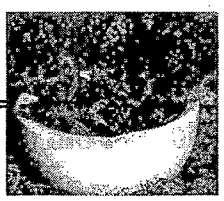
INTRODUCTION

Medicinal Plant:
"Jagatyevan anoushadham na kinchit vidyate dravyan vasatnanartha yoga yoh"

General Introduction

Ancient Indian literature incorporates a remarkably broad definition of medicinal plants and considers '**all**' plant entities to be potential source of medicinal substances. While all plant entities are potentially medicinal, only those plants are considered 'medicinal' whose medicinal use has already been discovered for human or animal application. Medicinal plants originate from almost every part of the globe. They range from small perennial herbs adapted to high elevation mountain areas, to the enormous baobao, one of the most renowned trees. Contribution of the traditional medicine to human health in the 21st century is of paramount importance.

According to the World Health Organization 80% of people worldwide rely chiefly on traditional, largely herbal, medicine to meet their primary healthcare needs (Farnsworth and Soejarto, 1991; Pei Shengji, 2001). This is because of easy availability and low price in contrast to the costly inputs of allopathic medicines and technology (Jasrai and George, 2000). Higher plants are still the sleeping giants of drug development, a virtually untapped reservoir of potentially useful sources of drugs (Farnsworth, 1984), which will continue to serve mankind in the twenty first century as they have done since the dawn of history (Tyler, 1988). World Health Organization recently launched global strategy aimed at bringing complementary or alternative medicines (CAMs) and traditional medicines (TMs) into the ambit of mainstream health services. Traditional medicines though considered part of CAM, are referred to as a separate system and include Chinese medicines, Ayurvedic cures, Unani medicines and various other forms of indigenous medicines. Complementary or alternative medicines are extensively used in developing countries (Koshy and Gupta, 2002) and becoming popular in developed countries (Fig. 1.1A,B).



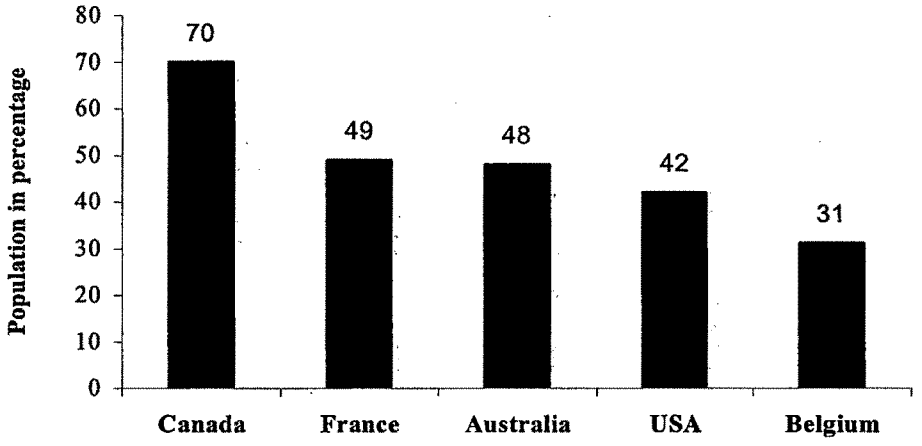


Figure-1.1A: Complementary/alternative medicines being used in developed countries

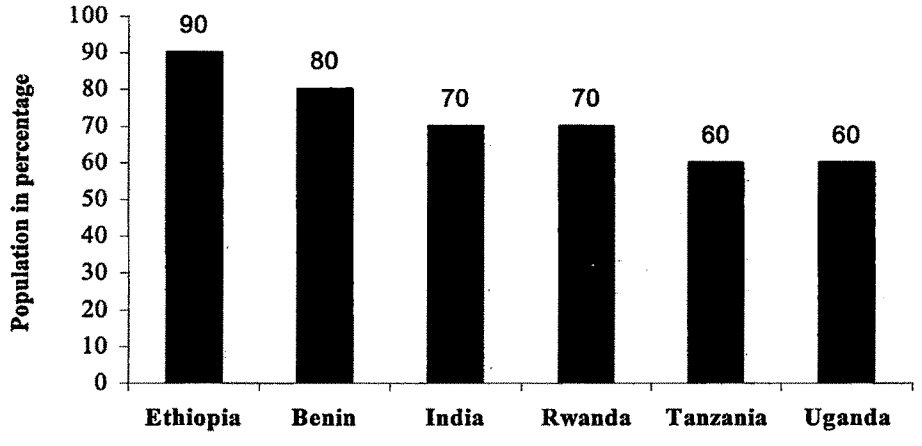
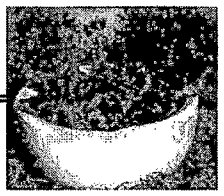


Figure-1.1B-: Extensive use of traditional medicines for healthcare developing countries



Increasing Popularity of Medicinal Plants:

Traditional medicines incorporating the plant parts have maintained its popularity in all regions of the developing world and its use is rapidly spreading in industrialized countries.

Global Use

A. In China, traditional herbal preparations account for 30-50% of the total medicinal consumption.
B. In Ghana, Mali, Nigeria and Zambia, the first line of treatment for 60% of children with high fever resulting from malaria is the use of herbal medicines at home.
C. In several African countries, traditional birth attendants assist in the majority of births.
D. In Europe, North America and other industrialized regions, over 50% of the population have used complementary or alternative medicine at least once.
E. In San Francisco, London and South Africa, 75% of people living with HIV/AIDS use Traditional Complementary Alternative medicines.
F. 70% of the population in Canada has used complementary medicine at least once.
G. In Germany, 90% of the population has used a natural remedy at some point in their life. Between 1995 and 2000, the number of doctors who had undergone special training in natural remedy medicine had almost doubled to 10,800.
H. In the United States, 158 million of the adult population use complementary medicines and according to the USA Commission for Alternative and

Complementary medicines, US $17 billion was spent on traditional remedies in 2000.

I. In the United Kingdom, annual expenditure on alternative medicine is US $ 230 million.

Indian Scenario:

The use of herbal medicines is a tradition in India and surrounding countries. It is perhaps the largest producer of medicinal herbs and is rightly called the Botanical Garden of the World as it is sitting on a gold mine of well-recorded and traditionally well-practiced knowledge of herbal medicine (Dubey et al, 2004). It is a vast country with rich biological diversity of about 45,000 species, of which more than 15,000 are higher plants. According to (Anonymous, 2002), over 46,000 plants species have been recorded (Table-1.1).

Table-1.1: Recorded Plant Diversity of the World, India and Gujarat

Sr. No.	Plant Group	World	India	Gujarat
1	Vascular plants	250750	17064	2199
2	Pteridophytes	13000	1022	16
3	Bryophytes	16000	2700	08
4	Algae	40000	2500	1933
5	Fungi	89000	23000	164
	Total	**408750**	**46286**	**4320**

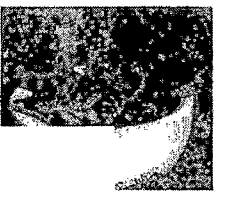
Source: Anonymous, 1996

India is bestowed with unique diversity in culture and natural vegetation exhibiting rich plant diversity. The bio-geographic position of India is so unique that all known types of ecosystems ranging from coldest place like the Nupra valley with

-57^{O} C, dry cold deserts of Ladakh, temperate and Alpine sub-tropical regions of the North-West and Trans–Himalayas, rain forests with the world's highest rainfall in Cheerapunji in Meghalaya, wet evergreen humid tropics of Western Ghats, arid and semi-arid conditions of Peninsular India, dry desert conditions of Rajasthan and Gujarat to the tidal mangroves of Sunderban.

India is rich in all the three levels of biodiversity- such as species diversity, genetic diversity and habitat diversity. Over 4,000 years, India has been practicing and using its rich biodiversity in the health care segment (Biswas et al, 2003). It has one of the oldest, richest and most diverse cultural traditions including nature conservation associated with the use of medicinal plants, which is reflected not only in old literature and cultural ethics but also in the constitution, policies, legislation and organizations.

The traditional health culture of India functions through two social streams. One is the codified stream, which include well-developed system of medicines like Ayurveda, Siddha, Unani and Tibetan. The other is the ecosystem rooted folk stream. In other words, rich traditional experience and wisdom of our country has been depicted in the traditional system of Indian medicines (Fig.-1.2) namely Ayurveda, Siddha and Unani (Koshy and Gupta, 2002). Complementing the village based carriers, there are around 5,00,000 licensed, registered medical practitioners of the codified systems of Indian Medicines. The codified systems have sophisticated theoretical foundations.



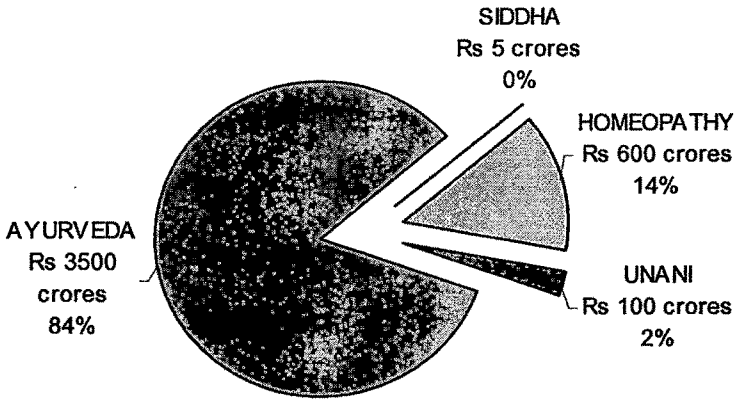


Figure-1.2: Contribution of alternative medicines in India

There are hundreds of medical texts and manuscripts in the form of S*amhitas*, *Nighantus* and Granthas written between the 7th and 16th Centuries and regional commentaries including specialized texts on *Bhaisajya Kalpana* (Pharmacy) that specially provide very valuable information of plants and plant products (Table-1.2). There are over 25,000 herbal products documented in medical literature. In 1563, Garcia da orta, the personal physician of the Portuguese Governor in India published his "Colloquies on the Simples and Drugs of India" This was followed by Henrich Van Rheede, the Dutch Governor of Cochin, who published a 12-volume work on Kerala Medicinal plants (1678-1703) from Amsterdam. Systematic work on Indian medicinal plants have been carried out in earlier years by Chopra et al, (1956), Kirthikar and Basu (1975), Nadkarni (1976). Important studies on medicinal plants have also been done by Aiyar et al, (1957), Aiyer and Kolammal (1960-1966), Kolammal (1979), Mooss (1976, 1978), Nambiar et al, (1986).

