MEDICINAL PLANT RAW MATERIALS FOR INDIAN DRUG AND PHARMACEUTICAL INDUSTRY I. AN APPRAISAL OF RESOURCES

Y.K. SARIN*

Introduction

Plants have been used as healers and health rejuvenators since time immemorial. Even now, they play an important role in the health care of about 80 per cent of World population. The rest 20 per cent also depend substantially on plant based medicines. It is estimated that more than half of the drugs under clinical use at present owe their origin to plants. There has been an upsurge in the production of plant based medicines, tonics and body care products in recent years. According to World Health Organization (WHO) estimate, the global trade in plant based medicines and health products amounted to US $ 500 million in the year 1980. Subsequent survey by various agencies put the international market in natural product medicines at US $ 50 billion in 1993 with an annual increase potential of 30 per cent (Srivastava *et al.*, 1995).A tremendous increase in the production of herbal medicines and other products based on Ayurvedic, Unani and other traditional systems has been witnessed in India also. Besides, the rich biodiversity of the country is yielding plant sources of various therapeutically valuable chemical compounds or their precursors which are in great demand in national as well international drug and pharmaceutical industry. This has put a great pressure on the raw materials, majority of which are obtained from plants growing in the forests or are associated with other forms of natural vegetation. There has been a gross depletion of the natural population of a number of medicinal plants. Quite a few of these have become vulnerable while at least ten are endangered and on the verge of extinction. A sort of scare prevails at various quarters with regards to the decline or even discontinuation of supplies. Though the fears expressed are quite valid, the situation can be improved through various remedial measures, taken in time. Past success in augmenting the resources through large scale cultivation of *Saussurea costus, Rauvolfia serpentina, Withania somnifera* and *Gloriosa superba* and introduction of some valuable exotics such as Belladonna, Cinchona, Ipecac and Senna and recently of *Artemisia annua, Dioscorea floribunda* and certain rutin yielding species of *Eucalyptus*, justify this optimism.

Indian drug and pharmaceutical industry using plant raw materials

India has a well established and fast growing drug and pharmaceutical industry utilizing plant based raw materials. There are around 7,000 big and small pharmacies manufacturing medicines and Over-The-Counter (OTC) products like digestives and

* 21-C, Chandralok Colony, Rajpur Road, Dehra Dun (Uttaranchal). [Formerly Jt. Director, RRL (CSIR) Jammu].

laxatives, cosmetics, hair oils, aphrodisiacs and other tonics based on Ayurvedic, Unani and Siddha systems of medicine. The annual value of these products, at present, is variously estimated at between Rs. 4,000 to 4,500 crores (Handa, 1996). A number of drug and pharmaceutical firms, which include many multinationals, are engaged in the production of phyto-pharmaceuticals which consist of various important and largely used alkaloids, glycosides and other physiologically active organic compounds. India exported about 1,400 tonnes of these products during the year 2000-2001 (Anon., 2001). Other big consumers of herbal raw materials are the producers of plant extracts. Currently, emphasis is being laid on using standardized extracts in place of raw plant materials. These extracts are used for separation of therapeutically active chemicals or in the preparation of health promoting articles. This has created a new sector in the pharmaceutical industry known as phyto-extraction industry. There are more than 50 big or small units in India producing extracts of a large number of medicinal plant raw materials (Shah, 1997).

India is also a major exporter of medicinal plant raw materials and their extracts. These include Senna leaf and pod, Psyllium husk and seed, Galangal roots, Bael fruits, Karaya gum, Kamila powder, Nux-vomica seed, Chebulic, Belleric and Emblic myrobalan and at least 100 other materials. The country exported a total of 42,000 tonnes of medicinal plant raw material to other countries during the year 2000-2001. Of this, psyllium husk and seed (ex *Plantago ovata*), senna leaf and pod (ex *Cassia angustifolia*), vinca herb (ex *Catharanthus roseus*) and a few other sources of phyto-pharmaceuticals accounted for 32,209 tonnes. The export of materials employed in Indian System of Medicines (ISM) was 9,740 tonnes during the same period (Anon., 2001). Bulk of the latter came from the plants occurring wild.

The raw material consists either of the whole plant or one of its vegetative parts, an exudate, fatty or volatile oil having specific therapeutic properties or yielding a physiologically active chemical compound. Unprocessed material or crude drug, as it is commonly known, is employed chiefly in the medicines and OTC products based on Ayurvedic, Unani, Siddha and other traditional systems of medicine practiced in the Indian sub-continent. These are either used as such, in powder form, burnt under special process (*Bhasma*) or extracted with oil, animal fat, water or even animal urine. Allopathic and homoeopathic systems use extracts, tinctures or therapeutically active chemical compounds isolated from the raw material or synthesized from the precursors. Large scale commercial production of drugs, OTC, and other products based on traditional systems and substantial increase in the production of phyto-pharmaceuticals for use in western medicine has changed the pattern of consumption of herbal raw materials by the industry. Now the material is processed in bulk and in few lots, requiring large quantities of the raw materials at short intervals. This has put great pressure on the agencies supplying the raw material who procure it through all possible means without any consideration of the quality of the raw material, its conservation and augmentation of resources.

The number of medicinal plants in India

The number of medicinal plants in

India, both indigenous and introduced, has been variously put at between 3,000 to 3,500 species of higher plants. The *Glossary of Indian Medicinal Plants* has listed around 3,000 plants (Asolkar *et al.*, 1992; Chopra *et al.*, 1956, 1974). Two thousand five hundred plants have been reported to be used in ethno-medicine (Jain, 1991). The Ministry of Environment and Forests, Government of India, launched an All-India Coordinated Project on Ethno-biology in 1982. The interim report so far places the number of plant species used as ethno-medicine at 7,500. The final report, however, is still awaited and can be taken into account only when it comes out officially (Ahuja, 2001). The number of plants listed in Ayurvedic *Materia Medica* range from 260 in Dhanvantri's *Nighantu* to 560 in Bhav Prakash *Nighantu* (Kumar, 2000). The *Ayurvedic Drug Formulary* prepared by Department of Indian System of Medicine, lists 387 plants (Sarin, 1996). The Unani system of medicine describes 440 plants (Said, 1969) out of which 360 are common to other systems practiced in the country. Sixteen medicinal plants of exotic origin, introduced in India from time to time, are under cultivation and are now considered a part of the Indian medicinal plant resources. Notable among these are, Senna, Psyllium, Belladonna, Cinchona, Eucalyptus, Ipecac, Digitalis and Mexican Dioscorea. The number of plants having confirmed therapeutic properties or yielding a clinically useful chemical compound, thus lies around 700 species. Out of these the plants providing largely and/or regularly used raw materials by Indian Drug and Pharmaceutical Industry restricts to 335. This figure includes the raw materials imported from other countries, some of which such as liquorices, henbane, cassia bark, galangal , ephedra, long pepper, and star anise are used in appreciably large quantities. The occurrence of these medicinal plants and availability of raw materials derived from them is as follows :

Plants occurring wild in forests, grasslands, aquatic and desert ecosystems or associated with other forms of natural vegetation (Table 1) : The number of such plants is around 145. These include such important sources of raw materials as *Ephedra gerardiana, Saussurea costus, Podophyllum hexandrum, Taxus buccata* ssp. *wallichiana, Aquillaria malaccensis, Valeriana jatamansi, Strychnos nux-vomica, Terminalia chebula, Rauvolfia serpentina* and various species of *Berberis*. The raw material from more than 80 of these plants consists of root, rhizome or other underground parts; heartwood or whole herb which are non-renewable. The plants where the raw material is leaf, flower, fruit, seed, exudate or other renewable part also suffer if the collection method is destructive.

Plants growing as weed or have run wild (Table 2) : Fifty four species of plants in this category, provide the raw materials. Some of these such as *Adhatoda zeylanica, Andrographis paniculata, Phyllanthus amarus, Boerhavia diffusa, Convolvulus microphyllus, Gymnema sylvestre* and various species of *Datura* have large demand. These plants usually occur in fallow agricultural land, along roads and railway tracts, in gardens and orchards, on dust and organic dumps, ponds, marshes and other waste places. Some of these are escapes from cultivation or colonizers of secondary scrub springing up in cleared or degraded forest land. The weeds are prone to decline in growth and spread due to a change in the site conditions or through competition from an

Table 1

Medicinal Plants growing in forests, grasslands, running or stationary water bodies, deserts and other forms of natural vegetation.

