Annexure: 2

Paper published:

- **Strength and Opportunities for Herbal Industry in Gujarat** has been published in Social Asian journal of social and political science" Vol. 7:97-100, (2003).
- **Very important traditional knowledge on plant conservation: linked to beliefs or religious rites** has been published in Agri history journal Vol. 9:319-325, (2003).
- **Clonal propagation of value added medicinal plant — Safed moosli (*Chlorophytum borivilianum*)** has been published by Studium Press LLC, USA in the book entitled "Recent progress of medicinal plants Vol. 9:383-388, (2005).
- ***Bacopa monnieri* (L) Pennell: A Rapid, Efficient and cost effective micropropagation** has been published in Plant tissue culture and Biotechnology. Vol. 15:167-175, (2005).
- ***In vitro* rapid propagation of *Withania somnifera* (Indian Ginseng), a high valued medicinal plant through axillary bud proliferation and internodal callus** has been published in Book on the honor of Prof. C.P. Malik, Jaipur, Rajasthan, (2005).
- **A valued medicinal plant - Chitrak (*Plumbago zeylanica* Linn.): successful plant regeneration through various explants and field performance** has been published in Plant tissue culture and Biotechnology. Vol. 16:77-84, (2006).

Paper accepted for publication in journal:

- ***In vitro* rapid propagation of *Aloe vera* L., a high valued medicinal plant through rhizome and axillary bud proliferation** in ICFAI (Biotechnology) Journal.

Paper communicated:

- **Rapid clonal propagation and increase in biomass of an Indian Pennywort (Mandukparni): *Centella asiatica* Linn** in Phytomorphology journal.

Paper presented:

- **Efficient *in vitro* multiplication of Medhya Rasayana: *Bacopa monnieri*** at International seminar on Ayurved University, Jamnagar held on 5-7 January 2003.
- **Technology for cloning of medicinal plants** at National seminar on Herbal Technology held at Dept. of Botany, M.S. University of Baroda, Vadodara, held on 28-29th January 2005.

Paper Cuttings:

19th March 2005 Rajasthan Patrika


सहकारिता खेती को प्राथमिकता मिले : दवे

21st March 2005 Rajasthan Patrika

21/3/05

विश्व व्यापार संगठन एवं कृषि कार्यशाला

उदयपुर। विश्व व्यापार संगठन एवं कृषि के बारे में विज्ञान एवं प्रौद्योगिकी विभाग, एशियन एग्री. हिस्ट्री फाउण्डेशन, माणिक्यलाल वर्मा आदिम जाति शोध संस्थान के संयुक्त तत्वावधान में टी.आर.आई. सभागार में शनिवार को आयोजित की गई। कार्यशाला में प्रमुख वक्ता कृषि अनुसंधान परिषद, नई दिल्ली के सहायक महानिदेशक जे.पी. मिश्रा ने बौद्धिक सम्पदा अधिकार पर वार्ता प्रस्तुत की। समूह वार्ता में पेटेन्ट प्राप्त करने की विधि को सरल बनाने, सभी विश्वविद्यालयों में बौद्धिक सम्पदा अधिकार की जानकारी पाठ्यक्रम में शामिल करने, आयुर्वेदिक औषधीय पौधों एवं उनसे प्राप्त रसायनों के लिए विभिन्न आयुर्वेद विश्वविद्यालय एवं संस्थानों के वैज्ञानिकों को सुविधाएँ देने की अनुशंसा की गई। सामूहिक चर्चा में डॉ. के.एन. नाग, डॉ. एम.एम. सिमलोट, डॉ. आर.सी. सक्सेना, डॉ. एम.सी. भारद्वाज, श्रीमती विनिता वर्डिया, के.एस. बाबेल ने भाग लिया।