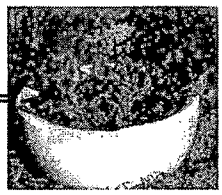


Table-1.2: Well known literatures and Number of medicinal plants used

Sr. No.	Famous literature	Period	Medicinal plant used
1	*Rigveda*	3500-1600 BC	67
2	*Yajurveda*	1000 BC	81
3	*Atharvaveda*	2000-1000 BC	290
4	*Brahamana*	800 BC	130
5	*Charak Samhita*	1000 BC	400-450
6	*Sushruta Samhita*	1000- 500 BC	573
7	*Dhanvantri Nighantu*	5th Century	373
8	Narhari Pandita's *Raja Nighantu*	12th Century	750
9	Madan Pala's *Madan Pala Nighantu*	12th Century	569
10	Bhav Misra's *Bhav Prakash*	16th Century	470

India represents a striking example of the intimate link between biodiversity and cultural diversity. The remarkable fact is that it is still a living tradition. This is borne out by the fact that there still exist around a million traditional, village based carriers of herbal medicine traditions in the form of traditional birth attendants, bone-setters, herbal healers, local vaidhyas, tribal doctors and wandering monks who use hundreds of ecosystem specific bio-resources. The agenda 21 of Rio-Earth-Summit held in 1992 stated that indigenous people and their communities have a vital role in environmental management and sustainable development because of their knowledge and traditional practices.

Ethnobotanical investigations in tribal areas, part of the All India Co-ordinated Research Project on Ethnobiology (AICRPE), revealed that the tribal people in the areas investigated, had specific knowledge about the uses of over 8000 species of wild plant. All India Ethnobiology survey had estimated that 4,653 ethnic communities are using over 7,500 wild plant species for human and veterinary health-care across the country and 950 are found new claims and are worthy of scientific scrutiny. The use of plants as the source of medicines has been increasing tremendously due to the fact that they have no side effects. In India "Health tourism" has also been promoted, as recently around 3 lacs foreigners had applied for visa for availing themselves of medical aid through ayurvedic treatment including yoga. The WHO lists over 21,000 plant species that have reported medicinal uses around the globe. In fact, a recent survey conducted by the International Union for Conservation of Nature (IUCN) speaks of 25,000 species. India alone has a record of 7,000 species of medicinal plants, which are used by different indigenous tribes and system of medicines. In India there are about 10,000 licensed pharmacies practicing the Indian system of medicine.

Indian Medicinal Plants: Distribution across diverse habitat

A. Of the total 17,000 species of Indian flora about 7,500 species of higher plants are reported to possess medicinal value (ie 44% species possess medicinal value). On the contrary, plants having medicinal value in some other countries viz China, Mexico and North America is 44%, 7% and 13% of their total reported species respectively.

B. As regards to the habit of the medicinal plants, about one third of all species are trees, 32% herbs, 20% shrubs, 12% climbers and 3% species belonging to other categories (Fig.- 1.3). A very small proportion of the medicinal plants are lower plants like lichens, ferns algae, etc. Majority of the medicinal plant are higher flowering plants.

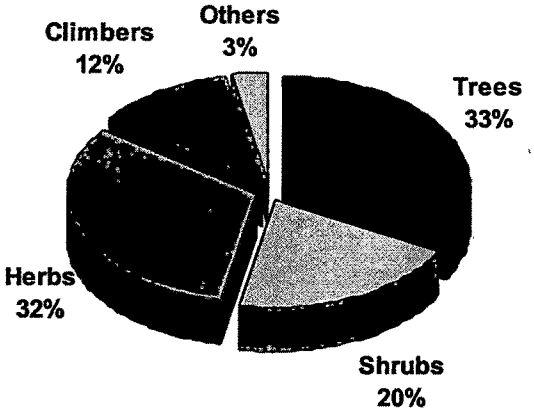
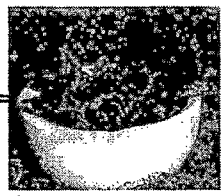


Figure-1.3: Habit based distribution of medicinal plants

C. Of the 386 families and 2200 genera in which medicinal plants are recorded, the families Asteraceae, Euphorbiacae, Laminaceae, Fabaceae, Rubiaceae, Poaceae, Acanthaceae, Rosaceae and Apiaceae share the larger proportion of medicinal plant species with the highest number of species (419) falling under Asteraceae (Fig.- 1.4).

D. About 70% of India's medicinal plants are found in mostly tropical forest types. Although less than 30% of the medicinal plants are found in the temperate and alpine areas and higher altitudes. This includes species of high medicinal value. Macro studies reveal that larger percentage of the known medicinal plants occurs



in the dry and moist deciduous vegetation as compared to the evergreen or temperate habitat.

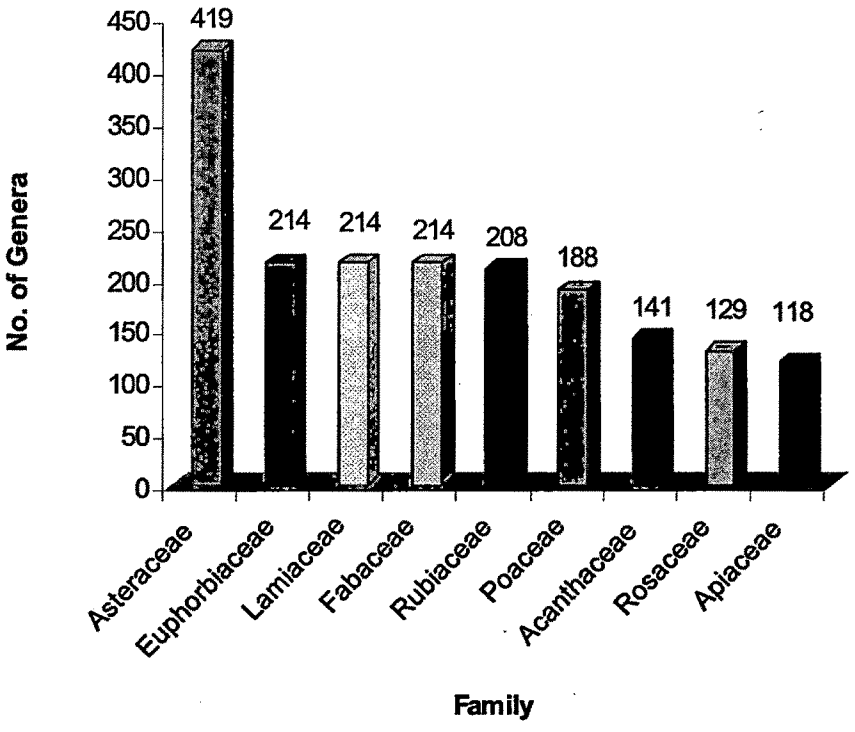


Figure-1.4: Family wise distribution of medicinal plant

E. About 70% of India's medicinal plants are found in mostly tropical forest types. Although less than 30% of the medicinal plants are found in the temperate and alpine areas and higher altitudes. This includes species of high medicinal value. Macro studies reveal that larger percentage of the known medicinal plants occurs in the dry and moist deciduous vegetation as compared to the evergreen or temperate habitat.

F. As per an estimate by Anonymous (2002), 881 species are currently used in industry for production of herbal products. In fact, around 60 species are imported, about 60 species are cultivated and around 760 species are harvested from the wild. Thus, around 90% of medicinal plants used by pharmacies in India

are collected from the wild. Moreover, more than 70% of the plants collected from the wild involve destructive harvesting (Shankar and Ved, 2003).

Biodiversity in Gujarat

A. Historically, geographically, socially, economically and ecologically, Gujarat is a unique state of India. Its human and biological wealth is immense.

B. After the bifurcation of Bombay state, Gujarat state was formed on 1st May 1960. Experts and Vaids have described the past glory of Gujarat land in the field of Ayurveda and its development.

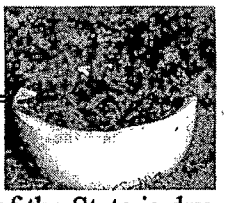
C. Being the second most industrialized state of India, it has certainly witnessed a heavy degradation of its biodiversity. But, at the same time one finds in the very same place initiatives and success stories in the field of biodiversity conservation.

D. It has an area of 1,96,024 km^2 and a coastline of around 1600 km - the longest coastline in India.

E. It has extension of four major hill ranges of the country viz Aravallis, Vindhyas, Satpudas and Sahyadris (Western Ghats) located in the same order from north to south.

F. The state has four major rivers viz Narmada, Tapi (Tapti), Mahi and Sabarmati. The tropic of cancer passes over Gujarat giving normal sub-tropical climate to Gujarat.

G. It has varied agro-climatic zones with different types of vegetation. Climate varies between extreme aridity to extreme humidity. It is high arid in Kachchh, medium semi-arid in Rajkot, Jamnagar and Amreli districts, semi-arid in Junagadh, Bhavnagar, Ahmedabad and Kheda districts, sub-humid in Bharuch, humid in



Surat and very humid in Valsad district. The north-western part of the State is dry, with less than 500 mm of rain a year. In the central part of the State, the annual rainfall is more than 700 mm. In the southern part of Gujarat, rainfall averages 2000 mm a year. In the winter temperature ranges between 12° and 27°C, although freezing levels have been recorded in the State. In the summer temperatures average between 25° C and 43° C and have been known to reach as high as 48° C.