Name of the plant	Part used	Main areas of natural occurrence	Resources	Demand
1	2	3	4	5
Abies spectabilis	LF	Sikkim, Arunachal, 3500-4200m	fair	Mar
Abroma augusta	STBK	W.B., Assam, Meghalaya upto 1200m	good	Low
Acacia catechu	STBK, EXT	North, West & Central India; upto 800m	poor [VU]	Med
Achillea millefolium	WP	J&K and HP, 2700-4000m	fair	Low
Aconitum chasmanthum	RT	Kashmir Hills, above 3600m	rare [CR]	Low
Aconitum deinorrhizum	RT	Jammu Hills, HP, 3500-4000 m	rare [CR]	Low
Aconitum heterophyllum	RT	J&K, HP and Uttaranchal, 3000-4500m	v.poor [EN]	Med.
Acorus calamus	RH	North and NE India, ascending to 1700m	fair [VU]	High
Adiantum pedatum	WP	Himalayan foothills; throughout	good	Low
Aegle marmelos	FR-RT	Central and South India up to 1000m	good [*]	High
Alangium salvifolium	FR	UP, Jharkhand, Orissa, sub-hill area	fair	Med
Alhagi pseudalhagi	WP	Haryana, Rajasthan, Gujarat; arid plains	poor [VU]	Low
Alstonia scholaris	STBK.	Western Ghats; Maharashtra to Goa	good	Mar
Aquillaria malaccensis	WD	NE Himalayas; foothills to 1800m	v.poor [EN]	Med
Argyriea nervosa	RT	Throughout India, sub-hill regions	good	Med
Aristolochia indica	RT	Western Ghats and coastal plains	fair	Mar
Arnebia benthami	WP	J&K, HP alpine valleys, 3500-4600m	v.poor [EN]	Mar
Artemisia maritime	HB	J&K., HP alpine valleys above 3500m	good	High
Artemisia nilagirica	HB	Throughout India, 1500 to 3000m	good	Med
Asparagus racemosus	RT	Jammu hills, HP and UA, 1000-1500m	poor [*]	High
Bacopa monnieri	WP	Throughout Indian plains	fair	Med
Balanitis aegyptiaca	FR	Rajasthan and Gujarat, arid hills	good	Low
Bambusa arundinacea	Manna	NE India, foothills upto 1500m	v.poor [EN]	High
Barleria prionitis	HB	North, West & Central India, upto 800m	good	Med
Barringtonia acutangula	SD	Orissa, Andhra, Ghat and Coast	fair	Med
Bauhinia variegata	STBK	Throughout India, sub-hill regions	good	Med
Berberis asiatica	RT	UA, outer hills, 800-1400m	poor [VU]	High
Berberis aristata	RT	HP and UA 1500-2200m	fair [VU]	High
Bergenia ciliata	RH	Jammu hills, HP, UA 1000 to 4500m	good	Med
Betula utilis	ST BK	Throughout Himalayas, above 3800m	v.poor [VU]	Low

Contd...

1	2	3	4	5
Bombax ceiba	RT/GM	Throughout India upto 500m	good	Med
Boswellia serrata	GM	Western and Central India	fair	Med
Butea monosperma	SD	North, South-eastern and Central India	good	Low
Caesalpinia crista	SD	Throughout India upto 1000m	good	Med
Callicarpa macrophylla	FLBUD	J&K, HP and UA. Outer foothills	good	Mar
Cassia fistula	FRPULP	Throughout India upto 1200m	good	Med
Cedrus deodara	WD	J&K, HP and UA, 1600-2700m	good	Mar
Celastrus paniculata	FR	Throughout India, upto 1200m	good	Med
Centella asiatica	WP	Throughout India upto 1000m	good	V.high
Chlorophytum spp.	RT	Western and Central India, arid plains	poor[VU][*]	Med
Cichorium intybus	RT/SD	J&K, HP, 2600-3800m	good	Mar
Cinnamomum tamala	LS/BK	UA & East Himalayas, 1500-2200 m	good	Med
Cissampelos pareira	WP/RT	Throughout India upto 1500 m	good	Low
Clerodendrum serratum	RT	UA, Bihar and Jharkhand, sub-hill areas	fair	Med
Colchicum luteum	Corm	J&K , Chamba (HP), 1700-4000 m	poor[VU]	Med
Coleus forskoholii	RT	Kumaon hills (UA), 600-1200 m	fair	Mar
Commiphora wightii	GM	Rajasthan, Gujarat, arid hills and Bet	v.poor[EN]	High
Coptis teeta	RT	Arunachal, 1500-2000m	poor[VN][*]	Low
Coscinium fenestratum	ST	Western Ghats, Karnataka to Kerala	poor[VN]	Med
Costus speciosus	RH	Throughout India upto 1000m	good	Mar
Crataeva nurvala	STBK	Throughout North and Central India	good	Med
Curcuma aromatica	Corm	Karnataka and Kerala, coastal forests	good	Low
Curcuma zedoaria	RH	NE India, throughout plains upto 1500m	good	High
Dactylorhiza hatagirea	RT	J&K, HP, UA and Sikkim, 4000-4800m	rare[CR]	Mar
Didymocarpus pedicillatus	RT	UA, sub-Himalayan region	v.poor[EN]	Low
Desmodium gangeticum	RT	North and Central India, sub-hills	good	Med
Dioscorea bulbifera	RH	Throughout India, sub-hill regions	good	Low
Dioscorea deltoidea	RH	J&K, HP, UA, 1500-2500m	poor[VU]	v.high
Embelia ribes	FR	NE Hill Regions, upto 1200m	fair[VU]	High
Embelia tsjerium-cottam	FR	NW and Central India, upto 1500m	good	High
Emblica officinalis	FR	Northern and Central India, upto 1000m	good[*]	v.high
Ephedra gerardiana	ST	J&K, HP, alpine valleys upto 4000m	fair[VU]	High
Ephemerantha macraei	WP	Sikkim, WB and Meghalaya upto 2000m	poor[VU]	Low
Erythrina indica	STBK	Karnataka and Kerala, coastal forests	poor[*]	Mar
Fagonia cretica	WP	Haryana, Rajasthan, Gujarat, arid plains	fair	Mar
Ferula narthex	GM	Ladakh	Extinct ?	High

Contd...

1	2	3	4	5
Gaultheria fragrantissima	LS	Sikkim and Arunachal, 1200-2200m	poor [VU]	High
Garcinia indica	FR	Maharashtra, Karnataka, W.Ghats	fair	Med
Gentiana kurroo	RT	J&K, HP and UA, 2700-4500m	rare [CR]	Med
Gloriosa superba	RT/SD	Throughout India upto 1000m	good [*]	High
Gmelina arborea	RT	North, West and Central India upto 1500m	good [*]	Med
Grewia tenax	ST	Rajasthan, Gujarat and other arid areas	poor	Med
Gymnema sylvestre	LS/RT	Andhra, Karnataka, TN, Kerala plains	fair [*]	Med
Gynocardia odorata	SD	Sikkim, Assam and Meghalaya, foothills	good	High
Hedychium spicatum	RH	Throughout Himalayas upto 1500m	good	High
Helicteres isora	FR	Northern and Central India upto 1000m	good	Mar
Hemidesmus indicus	RT	Karnataka, Kerala; Ghat, coastal forest	fair [*]	Med
Heracleum lanatum	RT	J&K, HP and UA, 1500-3000m	fair	Med
Hippophe rhamnoides	FR	J&K, HP and UA, 3000-4000m	good	Low
Holarrhena antidysenterica	STBK	Throughout India, sub-hill regions	good	High
Hydnocarpus pentendra	SD	Assam, West Bengal and Orissa	good	High
Hypericum perforatum	WP	J&K, HP, UA foothills upto 1200m	poor	Mar
Ichnocarpus frutescens	RT	Northern and Central India, sub-hills	good	Low
Iphegenia stellata	SD	Maharashtra, Ghat forests	poor[VU][*]	Low
Ipomoea hederacea	SD	UP, Bihar, W. Bengal Gangetic plains	good	Med
Juniperus communis	FR	Himalayas, throughout 4000-4500m	poor	Med
Leptadenia reticulata	RT	Gujarat, Rajasthan, Maharashtra, arid plains	fair	High
Lycopodium clavatum	Spore	Sikkim, 1600-2500m	poor [VU]	Med
Macrotomia benthami	RT	J&K, HP, arid areas, 3500-5000m	v.poor[EN]	Mar
Madhuca longifolia	FR,SD	Central and South-eastern India	good	High
Mallotus philippinensis	FR rind.	Northern and Central India upto 1000m	good	Med
Mentha longifolia	WP	Western Himalayas, 2000-4500m	good	Med
Mesua ferrea	Anther	North-Eastern States upto 1200m	good	Med
Mucuna pruriens	SD	Throughout India upto 1500m	fair	High
Myrica esculenta	ST,BK	HP and UA, 1300 to 2500m	fair	Low
Nardostachys grandiflora	RT	UA, Sikkim and Arunachal, above 4000m	poor [VU]	High
Neolitsea chinensis	ST,BK	N and SE India upto1000m	v.poor[EN]	Low
Oroxylum indicum	RT	UP, Bihar, Gangetic plains	good	Low
Paederia foetida	RT	Northern and Central India upto 1000m	good	Mar
Paris polyphylla	RT	HP and UA, 2500-3800m	fair	Low

Contd...