26th February 2004 Rajasthan Patrika

राजस्थान पत्रिका उदयपुर, गुरुवार, 26 फरवरी, 2004

26 Feb 2004

लेमनग्रास से महकते हैं साबुन, शेम्पू

उदयपुर, 25 फरवरी। नींबू की ताजगी देने वाली महक से परिपूर्ण साबुन में नींबू नहीं वरन् लोमनग्रास की भूमिका होती है, जो कम्पनी नींबूयुक्त साबुन बनाने का दावा करती है दरअसल वह सिट्राल युक्त लेमन ग्रास तेल का ही प्रयोग करती है। यह तेल साढ़े तीन सौ से चार सौ रुपए किलो तक बिकता है। माणिक्यलाल वर्मा आदिम जाति शोध संस्थान में आयोजित दो दिवसीय 'औषधीय पौधों का उत्पादन व विपणन' विषयक प्रशिक्षण शिविर के समापन समारोह में वक्ताओं ने कृषकों यह जानकारी दी। जामारोजा, पामारोजा, सिट्रानिला, तुलसी, रजनीगन्धा, गुलाब मेन्था, जापानी पोदीना आदि के तेलों की भी बाजार में विशेष मांग हैं। शिविर में श्रीमती विनीता वर्डिया ने औषधीय हर्बल पादपों, ग्वारपाठा, ब्राह्मी, तुलसी आदि की खेती के सम्बन्ध में सी.डी. प्रदर्शन किया। पूर्व उपनिदेशक उद्यान जी.एस. वर्डिया ने फलदार औषधीय पौधों की कृषि की जानकारी दी। उपनिदेशक खादी बोर्ड पी.सी. गौड़ ने बोर्ड की योजनाओं सहित विपणन के बारे में बताया।

औषधीय पौधों का उत्पादन एवं विपणन कार्यशाला

राजकीय औषधीय पादप बोर्ड के जी.पी. सक्सेना ने औषधीय पौधों की खेती के बारे में खुली चर्चा की तथा शंकाओं का समाधान किया गया। विज्ञान एवं प्रौद्योगिकी विभाग के अनुसंधान अधिकारी गिरधारी लाल गर्ग ने औषधीय पौधों की खेती में नवयुवकों, कृषकों के लिए उद्यमिता अवसरों पर प्रकाश डाला। कार्यशाला में साठ कृषकों व संस्थाओं ने भाग लिया।

Strength and Opportunities for Herbal Industry in Gujarat



Binita B. Chaplot
Project Officer,
GSFC Science
Foundation

Dr. Ashok M. Deve
Member Secretary,
GSFC Science
Foundation

Dr. Yogesh T. Jasrai
Professor,
Maharaja Sayajiraao
University of Baroda.

Contribution of the traditional medicine to human health in the 21st century, remain the major source of health care for more than two thirds of world's population. Impressive progress has been made in certain developing countries like India and China through integration of traditional with Western system and the application of modern science and technology to the promotion and development of traditional medicine. Cultivation of medicinal plants should be viewed not only as a means for meeting current and future demands for large volume production of plant based drugs and herbal remedies but also as a means for relieving harvest pressure on wild populations. This article focuses on the strengths and opportunities in Gujarat for Herbal Industry. Scientific cultivation with modern marketing strategies has to be introduced. Efforts together made by NGOs, Industries, Government and farmers will lead to still better scope and opportunities in bringing awareness, cultivation, marketing and revenue generation to the Gujarat State.

Save plants to save lives - WHO

WHO emphasizes the importance of conserving the medicinal plants and using them in a sustainable manner. Biological diversity is a vital resource for human beings, both for the global community and for each nation. It is at the heart of economic productivity and livelihood today and its conservation and rational use are an absolute necessity to achieve sustainable development. It is a source of significant economic, aesthetic, health and cultural benefits which form the foundation for sustainable development. In addition, its protection and maintenance is an insurance policy for future generations (Swaminathan, 2002). However, it is observed that economic development in different regions has often been accompanied by a decline in biodiversity. There is general scientific consensus that the world is rapidly becoming less biologically diverse in terms of genes, species and ecosystems. The reason clearly specifies anthropogenic pressure. The scale of human impacts on biological diversity has been increasing exponentially primarily because of worldwide patterns of consumption, production, trade, agricultural, industrial and settlements development and human population growth. Threats of climate change, desertification, land degradation and the scale at which we are using up and destroying the very basis of our future survival.

Contribution of the traditional medicine to human health in the 21st century is of paramount importance. Over 4,000 years, India has been practicing and using its rich biodiversity in the health care segment. Rich traditional experience and wisdom of our country has been depicted in the traditional system of Indian medicines namely Ayurveda, Siddha and Unani. One of the earliest treatises of Indian medicine, the Charaka Samhita (1,000 B.C.) also mentions uses of 2,000 herbs for medicinal use. Further India is considered to be a treasure house of about 45,000 species, of which there are 15,000 being higher plants.

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. 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 to be 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, while a recent survey conducted by the International Union for Conservation of Nature (IUCN) speak 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. (Krishnamurthy, 2001)

Global Status of Medicinal Plant Market

International trade has always played a crucial role in the economic advancement of mankind. Exports and imports, over the years have become dynamic and also very complex. The herbal medicine trade is a booming business worldwide. The WHO estimated that the primary health care needs of approximately 80% of the developing World's population are met by the traditional medicine (Bannerman, 1982, Srivastava et al., 1995). As per recent 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.