H. It has four biogeographic zones out of ten and bestowed with a plethora of ecosystems under each zone (Table-1.3).

Table-1.3: Biogeographic zones of Gujarat

Sr. No.	Biogeographic zone	Biotic province
1	The Indian Desert	Kachchh
2	The Semi arid	Gujarat-Rajwara
3	The Western Ghat	Malabar Coast, Western Ghat Mountain
4	The Coasts	West Coasts

I. The number of flowering plant species documented from Gujarat are 2205 ie 12.6%. Out of that, 915 plant species (42%) are identified as medicinally important plants. If the number of species of Ayurvedic plants are taken into the consideration, the position of Gujarat is far ahead than any other state of India (Singh and Parabia, 2003).

J. Several highly valuable medicinal plants of rare occurrence are found in Gujarat. In spite of such valuable resources with the state of Gujarat, little efforts were made in the past on the development of agro- practices of medicinal plants.

K. Extensive and critical study on documentation of plant diversity of Gujarat state has been carried out (Table-1.4).

Table-1.4: Documentation of plant diversity of Gujarat state

Title	Author	Year
The Flora of British India	Hooker	1872 -1897
Flora of Bombay Presidency	Cook	1901-1908
Flora of Kutch	Blatter	1908
Flora of Barda Hills	Thakar	1910, 1918
Flora of North Gujarat	Saxton and Sedgewick	1918
Grasses of Junagadh, Porbandar and Kutch	Kapadia	1945, 1947 1954
Plants life of Maha Gujarat	Patel	1953
List of trees, shrubs and woody climbers of Gujarat in Kathiyawad	Patel	1957
Grasses of Gujarat state	Raizada and Vaid	1953
Glimpses of the vegetation of Okhamandal	Santapau	1953
The plants of Saurashtra, the contribution to the Botany of Dangs Forests, Flora of Saurashtra Part-I	Santapau and Raizada	1953, 1954-1955, 1962 and 1955
Contribution to the flora of the Gir forests	Santapau and Janardhan	1966
The Flora of Saurashtra	Chavan and Oza	1966
The Flora of Pavagadh	Pathak and Oza	1966

Weeds of Gujarat-I	Shah	1965
Forest Flora of Gujarat	Patel	1971
Flora of Gujarat State	Shah	1978
Biodiversity of Gujarat	Anonymous, GEC	1996

L. According to various surveys, number of angiospermic forms reported in Gujarat (Table-1.5).

Table-1.5: Angiosperms species observed by various group in Gujarat State

Publications	Plant group	Number of		
		Families	Genera	Species
Saxton and Sedgewick (1918)	Dicotyledons	74	278	442
	Monocotyledons	14	68	172
Patel (1971)	Dicotyledons	75	280	510
	Monocotyledons	10	60	101
Shah GL (1978)	Dicotyledons	125	638	1309
	Monocotyledons	30	184	499
Umadevi (1988)	Dicotyledons	103	656	-
	Monocotyledons	21	92	-
Anonymous (1996)	Dicotyledons	126	699	1602
	Monocotyledons	29	203	596
Singh and Parabia (2002)	Dicotyledons	127	702	1608
	Monocotyledons	29	203	597

Medicinal Plants of Gujarat:

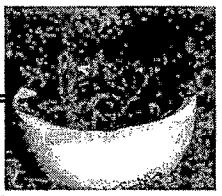
The Gujarat flora is very rich in terms of medicinal plants and 80% of them grow naturally in wild habitat encompassing a wide spectrum of habitats from tropical rain forests to coastal wetlands (Shah, 1978). The leading centres in Gujarat where medicinal plants have been studied practiced and utilized by our Rishis has been enlisted (Anonymous, 1966a) (Table-1.6).

Table-1.6: Leading centres of Gujarat Medicinal Plants

Centres Developed	Location
Sage Kashyap's Ashram	Kutch
Sage Atreya's Ashram	Girnar
God Dhanvantari's Ashram	Veraval
Dron-Ashram of Dronacharya	Girgadhda
Ashram of sage Gautam	River bank of Gautami, Shinor
Sage Bhragu's Ashram on the	River bank of Narmada, Bharuch
Ashram of Ashwani Kumars	River bank of Tapi
Ashram of sage Markendey	Shoolpaneshwar
Ashram of sage Vishwamitra	River bank of Vishwamitri at Pavagadh
Sage Galav's Ashram	River bank of Mahi
Sage Chyavan's Ashram	Bhavnath near Bhiloda
Ashram of God Brahma	River bank of Harnav near Khedbrahma
Ashram of Chitra-Vichitra	Triveni near Poshina

Source: Anonymous, 1966a

For controlling production and marketing of sub-standard and fake ayurvedic medicines in the state, the Government of Gujarat had issued a Government

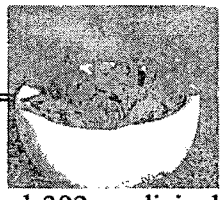


Resolution on 5th February 1964 and constituted **Vanaushdhi Udhyan Committee** under the chairmanship of Rajvaidya Shri Rasiklalbhai J. Parikh of Ahmedabad. The committee had suggested suitable places for Vanaushdhi udhyan, collection centres, store-houses and herbaria sections etc. It also suggested the establishment of pharmacies as a corporate sector in different parts of Gujarat and supply medicines to the government owned hospitals. Following were the extinguish members of the committee:

Table-1.7: Members of the Vanaushdhi Udhyan Committee

Sr. No.	Members of Committee	Designation
1	Shri B. V. Patel	Convenor, Director Drug Control Administration, Gujarat State
2	Shri Vasantbhai H. Gandhi	Practicing Vaids
3	Shri Santibhai P. Joshi	
4	Shri Vagjibhai K. Solanki	
5	Shri Dalpat R. Vasani	
6	Shri Jivraj K. Dron	
7	Shri Vallabhram V. Vaid	
8	Shri Jinabhai Darji	Pramukh, District Panchayat, Surat
9	Shri Chunibhai Desaibhai Desai	Congress Pramukh, Sabarkantha
10	Shri S. J. Kohilo	Udhog Niyamak, Gujarat state
11	Shri R. D. Joshi	Chief Conservator of Forests, Vadodara, Gujarat

The committee visited the important forests of Gujarat between 1964 to 1965. During their exploration of medicinal plant diversity in different forest types (Table-1.8), they also discussed the matter with local vaidyas, intellectuals, politicians and



ex-maharajas as well as forest dwellers. The committee had enlisted 392 medicinal plants across the state.

Table-1.8: List of Forests explored by the committee

Sr. No.	Forests	Sr. No.	Forests
1	Ahwa- Dangs	7	Chhotaudepur
2	Sasan-Gir	8	Botad-Palitana
3	Bhuj-Mundra	9	Patanvav-Dhumli-Ashram of Trikamji
4	Palanpur-Ambaji	10	Vijaynagar
5	Bhavnagar	11	Santrampur-Baria
6	Vansda-Valsad	12	Rajpipla-Surpan

The committee had made different suggestions to the state goverment such as establishment of medicinal plants gardens, storehouses for medicinal plants and raw material, exhibition of herbarium at Junagadh and Dangs as well as research centres, hospitals and collection centers at suitable locations (Fig.-1.5). The development of about 300 important and rare medicinal plants in different nurseries for their future commercial consumption were also suggested. Thus, the committee had widely explored the medicinal plant diversity of Gujarat and made pioneering suggestions to the Government of Gujarat for the conservation of 392 naturally growing medicinal plants.

Work on identification and status survey of medicinal plants has been carried out by Umadevi (1988), Anonymous (2002) and Singh (2003). GEER divided the whole state into six regions namely: South Gujarat, South-east Gujarat, Central Gujarat, North Gujarat, Saurashtra and Kachchh for documentation and classification of the medicinal plants according to the life forms (Table-1.9).