1	2	3	4	5
Parmelia perlata (lichen),	WP	UA to Arunachal, 1400-3000m	fair [VU]	Med
Picrorhiza kurroa	RT	Himalayas, J&K to Sikkim, above 3600m	poor [VU]	High
Pinus roxburghii	GM	J&K to UA, 1000-1300m	fair	Med
Plumbago indica	RT	West Bengal, TN, Orissa sub-hill regions	poor [VU]	High
Plumbago zeylanica	RT	Jammu hills to UA, sub-hill region	good	High
Podophyllum hexandrum	RT	J&K to Sikkim, 3000-4000m	poor [VU]	High
Piper longum	FR/RT	UA, Bihar, WB & Meghalaya, 700 -1200m	fair [*]	High
Pistacea integerrima	Gall	J&K and HP, 1000-1500m	poor [VU]	Med
Premna corymbosa	RTBK	UP, Bihar, Gangetic plains	fair	Med
Premna serratifolia	RTBK	TN, Kerala, Karnataka, coastal forests	fair	Med
Prunus cerasoides	STBK	HP and UA, 1300-2200m	fair	Mar
Pterocarpus marsupium	WD	UP, MP, Bihar, Jharkhand & Chattisgarh	fair	Med
Pterocarpus santalinus	WD	Andhra, TN, Eastern Ghats, dry hills	v.poor[EN]	High
Punica granatum	SD	Jammu Hills, Chamba (HP), 1000-1200m	good	Med
Pueraria tuberosa	Tuber	Throughout India, sub-hill regions	good	Low
Rauvolfia serpentina	RT	Throughout India, sub-hill regions	fair [*]	High
Rheum australe	RT	HP, UA above 4000m	fair [VU]	Med
Rhus parviflora	SD	HP, UA 1500-2600m	good	Mar
Rubia cordifolia	RT	Himalayas, throughout upto 2500m	good	High
Santalum album	WD	TN, Karnataka; Ghats and dry hill forests	fair [VU]	High
Sapindus mukrossi	FR	NW and Central India, throughout	good	v.high
Saraca indica	STBK	West Bengal, TN & Karnataka	fair [*]	High
Saussurea costus	RT	J&K, HP, above 3500m	poor [*]	High
Semecarpus anacardium	FR	Orissa, Chhattisgarh & Andhra, sub-hills	good	Low
Solanum indicum	RT	Northern and Central India, throughout	good	Low
Solanum khasianum	WP	Himalayan foothills throughout upto 1300m	good	Med
Stereospermum chelonoides	RT	UP, MP and Bihar, Gangetic plains	good	Med
Sterculia urens	GM	Andhra, Maharashtra and Gujarat, arid regions	good	Med
Strychnos nux-vomica	SD	WB, Orissa and Andhra Pradesh	good	High
Strychnos potatorum	SD	Karnataka, TN, Kerala, Ghat forests	good	Low
Swertia chirata	WP	UA, Darjeeling (WB) and Sikkim, 2000-3500m	v.poor[EN]	High
Symplocos racemosa	STBK	UA to Assam and Jharkhand, sub-hills	good	High

Contd...

1	2	3	4	5
Taxus wallichiana	STBK	HP and UA, 2500 - 3000 m	fair [VU]	High
Tecomella undulata	STBK	West Rajasthan, Gujarat and Central Maharashtra	poor [VU]	Med
Terminalia arjuna	STBK	Throughout India upto 1000m	good	Med
Terminalia bellirica	STFR	Throughout India upto 600m	good	Med
Terminalia chebula	FR	HP, UA, UP, Jharkhand and MP upto 800m	good	v.high
Tinospora cordifolia	ST	Throughout India upto 800m	good [*]	v.high
Urgenia indica	RT	UP, UA, Jharkhand and MP hills upto 1000m	fair [VU]	Med
Valeriana jatamansi	RT	J&K, HP and UA, 2000-3500m	good [VU]	v.high
Uraria picta	RT	UA, UP and Bihar, Gangetic plains	poor [VU]	Low
Viola pilosa & others	FL	J &K, HP, 1500 to 2000m	fair [VU]	High
Vitex negundo	LS/FR	Throughout India, upto 1000m	good	High
Woodfordia fruticosa	FL	Throughout India, foothills upto 1500m	good	High
Wrightia tomentosa	SD	Throughout India, upto 1000m	fair	Mar
Zanthoxylum armatum	FR	J&K, HP, UA, 800 - 1300m	poor [VU]	Med

Abbreviations and legends to Tables 1-6

Vegetative parts used : RT - root; RTBK - root bark; ST - stem; STBK - stem bark; LF - leaf; FL - flower; FR - fruit; SD - seed; GM - gum, oleoresin; WP - whole plant; HB - herb (aerial parts).

Resources : Good - No decline foreseen; Fair - May decline if there is increase in current rate of collection; Poor - Already declining; V. Poor - Declining sharply and may exhaust shortly; Rare - Almost exhausted in the wild; [*] - Declined in wild but progressively cultivated.

Threat categories (IUCN) : CR - Critically Endangered; EN - Endangered; VU - Vulnerable

Demand (in Drug & Pharmaceutical and export industry) : Mar (Marginal) - less than 100 MT per annum (p.a.); Low - between 100 and 500 MT p.a.; Med (Medium) - 500 to 2,500 MT p.a.; High - 2,500 to 5,000 MT p.a.; V.High (Very High) - above 5,000 MT p.a.

Table 2

Medicinal Plants growing as weed or under run wild conditions in secondary forest scrub, fallow agricultural land, orchards, organic dumps, along rail track or roads, in and around stagnant water bodies and other waste places

Plant	Part used	Main areas of natural occurrence	Resources	Demand
1	2	3	4	5
Abutilon indicum	WH,SD	Throughout Indian plains	good	Med
Acalypha indica	WP	Throughout Indian plains	good	Mar

Contd...