Global market for medicinal herbs and herbal products is about US $ 62 billion and will touch the level of US $ 5 trillion market by 2050. 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 of the 14-mega diversity areas of the world located within its border, it hardly generates a negligible sum of Rs. 4250 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. Further China has 4,941 of 26,092 native species, which are used as drugs in Chinese traditional medicine (Duke & Ayensu, 1985), an astonished 18.9 % while India has 3,000 of 15,000 native species (i.e. 20%).

Herbal business worth of Rs. 4250 crores includes Rs. 1000 crores from ethnic products, Rs. 450 crores by exports of different kind of extracts and over the counter (OTC) products, Rs. 2000 crores constituting OTC products like Chavanprash hair oils, skincare products, digestive and laxatives, brain tonics, aphrodisiac including general tonics (Fig.1) and Rs. 800 crores by generic products (classical formulations in various dosages as prescribed by practicing doctors). More than 8000 species of medicinal plants are being used and therauptic 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 as modern system has limited answer for adverse side effect and high drug resistance.

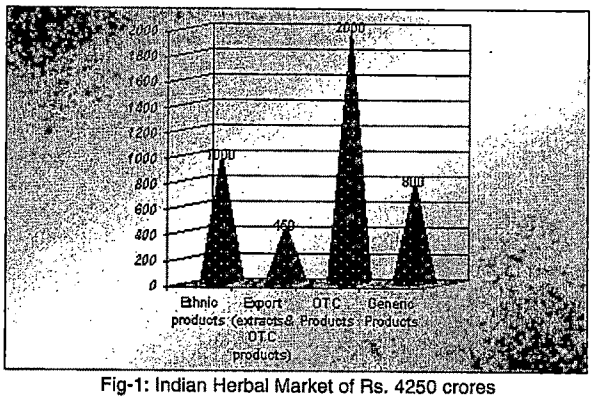


Fig-1: Indian Herbal Market of Rs. 4250 crores

A survey was conducted for assessing the strength, weakness, opportunities and threats (SWOT) in the Gujarat State in context with cultivation trade and market of medicinal plants. The survey has focused to grab the opportunities and use the strength, emerging in the State through cultivation of medicinal plants.

Strength:

Gujarat has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rain forests to coastal wetlands. Gujarat has wide collection of medicinal plants. More than 2000 medicinal plants are found growing in this State (Shah, 1978). The Gujarat flora is very rich in terms of medicinal plants and 80% of them grow naturally in wild habitat.

Moreover, Gujarat 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 temperatures average 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.

Gujarat has different types of soil. It has a fertile plain in the south cut by several rivers, low hills in the west, and broad mudflats in the north that adjoin the Thar (Great Indian) Desert. In South Gujarat deep black clayey soil, while in Kheda loamy soil, in Saurashtra medium black soil, in Kachchh sandy soil and further saline soil is found towards northwest. Due to such different type of soil pattern various kinds of plants are found to be growing in this area.

Gujarat with its strategic location serving as the natural gateway of India encompasses 1600 km of long coastline in India, dotted with 42 minor and intermediate ports. The Port related activities are carried out at 14 different locations in the State. The State now proposes to develop 10 new ports at other potential locations. Gujarat today contributes a share of about 17 to 20% of total exports in India.

Apart from ports, Gujarat also has excellent network of roads and rails complementing the export-import activities. National Highway No.8 passes through the State. Exports from Gujarat predominantly take place through Ahmedabad International Airport, Kandla Sea Port, other intermediate and minor ports, ICDs at Ahmedabad and Vadodara. Villages/rural areas are also well connected through roads. Now Intranet Facility projects in village areas are also in progress. This would facilitate farmers to get in touch with upcoming advances in their field