Figure : 1.5

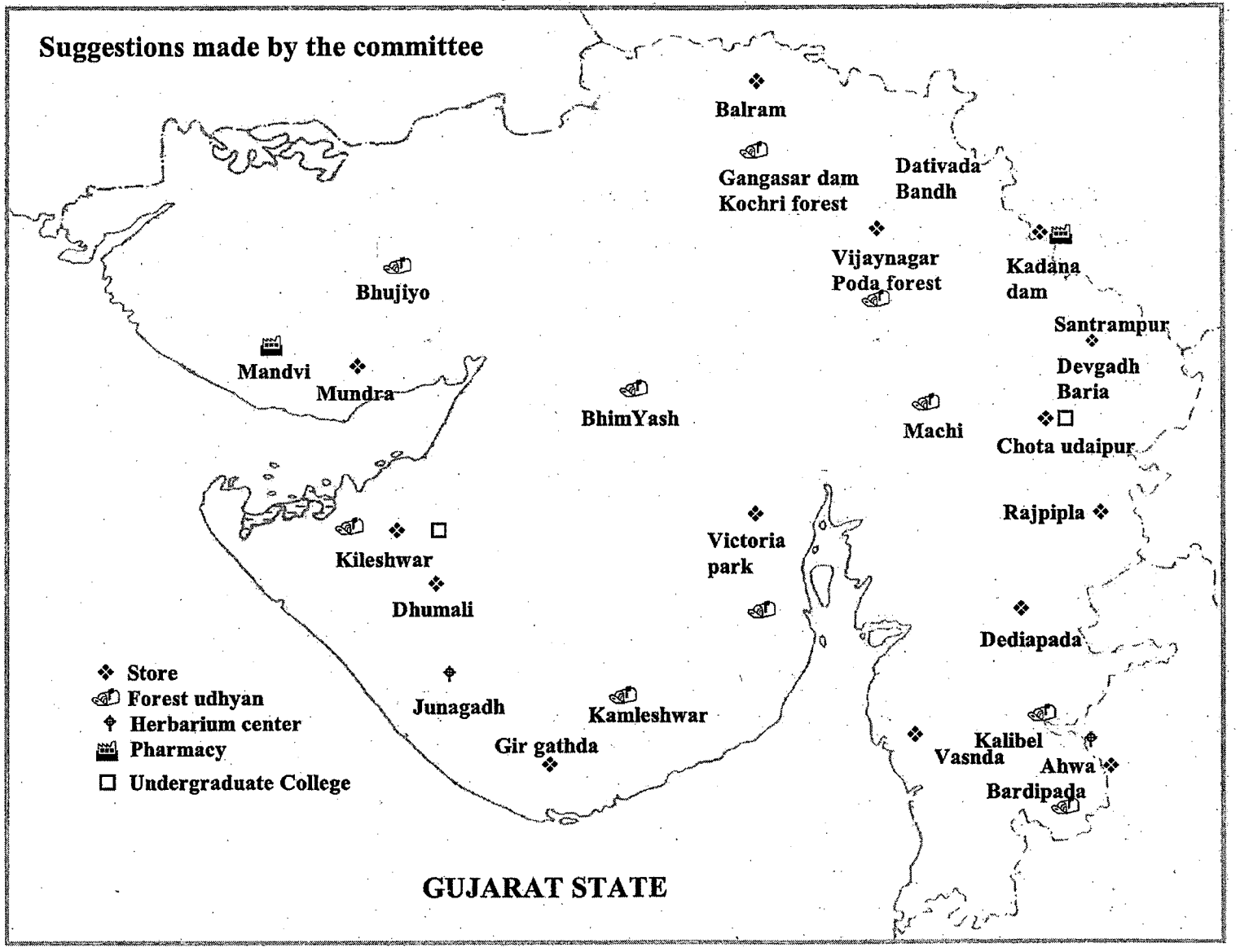

Suggestions made by the committee
Balram
Gangasar dam
Kochri forest
Dativada
Bandh
Vijaynagar
Poda forest
Kadana
dam
Santrampur
Devgadh
Baria
Bhujiyo
Mandvi
Mundra
BhimYash
Machi
Chota udaipur
Rajpipla
Victoria
park
Kileshwar
Dhumali
Dediapada
Store
Forest udhyan
Herbarium center
Pharmacy
Undergraduate College
Junagadh
Kamleshwar
Gir gathda
Kalibel
Vasnda
Ahwa
Bardipada
GUJARAT STATE

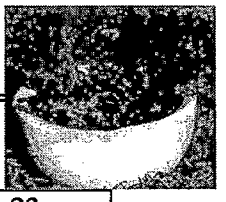
Table-1.9: Distribution of medicinal plant life forms

Sr. No.	Life forms	Umadevi	GEER
1	Trees	176	205
2	Shrubs	161	125
3	Herbs	344	467
4	Climbers	97	118
	Total	**748**	**915**

According to the morphological characters of medicinal plants, the workers have placed them into appropriate family. They also reported numbers of genus found in the family in Gujarat area (Table-1.10).

Table-1.10: Important medicinal plant family and genus observed by different groups

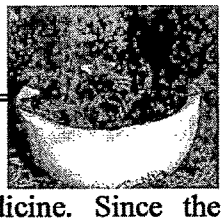
Sr. No.	Name of the family	Number of Medicinal taxa	
		Uma devi	GEER
1	Fabaceae	77	79
2	Asteraceae	35	44
3	Euphorbiaceae	37	41
4	Acanthaceae	19	38
5	Convolvulaceae	24	38
6	Malvaceae	28	36
7	Cucurbitaceae	25	29
8	Caesalpiniaceae	25	27
9	Lamiaceae	-	26
10	Poaceae	33	23



11	Mimosaceae	18	23
12	Amaranthaceae	13	19
13	Rubiaceae	16	19
14	Scrophulariaceae	10	19
15	Tiliaceae	11	19
16	Asclepiadaceae	-	16
17	Capparaceae	-	15
18	Moraceae	14	15
19	Apocynaceae	10	13
20	Bignoniaceae	-	12
21	Boraginaceae	-	12
22	Liliaceae	10	12
23	Verbenaceae	11	12
24	Rutaceae	-	11
25	Solanaceae	14	-
26	Brassicaceae	10	-
27	Cyperaceae	10	-

Revival of Herbal Medicines

An evolution of the pharmaceutical industry started around the early part of the 20th century globally. With the progress in chemical techniques, crude drugs came to be replaced by pure chemical drugs and the developed countries witnessed a decline in popularity of medicinal plant therapy. However, during the recent past, there is a resurgence of interest in study and use of medicinal. Now the medicinal



plants as a whole occupy a stable position in modern medicine. Since the pharmaceutical industry is showing special interest in using or synthesizing natural substances extracted from the plants, the scope of medicinal plant industry is booming. Further, there has been an ever-increasing demand especially from developed countries for more and more drugs from plant sources. This revival of interest in plant-derived drugs is mainly due to the current widespread belief that **'Green Medicine'** is safe and more dependable than the costly synthetic drugs, many of which have adverse side effects (Anonymous, 2000).

The advances in the field of Phytochemistry and hopes for remedies in chronic diseases generated a new enthusiasm in researchers to develop herbal medicine. Thus, the medicinal plants are moving from fringe to mainstream use with more people seeking remedies and health approaches. There has been also tremendous interest in natural products of plant origin to be used as pharmaceuticals, biocides, flavours, fragrances and as natural food colours. For various reasons, medicinal plants find increasing applications:

i as a source of direct therapeutic agents

ii affordable by the people

iii less adverse effects than synthetic drugs

iv raw material base for the elaboration of more complex semi-synthetic chemical compounds

v models for new synthetic compounds

vi taxonomic markers for the discovery of new compounds

vii production, consumption and international trade in medicinal plants and phytomedicines are growing and expected to grow in future quite significantly

viii greater interest by the developed countries

ix a renewable source

Modern pharmacopoeias still contain at least 25% drugs derived from plants and many others, which are synthetic analogues built on prototype compounds isolated from plants. Over one and a half million practitioners of the Indian System of Medicine use medicinal plants in preventive, promotive and curative applications in the oral and codified streams. Among the world's 25 best selling pharmaceutical medicines, 12 are plant derived (O' Neill and Lewis, 1993). The notable examples of commonly used plant based medicines include:

i Natural sex tonic: Saponins isolated from *Chlorophytum borivilianum*

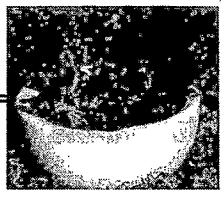
ii Antileukemia drugs: Vinblastin and vincristine isolated from Madagascar periwinkle

iii Cancer treatment: Use of a derivative of Mayapple (*Podophyllum peltatum*)

iv Herpes virus: Four cytotoxic lignans from *Podophyllum peltatum*

v Ovarian cancer: Taxol isolated from Yew tree

vi Plant sweetners: Leaves of *Stevia rebaudiana* with steviosides being 100 times more sweeter than sugar, *Dioscoreophyllum cumivisii* with sweet protein 'Manellin' which is 2500 times sweeter than sugar, *Thaumatococcus danielli* is a Nigerian plant having 'Thaumatin' a sweet protein 4000 times sweeter than sugar (Singh et al, 2004).



Impact of traditional medicine on infectious diseases:

i Chinese herbal remedy *Artemisia annua*, used in China for almost 2000 years has been found to be effective against resistant malaria and created a breakthrough in preventing almost one million deaths annually, most of them children, from severe malaria.

ii In South Africa, the Medical Research Council is conducting studies on the efficacy of the plant *Sutherlandia microphylla* in treating AIDS patients. Traditionally used as a tonic, this plant may increase energy, appetite and body mass in people living with HIV.

More than 8000 species of medicinal plants are being used and therapeutic properties of more than 2200 plant species have been studied. More and more products, prepared from medicinal plants, are increasingly being recognized even in western world.

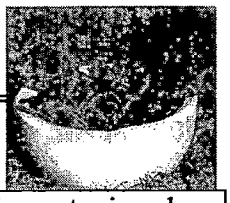
Traditional system drugs have been the starting points for the discovery of many modern drugs. This fact led to chemical and pharmacological investigations of these plants and to the undertaking of general biologically screening programs of plants not only in India but also all over the world. Some of the important plant based drugs used in modern medicine are atropine, caffeine, chymopapain, codeine, colchicine, colchicoside, digitoxin, emetin, ephedrine, gomishin, quinidine, quinine, reserpine, sennosides, vincristine, vinblastine and tenoposide. The current treatment of trypanosomiasis by benzimidazole, pentamidine, melarsoprol etc shows serious adverse effects. Various natural products of plant origin have antiprotozoal activity like berberine from *Berberis*, harmaline from *Peganum.* Triterpenes in *Simarubacius* species have potent antiprotozoal activity. Metronidalzole is the drug of choice as

amoebicidal, *Liquorice* is used in cleaning inflammed stomach, marketed carbenoxolone sodium has steroidal side effects. Oleanolic acid, sericic acid, quillia saponins are plant antiulcer activity. Colenol from *Coleus forskohli* is marketed by Hoechst under the name FORSKOLIN as a hypotensive drug. *Digitalis* is a cardiotonic, while yellow oleander is a steroidal cardiotonic. Some anticancer drugs to name are *Vinca* alkaloids, *Ochrosia* species, *Podophyllum* resin, tenoposide and etoposide. A variety of drugs available for antiasthmatic patients are viz lobeline from *Lobelia*, ephedrine from *Ephedra* and vasicine from *Vasaka*. There are plenty of plant cardiovasular drugs, diabetic drugs and other diseases to list.

There are many other medicinal plants with significant research data to be used as clinically useful drugs (Table-1.11).