1	2	3	4	5
Achyranthus aspera	WP	Throughout Indian plains	good	Low
Adhatoda vasica	LF	Throughout India upto 1000m	good	High
Andrographis paniculata	HB	UP, Bihar, W.Bengal, Gangetic plains	fair[VU][*]	High
Baliospermum montanum	RT	Throughout India ascending to 1000m	fair	Low
Blumea balsamifera	HB	Sikkim, N.Bengal, Arunachal, Meghalya	good	Low
Boerhavia diffusa	RT	Throughout India, ascending to 1000m	good	High
Calotropis gigantea	RTBK	West Rajasthan, Gujarat & South India	poor	Mar
Cannabis sativa	LS	Throughout India, upto 3000m	good	Low
Cassia absus	SD	HP & UA, foothills upto 1000m	fair	Med
Cassia occidentalis	SD	Throughout India upto 1200m	good	Med
Cassia tora	SD	Throughout India upto 1200m	good	Med
Centratherum anthelminticum	SD	Throughout India upto 1000m	good	High
Coccinia grandis	FR	Throughout India ascending to 1000m	good	Mar
Convolvulus microphyllus	HB	North, West & Central India, plains	good	High
Curculigo orchioides	RT	Throughout India, under mango groves	fair[VU]	High
Cyperus rotundus	Tuber	Throughout India upto 1200m	good	High
Cyperus scariosus	RT	UP, Bihar, W.Bengal, Gangetic plains	good	Med
Datura metel	LS/SD	Throughout India ascending to 800m	fair	Med
Datura stramonium	LS/SD	W.Himalayas, Southern hills upto 1500m	good	Med
Eclipta prostrata	WP	Throughout India, moist & marshy loc.	good	High
Gymnema sylvestre	RT/LS	Andhra,T.N & Kerala upto 1000 m	fair	Med
Hygrophila auriculata	HB/SD	North,West & Central India, plains	good	Med
Hyoscyamus niger	LS/SD	J&K, HP, 3000 to 4000m	poor	Low
Lactuca serriola	LS/SD	J&K, Himachal,1000 to 3000m	good	Med
Lepidium sativum	SD	Throughout India, often cultivated	good	Low
Leucas cephalotus	HB	Throughout Indian plains	fair	Low
Luffa echinata	HB,FR	Central & Peninsular India, arid plains	poor	Med
Mimosa pudica	SD	Northern & Central Himalayan foothills	fair	Mar
Nelumbo nucifera	SD	Throughout India in lakes & ponds	good	Low
Nepeta hindostana	WP	J&K, HP, UA, sub-hills	fair	Low
Nymphaea stellata	FL	Throughout India except arid regions	poor[VU]	Med
Ocimum basilicum	HB	Throughout India upto 1200m	fair	Med
Ocimum canum	SD	Throughout India, arid plains	good	High
Operculina turpethum	RT	Throughout India, arid plains	fair[*]	High
Pedalium murex	FR	TN, Andhra, Karnataka & Kerala	fair	Med

Contd...

1	2	3	4	5
Peganum hermala	SD	Rajasthan, J&K , 1500 to 4000m, arid hills	fair	Low
Phyllanthus amarus	HB	Peninsular & South India, plains	good	High
Physochalaina praealta	LS	Ladakh and Lahaul, 3500 to 4000m	poor[VU]	Low
Prunella vulgaris	WP	J&K, 1200 to 2000m	fair	High
Psoralea crylifolia	SD	UP, Bihar, Jharkhand, Chattisgarh,plains	fair[*]	High
Silybum marianum	SD	Himalayan foothills, J&K to UA	fair	Med
Sida cordifolia	SD	Throughout North & West Indian plains	good	Med
Sida rhombifolia	SD	Throughout India upto 1000m	good	Med
Sisymbrium irio	WP	Throughout North India upto 1500m	good	Low
Solanum nigrum	WP	Throughout Indian plains	good	High
Solanum surattense	WP,RT	Throughout Indian plains	good	High
Sphaeranthus indicus	FL	UP, Bihar, MP & Chhattisgarh, plains	fair	Low
Tephrosia purpurea	WP	Northern & Western plains	good	Low
Tribulus terrestris	FR,RT	Throughout India ascending to 1000m	good	High
Uraria picta / lagopoides	RT	UP, Bihar, Gangetic plains/ South India	good	Med
Vernonia cenerea	WP	Throughout India upto 600m	good	Med

Notes : (1) Abbreviations same as in Table 1.
(2) Plants considered controversial source of certain raw materials such as Ashtavarga, Nakuli, etc., have not been included in the above list.

aggressive intruder. Some of these are very selective on habitat and tend to disappear with a slight change in the edaphic, hydrological and other site conditions. The raw material originating from this group of plants also shows a great variation in active chemical constituents and therapeutic efficacy.

Plants cultivated as ornamentals or as cereal, fruit, vegetable, spice, oil seed, essential oil or other cash crop : Sixty eight plants in this category are also the source of medicinal raw materials (Tables 3 and 4). The raw material in these cases is either the product for which the plant is being cultivated such as clove, cinnamon, castor seed, turmeric or cumin or a byproduct such as Bael fruit, Asoka bark, Jamun seed and pepain etc.,

Plants cultivated as medicinal crop : Thirty or so medicinal plants are under regular and/or large scale cultivation (Table 5). The major among these are *Plantago ovata* (Psillium), *Cassia angustifolia* (Senna), *Withania somnifera* (Ashwagandha), *Saussurea costus* (Kuth) and a number of *Cinchona* sps. Majority of the plants in this category are cultivated by farmers as small holdings and the production depends on demand and good monetary returns. Work on domestication and cultivation of about 50 medicinal plants has been going on at various government, non-government and academic agencies but only a few have

Picrorhiza kurroa Royle ex Benth (Kutki)

Crocus sativus Linn. (Saffron)

Rhododendron arboreum Sm. (Burans)

Bergenia ciliata (Haw.) Sternb.

Cassia fistula Linn.

Table 3

Plants cultivated as avenue trees, embankment stabilizers , hedges or ornamentals in parks and gardens and yielding herbal raw materials

Plant	Part	Areas where cultivated	Demand
Acacia nilotica	STBK/GM	North,West & Central India on embankments	High
Aegle marmelos	RT/FR	Throughout India, around temples & villages	High
Albizia lebbek	STBK	Throuhout India as avenue tree	Low
Alpina galanga	RH	S. & W. Bengal, as ornamental herb	High
Alstonia scholaris	STBK	Throughout India as avenue tree	Mar
Althea rosea	FL	Throuhout India as flowering shrub in gardens	Med
Azadirachta indica	LS/,STBK/SD	Throughout, India as avenue tree	High
Cassia fistula	FR [pulp]	Throughout India as avenue tree	High
Catharanthus roseus	HB/RT	Throughout India as flowering herb	V.High
Clerodendrum multiflorum	RT	Throughout India as garden hedge	Med
Clitorea ternatea	FL/FR	Southern & eastern India as flowering shrub	Mar
Erythrina variegata	STBK	Throughout India as avenue tree	Med
Euphorbia neriifolia	Latex	Rajasthan, as hedge around agricultural fields	Mar
Ficus racemosa	STBK	Throughout India, as avenue tree	Med
Ficus religeosa	RT	Throughout India around temples & avenues	Med
Gmelina arborea	RT	Throughout India as avenue tree	Med
Hibiscus rosa-sinensis	FL	Throughout India as flowering shrub	Low
Mimusops elengi	FL/FR	Throughout as flowering tree in gardens	Low
Moringa oleifera	FR/SD	Throughout India as avenue tree	Med
Nyctanthes arbor-tristis	LS, FL	Throughout India as flowering tree	Low
Ocimum sanctum	LS/SD	Throughout India upto 1000m	High
Operculina turpethum	RT	Throughout as flowering climber in gardens	High
Plumbago indica	RTBK	Throughout as flowering shrub in gardens	High
Ruta graveolense	WP	Throughout India as flowering herb in gardens	Med
Saraca indica	STBK	TN, Karnataka & Kerala as flowering tree	High
Sophora japonica	FL	Ornamental shrub in Kashmir and Kulu	High
Syzygium cumini	SD	Throughout India as avenue tree	High
Tamarix gallica	Galls	Throughout Indian sea shores as land stabilizer	Med
Terminalia arjuna	LS, STBK.	Throughout India as avenue tree	High
Thespesia populnea	FL, FR	As flowering tree in Indian gardens	Low

Note : Abbreviations same as in Tables 1 and 2.