Table-1: List of medicinal plants growing in different parts of Gujarat

Common Name	Scientific Name	Part Used
Chanothi	*Abrus precatorius* L.	Seeds and leaves
Kanghi	*Abutilon indicum* L.	Seeds and leaves
Kher	*Acacia catechu* (L.f.) Willd.	Bark, wood
Safed bach	*Acorus calamus* L.	Rhizome
Ardusi	*Adhatoda vasica* Nees	Leaves
Bilva	*Aegle marmelos* (L.) Corr.	Fruits
Arduso	*Ailanthus excelsa* Roxb	Leaves
Kuvar pattu	*Aloe vera* (Linn.) Burm. F.	Leaves
Lilu kariyatu	*Andrographis paniculata* (Burm. F.)	Leaves
Kiramar	*Aristolochia bracteolate* Lamk.	Plant and root
Shatavari	*Asparagus gonocladus* Baker	Root
Neem	*Azadiracta indica* A. Juss	Leaves, root, seed, Bark
Brahmi	*Bacopa monnieri* L. Pennell	Plant
Punarnava	*Boerhaavia diffusa* L.	Whole plant
Saledo	*Boswelia serrata* Roxb. Ex Colebr	Gum
Palash	*Butea monosperma* (Lamk.) Taubert	Flower, seed
Akado	*Calotropis gigantea* Ait	Root, Bark, Flower
Akada, Rato	*Calotropis procera* (Willd)	Root bark
Senna, sonmukhi	*Cassia angustifolia* Vahl.	Leaves, fruits
Garmalo	*Cassia fistula* L.	Fruit pulp
Malkagni	*Celastrus paniculata* Willd.	Seeds
Jal Brahmi	*Centella asiatica* L. Urban	Whole plant, leaves
Dhodhi moosli	*Chlorophytum tuberosum* Baker	Tuberous roots
Arni, Bharangi	*Clerodendrum serratum* (L.) Spreng.	Roots, Leaves
Guggul	*Commiphora wightii* (Arnott) Bhandari	Gum exudates
Shankhavali	*Convolvulus microphyllus*	Whole plant
Dhatura	*Datura metel* L.	Leaves, seeds
Salavan	*Desmodium gangeticum* (L) DC.	Whole plant
Ratalu	*Dioscorea bulbifera* L.	Bulbs
Bhangaro	*Eclipta prostrata* (L.) L.	Plant juice
Amla	*Emblica officinalis* Gaertn.	Raw fruits
Lal dudhi	*Euphorbia hirta* L.	Whole plant
Jethi madh	*Glycyrrhiza glabra* L.	Root
Sewan	*Gmelina arborea* L.	Fruits
Madhunashini	*Gymnema sylvestre* (Retz.) Schult.	Leaves
Kutaja, Kudo	*Holarhena antidysenterica* L. Wall.	Bark, leaves, seeds
Jevanti, mithi dodi	Leptadenia reticulata *(Retz.)Wight & Arn.*	Whole plant
Aambo	*Mangifera indica* L.	Kernel
Sargavo	*Moringa oleifera* Lamk.	Seeds
Kaucha	*Mucuna prurita* Hook.	Seeds
Parijat	*Nyctanthes arbortristis* L.	Flower
Tulsi	*Ocimum sanctum* L.	Leaves and seeds
Afim	*Papaver somniferum* L.	Latex
Jangli amla	*Phyllanthus fraternus.* (Webster)	Whole plant
Isaphgol	*Plantago ovata* Forsk.	Seeds
Chitrak	*Plumbago zeylanicum* L.	Root
Karanj	*Pongamia pinnata* L. Pierre	Seeds
Aritha	*Sapindus trifoloatus* Vahl	Fruit, root, bark
Ubhi bhoringni	Solanum inacanum	Whole plant
Jambu	*Syzgium cumini* L. Skeels	Seeds
Sharpunkho	*Tephrosia purpurea* L. Pers.	Leaves, Roots
Baheda	Terminalia bellerica *(Gaertn.) Roxb.*	Fruits
Harade	*Terminalia chebula* Retz.	Fruits
Arjun	*Terminalia arjuna*	Bark
Gaddo,	*Tinospora cordifolia* (Willd.) Miers	Dry stem

from other and even far off sources.

For carrying out agricultural advance programs and training to the related subject, various research institutes like Rural Development Institute (IRMA), Gujarat Agriculture University (GAU) and its various campus at Anand, Dantiwada, Navsari, etc., various universities like Maharaja Sayajirao University (MSU, Baroda), South Gujarat University (SGU, Surat), Gujarat University (GU, Ahmedabad), North Gujarat University (NGU, Patan), National Research Centre on Medicinal and Aromatic plants (Boriavi), Gujarat Ayurveda University (Jamnagar) and many NGOs are contributing extensively for medicinal plants in the State.

Weakness:

In Gujarat, there is large indiscriminate deforestation including unscrupulous collection of plant material. Further basic problem is lack of sufficient data on wild plant population. Common people are not aware of these surrounding valuable medicinal plants. Though farmers have started showing interest in cultivation of medicinal plants but there is perceived need of agronomic standardization and recommendation. There is also lack of expertise in management of cultivation of medicinal plants and agricultural expertise. Other factors such as time, land, and lack of unavailability of quality planting material have also added to the weakness in cultivation of medicinal plants. Further, there is poor access to appropriate sound technology for harvesting and plantation development program. There is inadequate awareness on regulations and financial resources.