Table-1.11: Medicinal Plants with significant researches leading to be clinically useful drugs

Species AUthor	Drug	Action / Clinical use
Acorus calamus L.	Asarone	Tranquilizer
Adhatoda vasica Nees	Vasicine	Oxotocic, Bronchodilator
Andrographis paniculata (Burm. f.)	Andrographolide, Neoandrographolide	Bacillary dysentry, Hepatoprotective
Asparagus racemosus Willd.	Sapogenin glycosides	Antioxytocic, burns and wounds
Azadirachta indica A. Juss.	Azadirachtin	Insecticide, antifertility
Bacopa monnieri L. Pennell	Bacoside	Antianxiety agent, improvement of intellect, adaptogenic
Carica papaya L.	Chymopapain	Proteolytic, Mucolytic
Centella asiatica L. Urban	Asiaticoside	Antidiabetic, vulnerary
Cinchona sps. L.	Quinine	Treatment malaria
Cissampelos pareira	Cissampline	Skeletal muscle relaxation
Cocus nucifera L.	Novacaine, Cocaine	Local anesthetic, cocaine served as a

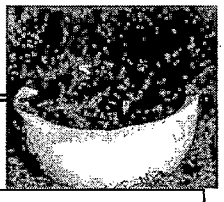


		blue print for less toxic, less addictive anesthetics
Curcuma longa Valet.	Curcumin	Choleretic
Gloriosa superba L.	Colchicine, thiocolchicoside	Oedema
Gossypium spp	Gossypol	Male contraceptive
Mappia foetida	Camptothecein	Anticancerous
Mucuna pruriens L. DC.	L-dopa	Antiparkinsonism
Phyllanthus amarus L.	Lignans	Antihepatotoxic (HBV)
Picrorhiza kurroa Pennell	Glycosides	Antihepatotoxic
Silybium marianum	Silmarium	Antihepatotoxic
Taxus baccata L.	Taxol	Anticancer
Tephrosia purpurea L.	Flavonoids, Alkaloids	Viral hepatitis
Urginia indica (Roxb.) Kunth.	Scillrin A and B	Cardiotonic
Valeriana wallichi Jones	Valeopotrates	Sedative

A list of major Ayurvedic drugs currently used in India is depicted in the Table-1.12

Table-1.12: Top twenty Ayurvedic drugs used in India

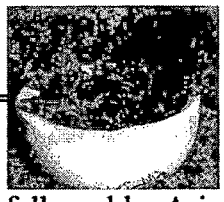
Botanical name	Family	Main activity
Phyllanthus emblica	Euphorbiaceae	Rasayana
Withania somnifera	Solanaceae	Immunomodulatory
Semecarpus anacardium	Anacardiaceae	Antiarthritic
Aegel marmelos	Rutaceae	Antidiarrhoel
Santalum album	Santalaceae	Antiviral
Plumbago zeylanica	Plumbaginaceae	Antitumour
Punica grantum	Punicaceae	Antidiarrhoel
Ricinus comunis	Euphorbiaceae	Hepatoprotective
Tinospora cordifolia	Menispermaceae	Immunodulatory



Curcuma longa	Zingiberaceae	Antimicrobial
Terminalia chebula	Combretaceae	Hypolipidemic
Rubia cordifolia	Rubiaceae	Antioxidant
Piper nigrum	Piperaceae	Bioenhancer
Azadirachta indica	Meliaceae	Antidiabetic
Piper longum	Piperaceae	Bioenhancer
Hemidesmus indicus	Asclepidaceae	Antiulcer
Zingiber officinale	Zingiberaceae	Antiemetic
Acorus calamus	Araceae	Psychotropic
Embelia ribes	Myrsinaceae	Antifertility
Glycyrrhiza glabra	Fabaceae	Antiulcer

Global Herbal Market:

Today the herbal medicine trade is a booming business worldwide. As per market study it was observed that people have used traditional medicines at least once, for example, 50% in USA, 75% in France and 90% in the United Kingdom. In Germany over 80% physicians regularly use herbal medicine. It is estimated that in 1980, the sales of herbal medicines in European communities accounted for US $ 2.25 billions (Rs 7,000 crores). This is only 3% of the European pharma market estimated at US $ 66 billion (Rs 2,11,000 crores). In the EC market for phytomedicines, Germany has the largest share at US $ 1.5 billion ie 2.2% of the total market. The size of French market for herbal medicines is US $ 0.21 billion, which amounts to less than 1% of the EC market. The UK market is US $ 425 million. The share of Indian market is negligible, not withstanding the fact that we have varied emporium of medicinal plants and the exporters of over 200 major drugs and pharmaceuticals (Farooqi and Sreeramu, 2000). While in 1999, the World market for herbal remedies



was US $ 19.4 billion, with Europe in the lead (US $ 6.7 billion), followed by Asia (US $ 5.1 billion), North America (US $ 4.0 billion), Japan (US $ 2.2 billion) and the rest of the world US $ 1.4 billion (Laird and Pierce, 2002).

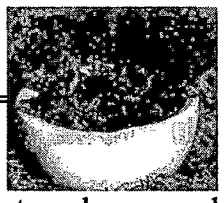
The largest global markets for medicinal plants are China, France, Germany, Italy, Japan, Spain, UK and US. Japan has the highest per capita consumption of botanical medicines in the world (Laird, 1999). In the US and Europe, the trade has typically been growing at an average of 10 percent per annum, partly because of the popularity of alternative treatments and partly because there is increasing official recognition of the benefits of traditional medical systems involving herbal preparations. The International Council for Medicinal and Aromatic Plants expected world growth during 2001 and 2002 to be approximately 8-10 per cent a year (Srivastava, 2000).

An estimate of the EXIM Bank puts the International market of medicinal plants related trade at US $ 60 billion per year growing at the rate of 7% only. Recent global market for medicinal herbs and herbal products is about US $ 62 billion and would touch the level of US $ 5 trillion market by 2050.

Table-1.13: World wide sales of plant derived drugs, 1997-2002 (US $ millions)

Plant drug category	1997	2002	AAGR % 1997-2002
Terpenes	7,660	12,400	10.1
Glycosides	7,300	9,230	4.8
Alkaloids	3,600	4,045	2.4
Others	4,048	5,013.5	4.4
Total	22,508	30,688.5	6.3

Source: Business Communications Company, Inc. AAGR: Average annual growth rate



India is a major exporter of raw medicinal and aromatic plants and processed plant based drugs. Seventy five to eighty percent of total exports from India are sent to six countries – France, Germany, Japan, Switzerland, UK and US. The principal herbal drugs that have been finding a good export market are *Aconite, Aloe, Belladona, Acorus, Cinchona, Cassia tora, Dioscorea, Digitalis, Ephedra, Plantago* (Isabgol), *Cassia* (Senna) etc. (Anonymous, 2000). Important crude drugs included *Plantago ovata, Panax spp. Cassia spp.* and *Catharanthus roseus*. Other major importers are Bangladesh, Pakistan and Spain.

Though India being the motherland of herbalism with a strong knowledge base in the traditional medicine and vast natural resources of biological diversity with two (ie Eastern Himalayas and Western Ghats) of the 14-mega diversity areas of the World located within its border, it hardly generates a negligible sum of Rs. 4,250 crores from this business, which is about 1.5-2.0 % of the international turnover while China, grab the maximum share of almost 40% of the trade (Fig-1.6).

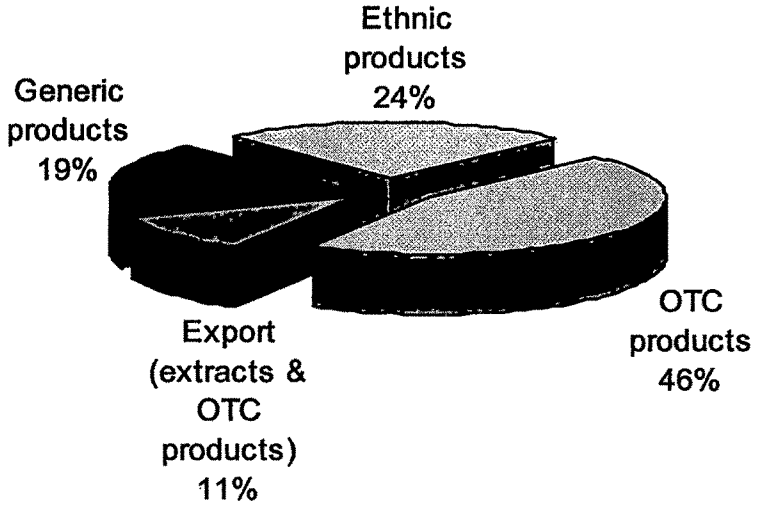
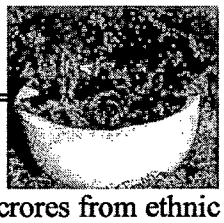


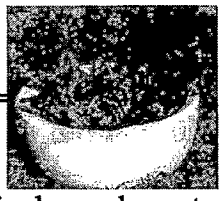
Figure-1.6: Status of Indian Herbal Market of 4250 Crores



Herbal business worth of Rs 4,250 crores includes Rs 1,000 crores from ethnic products, Rs 450 crores by exports of different kind of extracts and over the counter (OTC) products, Rs 2,000 crores constituting OTC products like Chavanprash, hair oils, skin products, digestive and laxatives, brain tonics, aphrodisiac including general tonics and Rs 800 crores by generic products (classical formulations in various dosages as prescribed by practicing doctors.)

The herbal trade is secretive, inefficient, imperfect, informal and opportunistic. Furthermore, the market is unstable, often manipulative and exploitative. Ninety percent of the medicinal plant species used by the Indian herbal industry are collected from the wild (Anonymous, 2002). Local people exploit forest herbs, particularly those that are more in demand and valuable, without regard for systematic exploitation or sustained yield (Anonymous, 2002). Destructive harvest from forests is also reported (Anonymous, 2000). This is supported by the statistics that indicate that more than 70% of plants collected from wild are harvested destructively (Anonymous, 2002). Medicinal plants are traded mostly in the form of barks, roots, twigs, leaves, flowers, fruits, seeds and even whole plant (Fig-1.7).

Often, however, collection of many medicinal plants is made illegally. The necessary plant material (roots, barks, leaves, etc) is collected and sold by the local people to the traders and the industry and exporters purchase them from traders. Since there is no scientific system of collecting or regenerating these plants, several plants have either been completely lost or have become endangered. Such plants are banned for export but, sometimes, still exported under other nomenclature. The industry is engaged in primary processing of plants, manufacturing intermediates, final



processing and manufacturing branded drugs, OTC products, food supplements, tonics and cosmetics.