Table 4

Plants grown as agricultural, horticultural or industrial crops and also yielding important herbal raw materials

Plant	Crop	Medicinal part	Demand
Allium sativum	Garlic (Lahsun)	Bulb/Oil	V.High
Ammomum subulatum	Large cardamoms	Fruit, Seed	Med
Amorphophalus campanulatus	Sooran	Corm	Mar
Anethum sowa	Indian Dill (Sowa)	Seed, Seed oil	V.High
Apium graveolense	Celery	Seed, Seed oil	Med
Areca catechu	Betelnut (Supari)	Seed	Med
Camellia sinensis	Tea	Tea leaf and waste	V.High
Carica papaya	Papaya (Papita)	Latex (Pepain)	V.High
Cinnamomum verum	Cinnamon (Dalchini)	Stem bark	Med
Citrus medica var. *acida*	Lime (Kaghzi Nimboo)	Fruit juice	Med
Cocos nucifera	Coconut (Narial)	Kernel, Oil	High
Coriandrum sativum	Coriander (Dhania)	Fruit	Med
Crocus sativus	Saffron (Kesar)	Pistil	Mar
Cuminum cyminium	Cumin (Zira)	Fruit	High
Curcuma longa	Turmeric (Haldi)	Root	High
Cydonia oblonga	Quince (Behi)	Seed	Mar
Cymbopogon citrates	Lemon grass	Essential oil	V.High
Dolichos uniflorus	Kulthi	Seed	Low
Elettaria cardamomum	Cardamom	Fruit, Seed	High
Foeniculum vulgare	Fennel (Saunf)	Fruit	Med
Lawsonia inermis	Mehndi (Henna)	Leaf	High
Linum usitatissimym	Alsi (Linseed)	Seed; Oil	Med
Memordica charantia	Karela	Leaf, Seed	Low
Mentha arvensis var. *piperascens*	Japnese mint	Essential oil/menthol	High
Mentha spicata	Spear mint	Essential oil	Med
Myristica fragrans	Jaiphal; Javitri	Seed & Aril	Med
Nicotiana tabacum	Tobacco	Leaf waste	High
Nigella sativa	Kalaunji	Seed	Low
Papavar somniferum	Opium poppy	Opium	V.High
Piper nigrum	Black pepper	Fruit	V.High
Prunus amygdalus	Badam (Almond)	Kernel/Oil	Med
Ricinus communis	Eranda (Castor)	Root/Oil	High
Rosa damascena	Rose (Gulab)	Flower/Oil	High
Sesamum indicum	Sesamum (Til)	Seed, Oil	High
Syzygium aromaticum	Cloves (Lavanga)	Flower bud	High
Trachyspermum ammi	Ajawain	Seed	High
Trichosanthes dioica	Patol, Parval	Leaf/Fruit	Low
Trigonella foenum-graceum	Fenugreek (Methi)	Seed	Low
Vitis vinifera	Grape, Munnaka	Dry fruit	High
Zingiber officinalis	Ginger (Sonth)	Rhizome	V.High

Table 5

Plants cultivated exclusively as medicinal crop

Plant	Part used	Areas where cultivated	Demand
Acorus calamus	RH	Karnataka*	High
Alpinia galanga	RH	Assam, W. Bengal, Karnataka and Kerala*	Med
Aloe vera	LF (Juice)	Coastal areas of Saurashtra (Gujarat)	V.High
Ammi majus	FR	Jammu, Punjab and Western UP*	Med
Andrographis paniculata	WP	UP, Bihar, WB, MP and Maharashtra*	High
Asparagus racemosus	RT	Neemuch (MP), Bundelkhand (UP)*	High
Atropa belladonna	RT/LF	Tangmarg & Kashmir Valley (J&K)	Low
Carum carvi	FR	Lahaul and Kinnaur (HP), Kumaon(UA)*	High
Cassia angustifolia	LF;FR	Tirunelvelli, Ramnathpuram Distt. (TN)	High
Catharanthus roseus	RT;HB	Peninsular and southern coastal region*	V.High
Cephaelis ipecacuanha	RT	Mungpo (WB)	Med
Chlorophytum borivilianum	RTS	Udaipur, Sikar (Rajasthan), Jalgaon (Maharashtra)*	High
Claviceps purpurea	Sclerotia	Nilgiri Hills, Bangalore and Jammu	High
Cinchona sps.	STBK.	Nungpo (W.Bengal), Nilgiri Hills (TN)	High
Digitalis lanata	LF	Nilgiri & Pulney hills (TN), Bangalore	Low
Dioscorea floribunda	RH	Goa, Bangalore, Nungpo (WB) and Tripura	High
Emblica officinalis	FR	Bundelkhand & Eastern UP, Nimar (MP) and Bihar*	V.High
Eucalyptus globulus	LF.OIL	Nilgiri hills (TN)	High
Gloriosa superba	RT/SD	Tiruchirapalli (TN)	Med
Inula racemosa	RT	Lahaul (HP)*	Low
Kaempferia galangal	RH	Karnataka, TN and Kerala*	Low
Matricaria chamomilla	FL	Kullu (HP)*	Low
Papavar somniferum	Latex	Ghazipur (UP), Mandsaur (MP)	V.High
Pimpinella anisum	FR	Haryana, UP and Punjab*	High
Piper longum	FR/RT	Bihar, Guntur (AP), Tura and Shillong (Meghalaya)*	High
Plantago ovata	SD/Husk	Mehsana and Banaskantha (Gujarat)	V.High
Rauvolfia serpentina	RT	Hazaribagh (Jharkhand)	High
Saussurea costus	RT	Lahaul (HP)	High
Withania somnifera	RT	Manasa (MP)	High

* Small holding over scattered areas.
Abbreviations same as in Tables 1-4.

Table 6

Raw materials imported entirely or partially (to supplement indigenous production) from other countries (except Nepal and Bhutan)

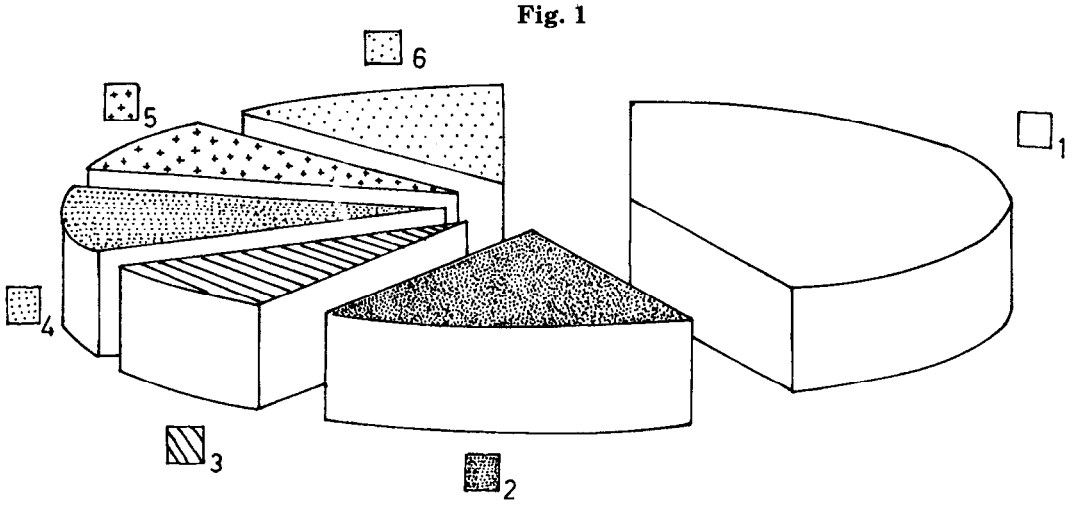
Plant	Part	Official/Trade Name	Demand
1	2	3	4
Acacia senegal	gum	Gum Arabic; Gond Babul	High
Aloe (various sps.)	dried leaf juice	Aloe, Eluva, Mussabar	High
Anacyclus pyrethrum	whole herb	Akarkara	Mar
Aquillaria agallocha	infected wood	Agarwood; Agaru	Med
*Artemisia absynthium**	dried herb	Absynth; Afsanatin	Mar
Astragalus gummifer	gum	Tragacanth gum; Katira gond	Med
Bambusa arundinacea	manna	Bamboo manna; Bansalochan	High
Boswellia carteri	oleo-gum resin	Olibanum, Kundur	High
*Carum carvi**	seed	Caraway; Siah Zira	High
Cinnamomum verum	stem bark	Cinnamon; Dalchini	Med
*Commiphora molmol**	oleo-gum resin	Heerabole	Low
Crocus sativus	dried pistils	Saffron; Kesar	Low
Cuscuta epithymum	whole plant	Aftimoon Vilayati	Mar
Ephedra gerardiana	stem	Ephedra	V.High
*Ferula asa-foetida**	gum resin	Asafoetida; Heeng	Med
*Gaultheria fragrantissima**	leaf oil	Winter green; Gandhapura	High
Gentiana lutea	root	Gentian, Traiman	Low
Glycyrrhiza glabra	root	Liquorice; Muletthi	V.High
Hyoscyamus muticus	seed, leaf	Hyoscamus, Ajwain Khurasani	Low
*Hyssopus officinalis**	dry herb	Jufa	Low
*Illicium verum**	fruit	Star Anis; Badian Khatai	Med
Juniperus communis	fruit	Juniper berry; Hauber	Med
*Lavandula stoechas**	whole herb	Uste-khuddus	Low
Myristica fragrans	seed/aril	Nutmeg/mace; Jaiphal/Javitari	Med
Matricaria chamomilla	flower	Gul Babunah	Mar
Operculina turpethum	root	Turbud	High
Piper cubeba	fruit	Cubebs; Kabab Chini	High
Paeonia officinalis	root	Ud -Salab	Low
Piper sylvaticum	fruiting spike	Long pepper, Bara Pipal	High
Pistacea integerrima	insect gall	Kakarsinghi	High
*Pistacea lentiscus**	gum-resin	Rumi Mastagi	Med
*Quercus infectoria**	insect galls	Gallnut; Majuphal	Med
Rheum palmatum	root	Rhi-chin; Revand Chini	Med
*Salix caprea**	whole plant	Bedmushk	Mar

Contd...

