Pogostemon cabin			•		o		
Syzygium aromatium		o	•		o		

Vanilla planifolium	o	o	•		o		
Vetiveria zizanioides		o	•				
Zingiber officinalis	o	•	o			o	

** From Country Reports of ASIUMAP, FAO/RAP, Bangkok, 4-9 Nov. 96 (see details in References)*
Legend: • *= major producer* o *= minor producer*

Access of raw material not available through cultivation: Certain species normally grow luxuriantly in wild state, but not in cultivation. Moreover, cultivation of these wild plants may be quite difficult and too costly to be undertaken.

Cultivation of AP in Asia

Although AP have been cultivated for a long time, they are mainly for direct uses as herbs and spices, or as medicinal plants. Those that were grown for the purpose of essential-oil extraction were of small-scale operation since the demand for essential oils was not great. Inadequate technology was another factor that was responsible for the lack of large-scale cultivation of AP. Only in a few countries in Asia has large-scale cultivation of AP for essential-oil extraction been made. These are China, India, Indonesia, and Sri Lanka.

Characteristics of Aromatic Plant Cultivation

Being relatively old crops in cultivation, a lot of farmers in the Region are presently engaged in the cultivation of AP. However, only few countries dominate cultivation of AP. At present, cultivation of AP is characterized by the following properties:

Subsistence cropping system: Production of AP in many countries in Asia is done by small farmers who grow different kinds of crops, including AP, in small areas. Normally, they are grown as mixed crops with various other cash crops, or as inter-crops under other perennial crops. Primitive varieties are commonly used.

As plantation crops: In certain other countries, particularly large producers of AP, and with certain species, AP are grown as plantation crops, occupying large area. The use of farm machinery and tools is necessary for this type of plantation.

Concentrated areas of production: Since AP are grown mainly for extraction of essential oils, there is a need for them to be planted near the factory. Thus, unlike medicinal plants, spices, or herb, AP are produced in specific locations having facilities for processing as well as suitable conditions for their cultivation, e.g. good soil, adequate source of water, availability of labor, fuel (for the factory), good transportation, etc.

Advantages of Commercial Cultivation of AP

Produce uniform material: Commercial cultivation of selected clones or improved varieties results in the production of uniform material. Such material yields consistent standard products of high quality, a prerequisite for successful flavor and fragrance industries.

Provide good income to the farmers: AP are high-valued crops; thus they bring higher income to the growers, particularly if high-yielding clones or varieties are used.

Provide opportunity for value-addition through processing: Technology for process-ing AP is quite simple and available in most developing countries in Asia. Commercial cultivation would provide raw material for further processing, many steps of which can be done in the locality where cultivation takes place, while another benefit is value-addition through industrial processing.

Create better environment in utilizing the waste and unproductive lands: As AP yield high income to the growers, costly inputs can be provided for their cultivation. This enables the utilization of the waste and unproductive lands which would otherwise remain idle.

Genetic Improvement

There are several approaches to obtain improved cultivars of AP. These are:

Introduction from other countries: This is a common approach attempted, since it is the easiest and least time-and effort-consuming. Moreover, introduced varieties normally yield standard marketable products.

Selection from the already-existing variants: Selection of the desired genotypes can be made from existing variants in the germplasm collection. In Thailand, for example, a selection, SoWo 1, of the Japanese mint has been made from introduced materials. It has very high fresh herbal yield, high oil content, and very high menthol content in the oil (90%) (Chomchalow 1978).

Conventional breeding: Unlike food or other crops whose major objective in their breeding programs is high yield of the biomass, the main objective of aromatic plant breeding is for high quality essential oils which are the major constituents of most AP. Of course, yields of each component and biomass are also of considerable importance. Other characters that are aimed at are the ease in extraction of active compounds, uniformity of the compounds and their products, early maturity, resistance to pests, diseases and environmental stresses.

Due to the lack of breeders and other facilities, not much breeding works on AP has been conducted in most Asian countries except for India. As an example, development of a new variety of *Jasminum grandiflorum* at the Indian Institute of Horticultural Research in Banglalore, India can be cited. A profusely-flowering strain, of 'Pink Pin' was developed with 0.35% concrete, and is capable of yielding 35 kg. concrete per ha. A triploid genotype of this species has been found to yield flowers containing 0.4% concrete (IIHR 1993).

Mutation breeding: Induction of mutation by various physical and chemical means can enhance the amount of variability of the crop. Induced variants of scented-rose geranium (*Pelargonium graveolens*) have been obtained in the mutation-breeding program of the Indian Institute of Horticultural Research in Banglalore, India, initiated with the objective of developing high-yielding clones with tolerance to wilt disease (IIHR 1993).

Biotechnological approach: Recent advances in biotechnological research have been applied to genetically improve AP for commercial exploitation. These are used as a means of: (i) increasing genetic variability, (ii)culturing and selecting desirable genotypes, (iii) rescuing embryo of selected genotypes, (iv)rapid multiplication of clones of selected genotypes,(v) transferring genes from distant parents, (vi) specific gene transfer

Although many of the techniques are not yet successfully applied to improve AP, some have already been made quite successfully.

Cultural Improvement

Next to genetic improvement, cultural improvement contributes significantly to the success of commercial cultivation of AP. Several methods have been made to improve the cultivation of AP. These are:

Good agrotechnological practices (GAP): It has been demonstrated in a number of species of AP that improved cultivars alone cannot produce high yield and desirable quality of the products. It has to be accompanied by GAP such as proper soil preparation and fertilizer application, plant spacing, control of weeds, insects and diseases, proper time and technique of harvesting, all the way to proper post-harvest treatment. In addition, knowledge of biosynthetic pathways that lead to the production of physiologically important constituents that make these crops economically valuable is of great importance. Likewise, knowledge of physiological response of genotype to the environment will help in the understanding of the crop's behavior, especially with respect to enhanced fertilizer responsiveness, water and light requirement. These will also help in the reduction

of crop duration in the field, increase the amount of desirable secondary metabolites and even the reduction of any undesirable constituents.

Cropping systems: In order to obtain maximum benefits of existing space, season, soil moisture and nutrients, several cropping systems involving AP have been employed. These include:

Inter-cropping: Several cash crops, e.g. vegetable, legumes, cereals, root crops, etc. can be grown together with AP with several advantages, e.g. reduction of weed, extra income from the same area. This practice is particularly recommended for AP with slow growth like vetiver and palmarosa. Inter-cropping trials on vetiver for achieving higher productivity, for example, were conducted by the Indian National Bureau for Plant Genetic Resources which indicated that vetiver-guar/cowpea, intercropping gave higher overall monetary returns over the sole vetiver crop and did not affect oil quality of vetiver. Similarly, in palmarosa, inter-cropping with short duration pigeonpea was highly profitable (NBPGR 1993).

Crop Rotation: This practice reduces the incidence not only of weed growth but also of seed-born diseases. Normally, leguminous crops which possess the ability to fix atmospheric nitrogen are often used in the crop rotation program with AP.

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