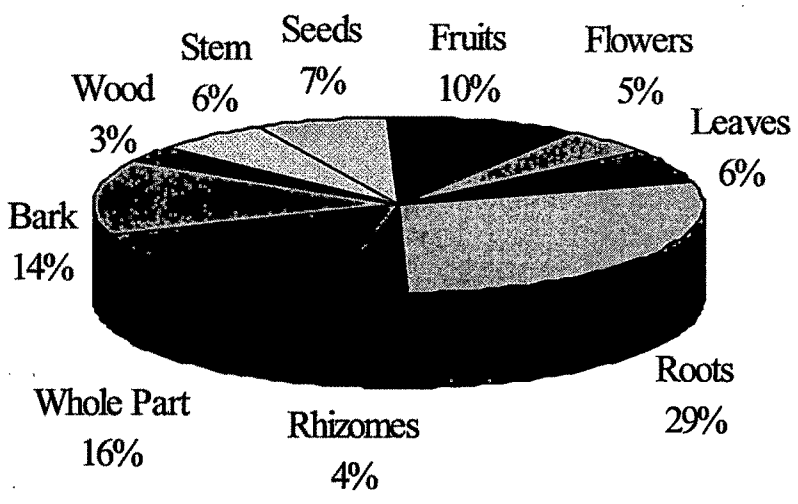
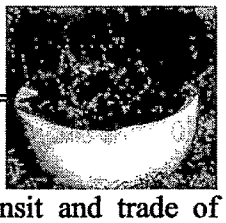


Figure-1.7: Harvesting of medicinal plants from the wild in various forms

It constantly faces the problems of raw material supply. There is also limited industrial research and clinical trials, latter due to prohibition to medical practitioners in prescribing drugs from other disciplines. However, the developed countries are showing rising interest in Indian herbal products in food supplements (Neutraceuticals), cosmetics and intermediates. Several ingredients in Indian plants are being investigated extensively and have found application in many allopathic drugs (Phytopharmaceuticals) manufactured for treatments on cancer, AIDS, blood pressure, heart diseases, diabetes, etc.

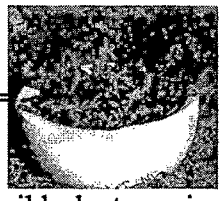
There is general lack of reliable, authentic and comprehensive information on trade, but it is feared that large-scale illegal trade is threatening biodiversity. Poor



regulation by State Forest department's results in collection, transit and trade of legally protected medicinal plants.

In order to position the medicinal plants sector on its growth path, an all-out, plant based action in cultivation, post harvest technology, processing, manufacturing, research, patenting and marketing is necessary. In view of large number of medicinal plants found in India and increasing commercial demand, the Government of India has recently constituted a National Medicinal Plant Board, which helps in cultivation, procurement and regulation of the movement of medicinal plants in National and international trade. They have short listed the commercial plants, taking into account the endemic nature of plants, volume of domestic and export demand, the endangered nature of the plant and documented use in traditional systems of medicines (Table-1.14).

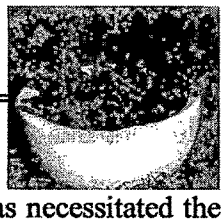
Despite legislation for restriction (Netshiluvhi, 1996; Mander, 1998), the extraction pressure on the natural populations of these medicinal plants in the wild is still very high indicating that the enforcement is incapable of curbing over-exploitation (Cunningham, 1988). With the current rate of harvesting, the plant supplies will, in time, dwindle and many of the species will eventually become extinct (Anonymous, 2000). The rural dwellers that are the most dependent on these plants will be the most affected. Further, the current rate of depletion of natural forest due to ever increasing utilization of land for food crops and uncontrolled exploitation of the natural resources has led to extinction of many species in the wild and has made it acutely difficult to procure most of the available raw materials at desired quality and insufficient quantity. Wild populations of medicinal plants typically have a high degree of genetic variability and therefore represent a substantial part of the available



genetic diversity in the world but due to excessive harvest many wild plant species face extinction.

Table-1.14: Plants shortlisted by National Medicinal Plant Board

Botanical name	Sanskrit name
Aconitum ferox Wall.	Vatsnabh
Aconitum heterophyllum Wall. ex Royle	Atees
Aegle marmelos (Linn) Corr.	Bael
Andrographis paniculata Wall.ex Nees	Kalmegh
Asparagus racemosus Willd.	Shatavari
Bacopa monnieri (L.) Pennell	Brahmi
Berberis aristata DC.	Daruhaldi
Cassia angustifolia Vahl.	Senna
Chlorophytum borivillianum Sant.	Safaid Musali
Coleus barbatus Benth.	Pather Chur
Commiphora wightii (Arn.) Bhandari	Guggal
Crocus sativus Linn.	Kesar
Embelia ribes Burm. f.	Vai Vidang
Emblica officinalis Gaertn	Amla
Garcinia indica Chois	Kokum
Gloriosa superba Linn.	Kalihari
Glycyrrhiza glabra Linn.	Mulethi
Gymnema sylvestre R.Br.	Gudmar
Nardostachys jatamansi DC.	Jatamansi
Ocimum sanctum Linn.	Tulsi
Phyllanthus amarus Schum and Thonn.	Bhumi, amlaki
Picrorhiza kurro Benth ex Royle	Kutki
Piper longum Linn.	Pippali
Plantago ovata Forsk.	Isabgol
Rauwolfia serpentina Benth. ex Kurz	Sarpgandha
Santalum album Linn.	Chandan
Saraca asoca (Roxb.) de Wilde	Ashok
Saussurea costus C. B. Clarke (*S.lappa*)	Kuth
Solanum nigrum Linn.	Makoy
Swertia chirata Buch-Ham.	Chirata
Tinospora cordifolia Miers	Giloe
Withania somnifera (Linn.) Dunal	Ashwagandha

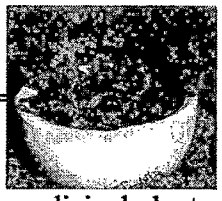


Seeing the increasing demand for internal use and export has necessitated the production of medicinal plants on large scale. There is need to introduce these crops into cropping system of the country which besides meeting the demands of the industry, will also help in maintaining the standards on quality, potency and chemical composition.

The shrinkage of plant gene pool being an irreversible process and the regeneration potential of the disturbed ecosystem being weak, cultivation of medicinal plants will be a logical route to pursue.

The cultivation of medicinal plants is necessary because of the following reasons:

a. In nature, there remains a wide variation among the plants with regards to their active principles. As only the best among them are used for cultivation, it enables us to obtain raw material of homogenous quality and high potency.
b. It is easy to grow and fulfill the commitment of large-scale supply through cultivated sources rather than from natural resources, which mainly depends on nature for their regeneration and availability.
c. The growing pressure of population/urbanization and the development of roads to remote areas have resulted in deforestation and the loss of natural plant resources.
d. In many cases, plant collectors are engaged in destructive collection/extractive methods, which have resulted in many plants becoming extinct or being listed as threatened.



e. Despite the fact that our forests are a major resource base for medicinal plants, as many of them appear in the wild, the importance of this has been totally unappreciated by the concerned government agencies.

Concerned areas for medicinal plants:

i. Medicinal plants are traded mostly as bark, stem, root, leaves, flowers, fruits and seeds. The chances of adulteration both deliberately and unintentionally are very high. Many a times substitute is used for eg roots of *Chlorophytum borivilianum* are substituted with the roots of *C. tuberosum, C. arundinaceum* and *Asparagus adscendens*. The drug known as 'Shankpuspi' is prescribed in Ayurveda for improvement of memory and other problems related to dementia. It is also used in skin diseases, cough, diabetes and other ailments. *Evolvulus alsinoides*, considered as the real shankpusphi, is used as a tonic, vermifuge and a febrifuge, where as *Clitoria ternatea* is a powerful cathartic and diuretic. However for Shankpuspi, the name refers to *Clitoria ternatea* L. in South, to *Evolulus alsinoides* L. in some parts of Rajasthan and to *Canscora decussata* Schult. in other parts of the country. *C. decussata* is prescribed in cases of insanity, epilepsy and nervous debility. One could visualize the disastrous results if *C. decussata* is used for treating fever instead of *E. alsinoides*. Similarly, *Centella asiatica* and *Bacopa monnieri* are sold as brahmi while *Boerrhavia diffusa* and *Trianthema portulacastrum* are sold as Punarnava, reputed in ayurveda that helps rejuvenation (Chaudhary, 1992). Material of *Phyllanthus amarus*, which is valued as hepatoprotective agent, is

often mixed that of the other *Phyllanthus fruternus* or *P. madraspatensis, P. simlex* that grows in similar habitats (Handa, 1993).

ii. Another area of concern is the deliberate substitution with a cheaper material that resembles the required part from therapeutically important plants, eg the bark of *Wrightia tinctoria* is regularly adulterated with that of *Holarrhena antidysentrica* and *Saraca asoka* bark is replaced with the cheaper substitute from *Trema orientalis* or *Polyalthia longifolia.* The root of *Rauvolfia serpentina* is mixed with *Tabernaemontana divaricata* and roots of *Gloriosa superba* is mixed with roots of *Costus speciosus.*

iii. The increasing demands of the pharmaceutical industry have created problems of supply and one of the major limitations experienced is obtaining sufficient quantities of medicinal plants for the manufacture of genuine formulation. In the absence of standards for crude drugs, adulteration and substitution have become common.

To control this situation, measures are needed to promote conservation and cultivation of medicinal plants and to regulate commerce to protect both producer and consumer. In practice, however, this is not so easy, if planting materials are produced in bulk, the available land for the cultivation in a highly populous nation is fast declining. So there is need to use the technology, which can generate the medicinal plants in large scale using less land.

Plant Tissue Culture

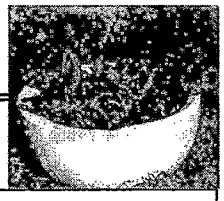
Micropropagation of medicinal plants can provide planting material for organized cultivation, chemical extraction later and/or plants for use in trials aimed at selecting varieties with improved yield (George, 1996). There has been an increased interest in recent years in *in vitro* culture techniques, which is a viable tool for mass multiplication and germplasm conservation of rare, endangered and threatened medicinal plants (Bajaj et al, 1988; Vincent et al, 1992; Krishnan and Seeni, 1994; Patnaik and Dabata, 1996; Sahoo et al, 1997; Ajitkumar and Seeni, 1998). This method is successfully employed for medicinal plants, which have high value in nature or have certain problems in their conventional propagation (Giles and Morgan, 1987). This technique has been applied for the propagation of approximately 20% of 7000 known medicinal plant species (Table-1.15).