1	2	3	4
*Shorea robusta**	Resin	Raal	Mar
*Smilax china**	Root	Sarsaparilla; Chopchini	Med
*Smilax ornata**	Root	Ushba	Mar
Syzygium aromaticum	Flower bud	Clove, Lavanga	Med
*Vitex agnus-castus**	Fruit	Renuka beej	Mar
Zizyphus vulgaris	Fruit	Unnab	Med

* denotes entirely imported raw material.
Abbreviations same as in Tables 1-5.

Fig. 1



Plant species providing medicinal raw materials to Indian Drug & Pharmaceutical Industry (by origin)

been put to cultivation and that also on small scale only. This is in spite of the claims made with regards to success achieved in their cultivation at various quarters. Examples of *Podophyllum hexandrum, Picrorhiza kurroa, Aconitum heterophyllum, Pterocarpus marsupium* and Manna yielding bamboo can be mentioned in this regard.

Medicinal plant materials imported from other countries (Table 6) : Around 40 raw materials are imported regularly and/or in substantially large quantities from other countries. Some of these such as liquorices, asafoetida, gall nut and a number of materials used in Unani drug formulation meet the entire consumption of the industry while others such as ephedra, long pepper,

juniper berry, kakarsinghi, cassia bark galangal, etc., are imported to supplement the supplies coming from within the country.

Critical examination of occurrence of plants providing raw materials for Indian Drug and Pharmaceutical Industry reveals that at least one viz., *Ferula narthex* is almost extinct from the area of its natural distribution in Ladakh. Four are critically endangered, 10 are endangered and thirty two are vulnerable (as per IUCN threat categories). There may be a decline in the supplies of another 30 raw materials within next 15 years if the collections at present rate are continued and no remedial steps are taken in near future. Out of 30 medicinal plants under cultivation, at least 10 are being gradually abandoned or replaced by other crops which are more paying or have a regular market. Notable among these are *Atropa belladonna* in Kashmir, *Saussurea costus* in the Lahaul (H.P.), *Rauvolfia serpentina* in Hazaribagh (Jharkhand) and some other areas in the country, *Coptis teeta* in Arunachal, *Gloriosa superba* in Trichurapalli (T.N.) and *Dioscorea floribunda* in Darjeeling hills and Bangalore. Supplies of some important raw materials imported from outside the country are declining or may decline due to political and other reasons. Asfoetida (Heeng), Ephedra, Juniper berry (Hauber), Unnab, Bamboo manna (Bansalochan) and Oak-gallnut (Majuphal) imported from Iran, Afghanistan, Pakistan, Indonesia and countries separated from erstwhile Yugoslavia respectively, are some such materials.

Collection, procurement and trade

The collection from forest areas is usually done by local villagers and tribal staying in the vicinity of forests. They collect the material in small lots in their spare time and store it till sold or bartered at a nearby shop. The local shopkeeper, in majority of cases, acts as a middleman between the collectors and drug dealers or sometimes the consumer himself. The material so collected from an area is sent out of forest after payment of a nominal fee. Sometimes large scale collections are organized by crude drug dealers or the drug manufacturers themselves. The collection of some selected raw materials is also handled by the forest department, forest corporations or co-operative societies. The pattern of collection and procurement is, however, the same, only difference being a better quality of raw material collected and dried under the supervision of procuring agency. The collection and export from a particular forest division is controlled through various regulations which differ from State to State. The villagers and tribals residing in the vicinity are usually the right holders to collect the medicinal plant raw materials along with other non-wood forest products. Restrictions have now been put on collection of such materials growing in the reserved forests as well as those collection of which has been banned by the State or Central Government. The raw material obtained from plants cultivated as medicinal crop are sold to consumers directly by the growers, through co-operative marketing societies or more commonly through the traders. There is a flourishing market of crude medicinal plant materials in India. The setup consists of local, regional and central markets. The local market deals in the produce of a particular area situated in the vicinity. The traders at local markets also act as procurement and forwarding agents for regional or central markets as also for the

consumer. The regional markets, such as Baramulla, Srinagar and Udhampur in J& K State, Chamba, and Kulu in Himachal, Bhuj and Rajkot in Gujarat procure the produce of a particular region and constitute the main supply line for main markets located at Calcultta, Mumbai, Chennai, Kochi, Tuticorin, Delhi and Amritsar. These markets also handle bulk of exports and imports (Fig. 1).