There are several advantages for micropropagation of medicinal plants (Bajaj et al, 1988). The specific advantages of micropropagation as an alternative method of propagation of medicinal plants are:

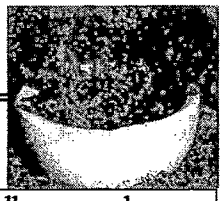
- Mass production of plants with control over the quality of plant material and the time of delivery
- Independence from environmental, seasonal, geographical and political constraints
- Reduced usage of land and agricultural resources
- Controlled growth and development to maximize active constituent
- Consistent quality and yield of plants
- Selection of individual, superior clones and genetic improvement through biotechnology

Table-1.15: List of medicinal plants subjected to techniques of tissue culture

Name	Explant	References
Acmella oppositifolia	Nodal	Salgado et al, 1996
Aconitum napellus	Shoot tips	Watad et al, 1995
Adathoda vasica	Nodal	Jaiswal et al, 1989
Aegle marmelos	Nucellus	Hossain et al, 1993
Allium cepa	Stem disc	Kahane et al, 1992
Allium sativum	Root tip	Haque et al, 1997
	Shoot tips	Nagakudo et al, 1993
	Stem tips	Nagasawa and Finer, 1988
Aloe vera	Rhizome, nodal	Chaplot et al, 2007 (In. press)
	Shoot tips	Chaudhari and Mukundan, 2001
Artemisia absinthium	Leaf, shoot tip	Nin et al, 1996
Artemisia pallens	Nodal explant	Benjamin et al, 1990
Averrhoa carambola	Cotyledons	Khalekuzzaman et al, 1995
Azadirachta indica	Anther	Gautam et al, 1993
	Cotyledons hypocotyls	Su et al, 1997
Bacopa monniera	Stem segements, Nodal	Ali et al, 1996
	Nodal, leaf, internode	Chaplot et al, 2005
Captotheca acuminata	Shoot tip	Jain and Nessler, 1996
Catharanthus roseus	Axillary bud	Karita and Jain, 1996
	Shoot tips	Mujib et al, 1995
	Shoot tip, nodal	Islam et al, 2001
Centella asiatica	Nodal segments	Tiwari et al, 2000
		Shashikala et al, 2005
Cephaelis ipecacuanha	Leaf callus	Rout et al, 1992
Chlorophytum borivilianum	Young shoot bases	Purohit et al, 1994
Cinnamomum zeylanicum	Nodal, hypocotyl segments	Rai and Jagdishchandra, 1987
Coriandrum sativum	Juvenile shoots	Kataeva and Popowich, 1993
	Shoot tips	Stephen and Jayabalan, 1998
Curculigo orchioides	Meristem tip	Wala and Jasrai, 2003
Dioscorea alata	Nodal	John et al, 1993
Dioscorea bulbifera	Nodal and internode segments	Forsyth and Staden, 1982
Dioscorea floribunda	Leaf	Sengupta et al, 1984
	male inflorescences	Borthaku et al, 2002
Dysosma pleintha	Immature seeds, mature	Chuang and Chang, 1987



	zygotic embryo	
Echinacea pallida	Leaf explant	Koroch et al, 2003
Eclipta alba	Nodal explant	Franca et al, 1995
Flaveria trinervia	Leaf	Sudarshana and Shanthamma, 1991
Gentiana kurroo	Shoot tip, Nodal explant	Sharma et al, 1994
Glehnia littoralis	Zygotic embryos	Hirai et al, 1997
Hedeoma multiflorum	Shoot tips, Nodal	Koroch et al, 1997
Hemidesmus indicus	Leaf, stem	Sarasan et al, 1994
	Nodal explant	Sharma and Yehne, 1995
Holarrhena antidysentrica	Leaf, stem and root	Kulkarni et al, 1992
Holostemma annulare	axillary bud, indirect organogenesis	Martin, 2002
Kaempferia galanga	Rhizome	Vincent et al, 1992
Lavandula stoechas	Nodal explant	Nobre, 1996
Lepidium sativum	Nodal explant	Pande, 2002
Mentha piperita	Leaf derived protoplasts	Sato et al, 1993
Nyctanthes arbor-tristis	Immature embryo, cotyledon, hypocotyls, root, leaves and internodes	Iyer et al, 1998
Phyllanthus amarus	Shoot tip	Bhattacharya and Bhattacharya, 2001
Piper longum	Shoot tips, leaf segments, internodes	Sarasan et al, 1993
Plantago ovata	Nodal	Barna and Wakhlu, 1988
Plumbago rosea	Nodal, tender leaves	Harikrishnan and Hariharan, 1996
	Internodal segments	Kumar and Bhavanandan, 1988
Plumbago zeylanica	Nodal and organogenesis	Chaplot et al, 2006
	Leaf	Das and Rout, 2002
Psoralea corylifolia	Root segment	Chand and Sahrawat, 2002
Rauwolfia serpentina	Axillary meristems	Roja and Heble, 1996
	Shoot tip	Roy et al, 1994
Rubia cordifolia	Axillary and apical buds	Shrotri and Mukundan, 2004
Solanum pseudocapsicum	Young leaves	Baburaj and Gunasekaran, 1995
Taxus brevifolia	Bark, stem, needle	Gibson et al, 1993
Thevetia peruviana	Callus cultures	Kumar, 1992
Tridax procumbens	Nodal explant	Sahoo and Chand, 1998
Uraria picta	Nodal explant, internodes	Anand et al, 1998



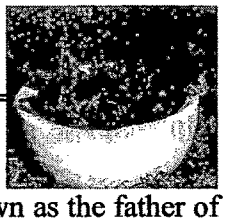
Vicoa indica	Leaf, stem	Thulaseedharan and Vaidyanathan, 1990
Withania somnifera	Leaf	Abhyankar and Chinchanikar, 1996
	Axillary meristem	Roja et al, 1991, Kannan et al, 2005
	Seedling shoot tips	Sengupta and Sharma, 1991
	Nodal, indirect organogesis	Chaplot et al, 2006,
Zingiber officinale	Rhizome	Bhat et al, 1994
	Young leaf	Kackar et al, 1993
	Organogenesis	Rout and Das, 1997

- Development of artificial seeds in plant, which do not set seeds. Generally clonally propagated plants will have identified phytochemical profiles
- In many species the *in vitro* derived plantlets produce higher amounts of desired compounds than the normal plants
- Usually multiple shoot cultures show stability of growth and secondary metabolite production characteristics of mature plants as reported in *Rauwolfia* and *Withania* (Roja et al, 1987)

This technique is also used for the long-term preservation and conservation of plant genetic resources.

Historical backgroud:

Schwann (1839) expressed the view that each living cell of a multicellular organism should be capable of independent development if provided with proper external conditions (White, 1954). A totipotent cell is one that is capable of developing by regeneration into a whole organism, coined by Morgan in 1901 (Krikorian and Berquam, 1969).



Haberlandt Gottileb, the German botanist (1902), aptly known as the father of tissue culture, originated the concept of cell culture and was the first to attempt to cultivate isolated plant cells *in vitro* on an artificial medium containing glucose, peptone and Knop's salt solution. Trecul (1953) pointed out that establishment of a tissue culture involves the process of cell dedifferentiation. The major break through in the field of plant tissue culture came with the establishment of long term unorganized tissue masses or callus from tobacco (White, 1939), potato and carrot (Gautheret, 1939). These developments coincided with the establishment of the chemical nature of IAA (Kogl et al, 1934). The most significant advancement was the discovery of liquid endosperm extracted from coconut (Van Overbeek et al, 1941). Ball (1946) demonstrated the possibilities of regenerating plants from isolated explants of angiosperm shoot apices. Later, Wetmore and Morel (1949) regenerated whole plants from shoot apices measuring 100-250 μM in length and bearing one or two leaf primordia. Skoog and Miller (1957) could regulate shoot and root formation from cultured callus tissues by varying the ratio of auxin and cytokinins in the medium. Jones et al (1960) induced growth in single cells as hanging drops in micro-chamber, while Bergmann (1960) could plate isolated single cells mixed with agar in petridish. Morel (1960) established the application of shoot apex cultures for the clonal multiplication of orchid *Cymbidium,* and modifications of his technique are currently used for the commercial production of orchid. Murashige and Skoog (1962) proposed a revised medium facilitating cell growth of many kind of tissue. Later, large number of embryos from pollen and microsporogenous tissues of anther was produced (Guha and Maheshwari, 1966 and Bourgin and Nitsch, 1967). Subsequently, development in this field was rapid and enormous. Results of which is very important

in the field of agriculture, forestry, horticulture and plant pathology (Steward et al, 1958; Guha and Maheswari, 1966; Cocking, 1960; Carlson et al, 1972; Melcher et al, 1978).

According to Street (1977), the term "tissue culture" can be applied to any multicellular culture growing on a solid medium (or attached to a substratum and nurtured with a liquid medium) that consists of many cells in protoplasmic continuity. Plant tissue culture, is one of the frontier areas in Biotechnology, which has emerged during the turn of the last century. Plant tissue culture is an alternative tool for large scale propagation (George and Sherrington, 1984) and is being used widely for the commercial propagation of a large number of plant species, which includes many medicinal plants.

Medicinal plant micro-propagation can provide plants for improved yield (George, 1996). This method is successfully employed in medicinal plants, which are high valued or certain problems are encountered with their conventional propagation. For example in *Cinchona* plants, seed propagation leads to variation in agronomic characters and bark alkaloid content. Since conventional clonal propagation means has been of little success, *in vitro* propagation systems proved to be useful. Besides having the advantages of being non-destructive to the mother plant, the technique also has a potential to reduce, by several years, the time to introduce new cultivars. The attention has now shifted from basic research to various applied applications like micropropagation, production of secondary metabolites, somatic hybridization, virus eradication, embryo rescue, production and utilization of somaclonal variants and gene transfer. Current plant tissue culture techniques are widely being used as tool for genetic manipulation of plants to obtain desirable traits. Most of the applications are

based on the characteristic of cytokinins to stimulate bud proliferation in the cultured shoot apex (Razdan, 1993).