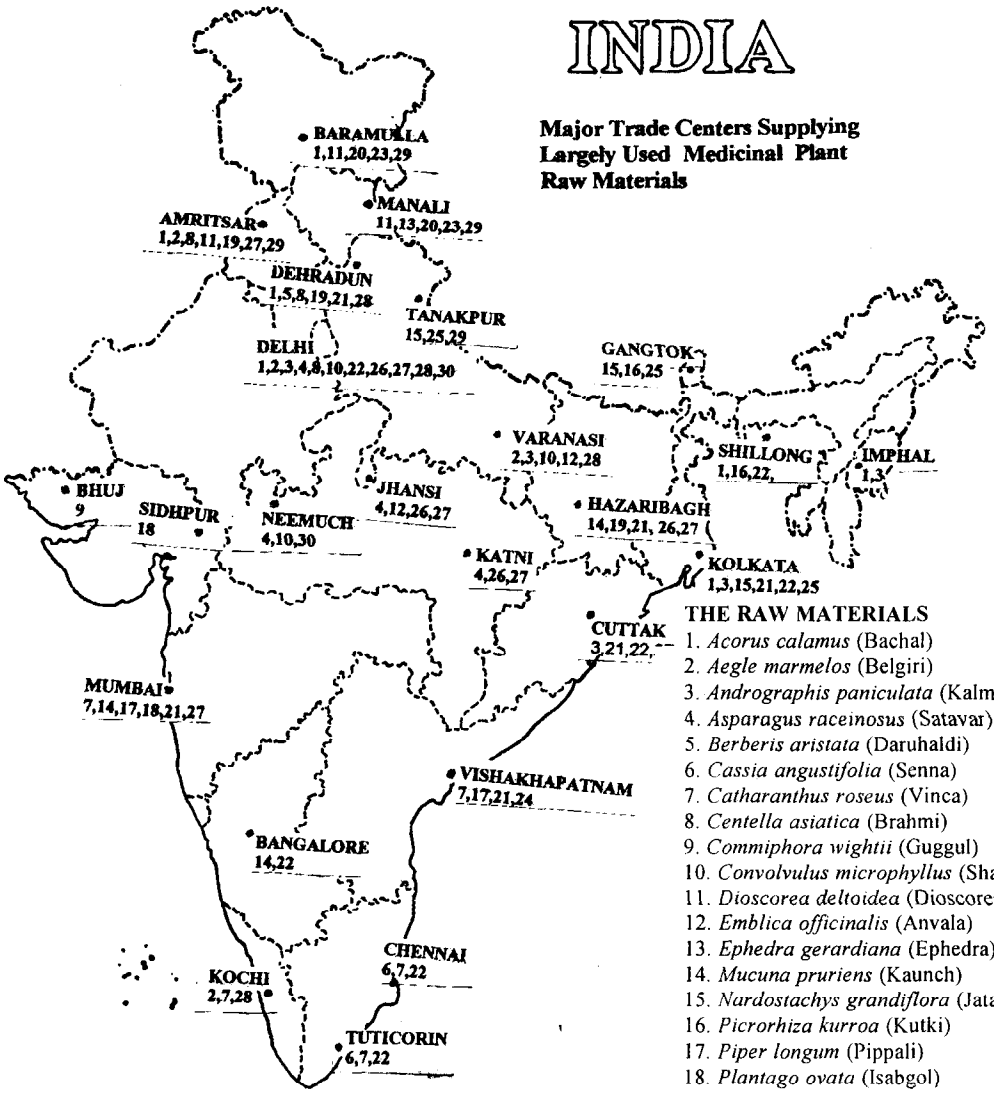
The requirement of the raw materials

No reliable data is available regarding annual requirements of the raw material by the Indian drug and pharmaceutical industry. This makes the estimation of requirements a difficult task. Such information emanating from various sources differs widely from each other. Chemical and Pharmaceutical Export Promotion Council (CHEMEXIL) has estimated the annual demand of raw materials from 55 species at around 32,000 MT (Prakash, 2001). Ayurvedic Drug Manufacturers Association puts such demand at 30,000 MT from 110 species of plants (Unial *et al.*, 2002). Out of 300 or so plants listed in Tables 1 to 6 of this paper, 112 are having a large demand in the preparation of medicines and over the counter products based on indigenous system of medicine (Kapur and Mitra, 1979) around 30 are processed for isolating various phyto-pharmaceuticals or their precursors and 10 such as psyllium seed and husk, senna leaf and pod and chebulic myrobalan fruit are exported in large quantities. Presumptions, based on data collected from a large number of sources, indicate that the present requirements of the raw materials lies between 1,50,000 and 2,00,000 MT per annum. This includes the materials coming from certain largely cultivated sources, such as cinchona, psyllium, senna, ashwagandha, tea, tobacco and opium poppy. The demand of the raw material may increase substantially in coming years due to enhanced production of medicines, phyto-pharmaceuticals, extracts and over the counter products by the Indian drug and pharmaceutical industry.

Prospects of augmentation of raw material resources

The above discussion reveals that out of 335 or so medicinal plant raw materials used by the Indian drug and pharmaceutical industry, at least 70 require steps for augmenting the resources. Most of the plants yielding these raw materials come from forests or other types of natural vegetation while a few such as the species of *Glycyrrhiza, Ferula, Anacyclus* etc., are imported from other countries. Among the plants facing depletion of natural stock, around 45 are at different stages of threatened existence. Another 30 may join this group in future if no remedial measures are taken in time. This calls for strategies which may not only maintain the existing resources at sustainable level but increase the production of required raw materials. Such a step will require a proper assessment of naturally growing stock based on systematic census of the plant source, delimitation of the extent and range of occurrence, study of distribution pattern under different site conditions and vegetation types with which it is associated. A knowledge of life history which includes phenology and reproduction as well as various ecological conditions influencing the growth and spread of the plant, will also be necessary. The collection of the raw materials from the wild by untrained collectors is destructive and unsystematic. Very often the field level

Fig. 2



THE RAW MATERIALS

1. *Acorus calamus* (Bachal)
2. *Aegle marmelos* (Belgiri)
3. *Andrographis paniculata* (Kalmegha)
4. *Asparagus raceinosus* (Satavar)
5. *Berberis aristata* (Daruhaldi)
6. *Cassia angustifolia* (Senna)
7. *Catharanthus roseus* (Vinca)
8. *Centella asiatica* (Brahmi)
9. *Commiphora wightii* (Guggul)
10. *Convolvulus microphyllus* (Shankbapushpi)
11. *Dioscorea deltoidea* (Dioscorea)
12. *Emblica officinalis* (Anvala)
13. *Ephedra gerardiana* (Ephedra)
14. *Mucuna pruriens* (Kaunch)
15. *Nardostachys grandiflora* (Jatamansi)
16. *Picrorhiza kurroa* (Kutki)
17. *Piper longum* (Pippali)
18. *Plantago ovata* (Isabgol)
19. *Plumbago zeylanica* (Chitraka)
20. *Podophyllum hexandrum* (Bankakri)
21. *Rauvolfia serpentina* (Sarpagandha)
22. *Saraca indica* (Asoka)
23. *Saussurea costus* (Kuth)
24. *Strychnos nux-vomica* (Kuchla)
25. *Swertia chirata* (Chirayita)
26. *Terminalia bellirica* (Bahera)
27. *Terminalia chebula* (Harra)
28. *Tinospora cordifolia* (Giloe)
29. *Valeriana jatamansi* (Tagar)
30. *Withania somnifera* (Ashwaganda)

forestry and wildlife staff is unaware of the plants under threat and collection of which is restricted or banned. This is further complicated by the fact that most of the medicinal plants are known by their trade or local names and are in dried raw drug form at the time of inspection. The concerned staff issuing transit or export permit are largely untrained in identification of plant materials in such forms. Many a times valuable plant material is smuggled out of the forest by giving a false identity to it. Proper training to the forest staff on such duty will go a long way to improve the existing system. The supervisory staff also needs training in efficient harvest and post harvest methods to control destructive harvesting by the collectors.

The augmentation of raw material resources will largely depend on domestication of wild plants and exotics and their large scale cultivation. There are, however, many problems in getting a wild plant or an exotic from far lands, domesticated in a new and different environment. Some of such problems are : difficulty in germination of seed or propagation material, juvenile mortality and susceptibility to insects and pests, change in the pattern of growth, phenology and biomass of the part constituting the required raw material and decline in chemical constituents and therapeutic efficacy. One can overcome these problems to a large extent if domestication is preceded by detailed studies on growth and distribution pattern, reproduction and habitat conditions of the plant growing in nature. In other words one has to undertake an intimate study of autoecology, a basic subject of plant ecology. Selection of suitable site for cultivation is also very important. It should resemble, as closely as possible the edaphic, topographic, climatic and hydrological conditions prevailing in the original home of the plant.

The Medicinal Plant Board, recently setup by the Government of India to co-ordinate in all matters related to medicinal plants and drawing up strategies for development of raw material resources has identified 28 species of plants for the purpose. This list, however, requires further additions. Majority of plants included in the list provide the raw materials employed in drug formulations and over the counter preparations based on Ayurvedic and Unani system of medicine. Many important and largely used plants even in this category, such as *Mucuna pruriens* (Kaunch), *Rheum australe* (Revand), *Convolvulus microphyllus* (Shankhapushpi) and *Embelia ribes* (Vidanga) do not find place in this document. There is no mention of most of the plants providing raw materials for the production of phyto-pharamaceuticals which constitute a very important sector of the drug and pharmaceutical industry. Some of the notable omission of this group are *Podophyllum hexandrum, Catharanthus roseus, Dioscorea deltoidea* and *Taxus buccata* ssp. *wallichiana* which yield some very important therapeutically active chemical compounds or their precursors such as etoposide, tenoposide, vincristine, vinblastine, diosgenin and texane. An indepth study of the requirements of medicinal plant raw materials by the industry reveals that about 40 species of plants require urgent research and development inputs for this purpose. These are: *Aconitum heterophyllum, Acorus calamus, Aloe vera, Andrographis paniculata, Asparagus racemosus,*

Aquillaria malaccensis, Bacopa monnieri, Berberis aristata and *B. asiatica, Catharanthus roseus, Chlorophytum arundinaceum* and other species, *Commiphora wightii, Convolvulus microphyllus, Curculigo orchioides, Dioscorea deltoidea, Embelia ribes, Ephedra gerardiana, Ferula asafetida* or *F. narthex, Gaultheria fragrantissima, Glycyrrhiza glabra, Gymnema sylvestris, Hemidesmus indicus,* Manna yielding varieties of bamboo, *Mucuna pruriens, Nardostachys grandiflora, Operculina turpethum, Panax pseudo-ginseng* var. *himalaicus, Phyllanthus amarus, Picrorhiza kurroa, Piper sylvaticum, Plumbago zeylanica, Podophyllum hexandrum, Pterocarpus santalinus, Saraca indica, Sida cordifolia, Swertia chirata, Symplocos racemosa, Taxus buccata* ssp. *wallichiana, Terminalia chebula, Tinospora cordifolia,* and *Valeriana jatamansi.*

Conclusions

The observations made in the foregoing discussion indicate that though there are problems facing the medicinal plant raw material resource in India, there is enough scope for its development to meet the requirements of Drug and Pharmaceutical Industry. Concerted multi-disciplinary efforts are required to execute large scale production of materials from both wild and cultivated sources. The augmentation and supplies of raw materials obtained from the plants growing in forests, specially those originating from trees and shrubs, may better be left with the foresters who may undertake *in-situ* conservation, restocking and forestation with desirable species. Steps for systematic census of medicinal plants associated with different types of forest vegetation and quantitative evaluation of the raw material available will also have to be undertaken by the forest department.