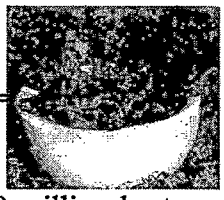
The recent advances and developments in plant genetics and recombinant DNA technology have helped to improve and boost research into secondary metabolite biosynthesis. A major line of research has been to identify enzymes of a metabolic pathway and then manipulate these enzymes to provide better control of that pathway. Transformation is currently used for genetic manipulation of more than 120 species of at least 35 families, including the major economic crops, vegetables, ornamental, medicinal, fruit, tree and pasture plants, using Agrobacterium mediated or direct transformation methods (Birch, 1997). However, Agrobacterium-mediated transformation offers several advantages over direct gene transfer methodologies (particle bombardment, electroporation, etc), such as the possibility to transfer only one or few copies of DNA fragments carrying the genes of interest at higher efficiencies with lower cost and the transfer of very large DNA fragments with minimal rearrangement (Gheysen et al, 1998; Hansen and Wright, 1999; Shibata and Liu, 2000). The gram-negative soil bacteria, *Agrobacterium tumefaciens*, and the related species, *A. rhizogenes*, are causal agents of the plant diseases crown gall tumour and hairy root, respectively. *Agrobacterium rhizogenes* has been used regularly for gene transfer in many dicotyledonous plants (Tepfer, 1990).

Genetic transformation has been reported for various medicinal plants. Naina et al, (1989) reported the successful regeneration of transgenic neem plants (*Azadirachta indica*) using *Agrobacterium tumefaciens* containing a recombinant derivative of the plasmid pTi 84. The genetic transformation of *Atropa belladona* has

been reported using *Agrobacterium tumefaciens*, with an improved alkaloid composition (Yun, 1992; Cucu et al, 2002).

Genetic transformation would be a powerful tool for enhancing the productivity of novel secondary metabolites of limited yield. Plant infection with this bacterium induces the formation of proliferative multibranched adventitious roots at the site of infection, the so-called 'hairy roots' (Chilton, 1982). This infection is followed by the transfer of a portion of DNA ie. T-DNA, known as the root inducing plasmid (Ri-plasmid), to the plant cell chromosomal DNA. Transformed hairy roots mimic the biochemical machinery present and active in the normal roots, and in many instances transformed hairy roots display higher product yields. A large number of plant species including many medicinal plants have been successfully transformed eg in *Aconitum heterophyllum* (Giri et al, 1997), *Digitalis lanata* (Pradel et al, 1997), *Atropa belladonna* (Bonhomme et al, 2000). *Pueraria phaseoloides* (Shi and Kintzios, 2003) and many others. Thus, these transformed hairy roots have great potential as a commercially viable source of secondary metabolites.

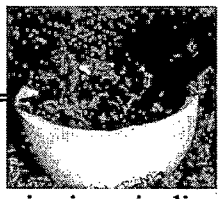
Genetically modified (GM) crops are expected to play an important role in improving agricultural productionand economic betterment of farmers. The adoption of GM crops is, in a worldwide view, a story without precedent in speed and distribution compared to any traditional breed. James (2002) compiled information on adoption rates globally. In 2002, four countries grew 99% of the global transgenic crop area. The USA led the world with 39.0 million hectares (66% of global total), Argentina followed with 13.5 million hectares (23%), Canada 3.5 million hectares (6%) and China 2.1 million hectares (4%). In 2002, the principal GM crops were: soybean occupying 36.5 million hectares (with 51% of all soybean transgenic), cotton



at 6.8 million hectares (12% of all cotton was GM), canola at 3.0 million hectares (12% of canola now GM) and maize at 12.4 million hectares (9% of maize now GM). Overall, The number of countries that grew GM crops increased from 13 to 16 in 2002 – 9 developing countries, 5 industrial and 2 Eastern Europe countries (James, 2002).

The first commercialised GM crops in India was granted to 3 cotton hybrids MECH-12 Bt, MECH-162 Bt and MECH-184 Bt developed by Mahyco (Maharashtra Hybrid Seed Co.) a leading seed company (Barwale 2002; Jayaraman, 2002). The core genetic engineering experiments culminated in development of insect pest resistant cotton (Bt cotton), comprised isolation of gene (cry) from *Bacillus thuringiensis* subspecies *kurstaki*, which produces a protein toxic to bollworm, thus providing resistance to the plant and significantly reducing the need for chemical insecticides. Commercial cultivation of Bt cotton was undertaken in 2002 in six states in India: Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka and Madhya Pradesh. The Bt hybrids approved for cultivation covered a total area of 0.038 million hectares (Barwale et al, 2004) and now in this 4 years, the number of Bt cotton hybrids released for cultivation has risen from 3 to 40 and the cultivated area under these hybrids has expanded to approximately 1.3 million hectares.

Recent developments in the plant tissue culture techniques have led to successful selection and clonal propagation of a variety of medicinal and aromatic plants including tree species of particular interest. Most interesting examples are taxol from *Taxus*, Camphothecia from *Nothapodytes*, Hydroxy citric acid from *Garcinia*, Ginkgolides from *Ginkgo*, Guggulsterones from *Commifera*, Quinodine from *Cinchona* and several others. Among the herbs and shrubs Digoxin from *Digitalis*,



Hyoscine from *Hyoscyamus*, Glycyrrihizin from *Glycerrhiza*, berberin, isoquinoline alkaloids from *Hydrastis canadenesis, Centella asiatica, Echinasia* etc are important examples. With the application of biotechnology, methods for fast multiplication of plantation and medicinal crops have been worked out. These have attracted not only the attention of the scientific community but also planners, governments and members of the general public all over the world. At present, micropropagation is the widest use among plant tissue culture technology. It was reported that there were over 300 commercial operators world wide in 1990. In Europe itself there were 172 micropropagation firms and about 1800 different species and varieties in culture amongst the plant tissue culture laboratories identified in 1993. Though the Indian micropropagation industry started a decade later, has expanded exponentially from 5 million annual capacities in 1988 to 190 million in 1996 (Govil and Gupta, 1997).

Many groups in India have commercialized tissue culture as a new business venture. Some of them are A.V. Thomas and Company- Cochin, Biocon-Bangalore, Avesthagen-Bangalore, SPIC Biotech- Chennai and Coimbatore, Ramco Biotech – Rajapalayam, IndoAmerican Hybrid Seeds – Bangalore, Godrej Biotech – Hyderabad, Microplantae Ltd. – Pune, Zandu – Mumbai, GSFC – Vadodara, Sun Agritech- Vadodara, GGRC- Dakor, GNFC – Bharuch, Shailly Biotech - Nandasan, Cadila – Ahmedabad, Dabur- New Delhi, EID Parry- Bangalore, Kothar Biotech – Bangalore, EPC Irrigation – Nasik, Mericlone – Hyderabad, In Vitro International – Bangalore, Vasishta Biotech- Bangalore, Kumar Biotech- Pune, Jain Irrigation – Jalgaon etc.

Phytochemcial analysis

25 million plant species known for their medicinal use, phytochemical test have been performed in about 5000 plants, and nearly 1,100 species are extensively exploited in 80% of Ayurveda, 46% of Unani and 33% of Allopathic medicines (Gauri, 1996).

Several analytical techniques like thin layer chromatography (TLC), high performance thin layer chromatography (HPTLC) and high performance liquid chromatography (HPLC) are available for analysis of plant derived specialty chemicals after their suitable extraction from various plant parts. Thin layer chromatography is widely adapted for qualitative and semi qualitative determination. For more accurate quantitative estimation of chemical compounds HPTLC and HPLC are employed (Deepak and Handa, 2000).

Need of the study

The over exploitation compounded with the rapid deforestation poses a potent danger of extinction of valuable medicinal plants (Arora and Bhojwani, 1989; Purohit et al, 1994; Sudha and Seeni, 1994). With increasing reliance on traditional and complementary medicinal systems, there is an urgent need to regularize and rationalize them for preventing unscrupulous use. To conserve, multiply and further use of the valuable medicinal plants, a coordination action plan for awareness, cultivation of medicinal plants, Techno-economy survey of medicinal plants of the area and large multiplication of medicinal plants in the Gujarat State is urgently needed.

Certain questions like whether the farmer should grow medicinal plants, the profitability of medicinal plants cultivation, the implications of cultivation practices, the terms and conditions of agreement between the farmer and company are still not very clear. Thus, there is a need to address such issues and this study is aimed at answering some of these questions. There is also need to assess the awareness of farmer's rights, Plant Breeder's Rights, Plant Variety Protection, Intellectual property rights and implications of World Trade Organization among the farmers of Gujarat State. Thus, through the survey, the interest for the cultivation of medicinal plants and marketing as a livelihood for farmers of Gujarat could be introduced.

Further the techno-economy status for future availability, usage and demand of medicinal plants in the State and enhancing large-scale cultivation of important and demanded medicinal plants of the State is also required to be checked. With assessing the cultivation interest of the farmers and demand of medicinal plants in the market

and agroclimatic conditions of Gujarat state, specific plants are needed to scrutinize for mass propagation.

With this preamble, study was initiated with following objectives –

1. Survey for assessing awareness among the farmers, demand and supply of medicinal plants in the state.
2. Survey of medicinal plants used by the pharmaceutical companies in Gujarat.
3. Documentation of medicinal plants in form of digital images.
4. Analyzing and discussing the implications of medicinal plants in market (WTO).
5. Standardization of commercial protocol for mass propagation of five important medicinal plants: *Bacopa monneiri* L. Pennell, *Centella asiatica* L. Urban, *Plumbago zeylanica* L., *Withania sominfera* Dunal and *Aloe vera* L.

The selected plants are highly useful and recommended in many seminars and conferences organized during the study period. Task force of international seminar on medicinal plants and spices, patents and export organized on April 6-7 2002 recommended cultivation for *Withania* and *Bacopa*. Plants *Bacopa, Centella, Withania* and *Plumbago* have high demand in indigenous drug industry (Prabhakaran et al, 2005). The tremendous scope of cultivation of *Withania* and *Aloe vera* has also been recommended by various groups (Jana, 2004, Anonymous, 2002).