Large scale cultivation of medicinal plants, both indigenous and exotics will be a desirable solution for ensuring unrestricted supply of the raw materials in required quantities. A number of medicinal plants have been brought under large scale cultivation in the past and there is no reason to question the continuation of this process under the present scenario also. Research and development studies on domestication of wild plants and introduction of certain exotics have been going on at a number of government, non-government and academic agencies since long but the success in large scale cultivation could be obtained in only a few cases. The causes of failures need critical investigation in the light of the fact that India is blessed with a wide spectrum of agro-climatic conditions; a chain of research institutions with competent workers in the field of biology, biotechnology and agricultural sciences and a hard working and enterprising farmer. There appears to be a lack of coordination among various workers and between organizations engaged in the development of medicinal plant resources as also between these and the farmer who is the ultimate agency to undertake the job and deliver the goods. Large scale production of senna, psyllium, ashwagandha, costus root and *Gloriosa superba* seed has been possible only because of the involvement of the common farmer in their cultivation. This calls for development of appropriate technologies which can be easily adopted by the farmer. Some medicinal plants, agro-technologies for which had been developed and perfected on experimental scale, failed to reach the farmland due to inability of

the farmer to absorb high-tech methods, a fear of poor marketability, comparatively low monetary returns and lukewarm response of the consumer. Cultivation of medicinal plants is inversely linked to prevalence of easy and cheap collection of medicinal raw materials from the wild; cornering of the profits by a vast network of traders and middlemen and absence of industry's interest in providing buy-back guarantees to the grower. These problems require immediate solutions to ensure the involvement of the farmers in this task. A lot of work has been done in various fields of development of medicinal plant resources of India. Valuable data on botany, distribution pattern, occurrence, chemistry, pharmacology and agro-technologies (where tried and developed) has been lying accumulated with various research institutions, universities and non-government organizations. Such data, retrieved and consolidated at one place, critically examined and documented will greatly help in devising strategies for proper development of medicinal plant raw material resources of the country.

SUMMARY

India has a fast growing drug and pharmaceutical industry producing plant based medicines, phyto-pharmaceuticals and over-the-counter products. The country also exports a number of crude drugs and their extracts. The number of plant species yielding raw materials used by the industry on regular basis and/or in substantially large quantities is put at around 340. Among these, 145 occur wild in forests or other forms of natural vegetation, 54 grow as weed, 70 are grown as cash crop for other plant based products, 30 are cultivated as medicinal crop and around 40 are imported from other countries. There has been a tremendous increase in the production of herbal medicines and other items in recent years. This has put great pressure on the raw material resources. Natural population of many medicinal plants has declined to a great extent while a few are at the verge of extinction. A sort of scare prevails among various quarters regarding the decline in the supply of the raw materials or even its discontinuation. Though the fears expressed are quite valid there is a scope not only for damage control but also augmentation of resources assuring continued supplies in future. This paper makes an appraisal of present status of raw material resources and discusses prospects of its development.

भारतीय औषधियां एंव औषध निर्माण उद्योग के लिए औषध-पादपीय कच्चा माल-संसाधनों की एक समीक्षा

वाई०के० सरीन

सारांश

भारतवर्ष का तेजी से बढ़ता जा रहा दवाइयों और औषध निर्माण उद्योग जो पादपों पर आधारित दवाइयां, पादप-औषधियां और दुकानों में बिकने के लिए उत्पाद तैयार करता है । देश से बहुत सारी कच्ची औषधियां और उनके निस्सार भी निर्यात किए जाते हैं । इस उद्योग द्वारा नियमित रूप से और अथवा काफी मात्राओं में उपयोग मे लाए जाने वाले कच्चा माल उत्पादक पादप जातियों की संख्या 335 के आसपास बताई जाती है । इनमें से 145 जंगलों अथवा दूसरे प्रकार की प्राकृतिक वनस्पतियों में जंगली उगती पाई जाती है; 54 खरपतवार की तरह होती है; 50 अन्य पादपाधारित उत्पादों के लिए नगदी फसलों की तरह उगाई जाती हैं, 30 चिकित्सीय फसल की भांति उगाई जाती है तथा करीबन 40 दूसरे देशों से आयात की जाती हैं । जड़ीबूटियों से दवाइयां तथा दूसरी वस्तुएं तैयार करने में विगत वर्षो में बहुत भारी वृद्धि हुई है । उसकी वजह से कच्चे माल के संसाधनों पर भारी दबाव पड़ा है । बहुत सारे औषधीय पादपों की प्राकृतिक संख्या बहुत ज्यादा घट गई है और कुछ तो विलुप्त होने की कगार तक पहुंच चुके हैं । बहुत से क्षेत्रों में कच्चे माल की आपूर्ति में

आई कमी यहां तक कि बन्द हो जाने तक की संभावना के कारण एक प्रकार का हड़कम्प फैला हुआ है । हालांकि जो भय अभिव्यक्त किया जा रहा है वह उचित ही है, फिर भी अभी हानि को नियंत्रित करने की ही नहीं संसाधनों को बढ़ाने की काफी गुंजाइश है जिससे भविष्य में आपूर्ति मिलते रहना सुनिश्चित बनाया जा सके । प्रस्तुत अभिपत्र में कच्चे माल संसाधनो की वर्तमान स्थिति की समीक्षा की गई है और इसके विकास की संभावनाएं विवेचित की गई है ।

References

Ahuja, A.K. (2001). Need for comprehensive approach to Medicinal Plants – Potentials and prospects. *Himalayan Medicinal Plants* (Samant *et al.*, eds.). Gyanodya Publications, Nainital. pp. 1-22.

Anon. (2001). *Monthly Statisics of Foreign Trade of India. Vol. I., Exports*, April 2000 to March 2001. GoI, New Delhi.

Asolkar, L.V. *et al* (1992). *Second Supplement to Glossary of Medicinal Plants*. (CSIR) NISCOM, New Delhi.

Chopra, R.N. *et al.* (1956). *Glossary of Indian Medicinal Plants,* CSIR, New Delhi.

Chopra, R.N. *et al.* (1974). *Supplement to Glossary of Indian Medicinal Plants.* CSIR, PID, New Delhi.

Handa, S.S. (1996). Medicinal Plants- Priorities in Indian Medicine Studies and Implications. *Cultivation and Utilization of Medicinal Plants, Supplement* (Handa and Kaul, eds.). RRL, Jammu, NISCOM New Delhi. pp. 33-51.

Jain, S.K. (1991). *Dictionary of Indian Folk Lore Medicine and Ethno-botany,* Deep Publications, New Delhi.

Kapur S.L. and R. Mitra (1979). *Herbal Drugs in Indian Pharmaceutical Industry*. N.B.R.I., Lucknow.

Kumar, Ravi *et al.* (2000). *100 Red Listed Medicinal Plants*. FRLHT Bangalore.

Prakash, Ved (2001). Indian Medicinal Plants - Current Status. *Himalayan Medicinal Plants – Potentials and Prospects.* Gyanodya Prakashan, Nainital. pp. 45-64.

Said, M. (1969). *Hamdard Pharmacopeia of Eastern Medicine*. The Times Press, Karachi (Pakistan).

Sarin, Y.K. (2000). Medicinal Plants of Western Himalayas: Resources and Extraction Trends. *Himalayan Medicinal Plants, Potentials and Prospects* (Samant *et al.*, eds.). pp. 363-376.

Sarin, Y.K. (1996). *Illustrated Manual of Herbal Drugs used in Ayurveda* (CSIR/ICMR), NISCOM, New Delhi.

Shah, N.C. (1997). Conservation of Medicinal Plants-Need for a comprehensive Strategy. *Kurukshetra* :15-18.

Srivastava, J.J. *et al.* (1995). *Medicinal Plants a growing role in development, a report*. World Bank, Washington, DC.

Sundresh, I. (1982). *Export Potential of Medicinal Plants and Their Derivatives from India, Cultivation and Utilization of Medicinal Plants.* PID, CSIR, New Delhi. pp. 800-823.

Unial, M.R. *et al.* (2002). Current requirement of Impqrtant Medicinal crude drugs by the the Drug & Pharmaceutical Industry. *Paper presented at Vanaspati Van conference*, Dehra Dun.