Marketing network, organized network and legal protection procedures are also lacking in the State compared to the other States like Maharashtra and Madhya Pradesh. Marketing is also one of the major causes of failure of cultivation of medicinal plant in Gujarat. We had carried out a survey for assessing the awareness, demand and supply of medicinal plants in Gujarat area. Good response was received from the farmers all over the State. More than 200 progressive farmers involved in cultivation of medicinal plants are facing the problem of proper marketing and revenue generation. It is lacking due to lack in awareness among people, being unaware of elite species, improper product quality, grading and packaging.

Opportunity:

Cultivation of medicinal plants should not only be viewed as a means for meeting current and future demands for large volume production of plant based drugs and herbal remedies, but also as a means for relieving harvest pressure on wild population. (Anonymous, 1995). Enthusiastic farmers are ready for cultivation of medicinal plants in their soil instead of cereals and pulses. They have been already introduced to biotechnological approaches in agriculture practices. Banana Tissue culture have been introduced since last few years and it has taken a large share in today's agriculture planning process in the state. In the same way now tissue culture raised Sugarcane and Date palm are in the pipeline. Many companies have ventured in the state developing tissue culture banana. (GSFC, Cadila, Sun Agrigenetics, etc.). Many large farms of medicinal plants have been developed. To site an example is the Nutech Farm at Rayan (Kachchh) growing large number of medicinal species, processing and marketing on a large scale.

The cultivation of medicinal plants plays an important role in the lives of rural people. They could be employed, earn their livelyhood, particularly in remote parts which are poorly served with health facilities. Products derived from plants are not only useful for traditional medicine, but also often have a considerable market

value. The sale of raw materials for pharmaceuticals can be especially important for subsistence farmers. Excellent export market can be generated if proper care in quantity and quality of the raw material and value added extract could be made. An excellent example is the successful implementation of the milk-cooperatives under the banner of AMUL for collection of milk and well being of its constitution members in the State. This has also helped in empowering the rural women for prosperity.

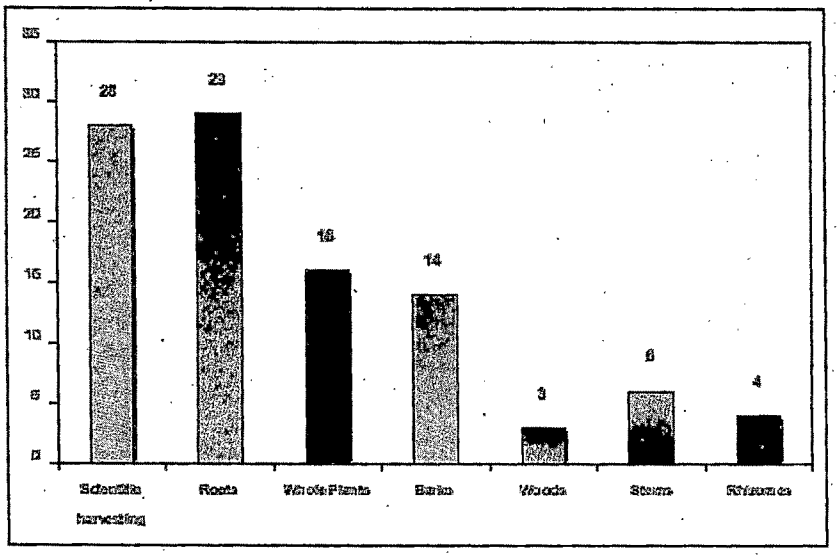


Fig-2:Destructive Harvesting of Plant Parts

Threats:

As demand for medicinal plants are rising, harvest rates has also increased. There are numerous documented cases of over-exploitation and even local extirpation in response to intensive harvest. Trade volumes are large and of significant value. The result is that the natural resource base is being degraded in certain areas, and an increasing number of species are becoming threatened. Some plants of the listed medicinal plants (Table-1) require attention for their sustainable existence in future in Gujarat.

About 90% of medicinal plants used by the industries are collected from the wild. Over 70% of the plant collections involve destructive harvesting because of the use of parts like roots, bark, woods, stems, rhizomes and the whole plant in case of herbs. These pose a definite threat to the genetic stocks and to the diversity of medicinal plants.

A market survey of medicinal plants for assessing the present and future requirements, promotion of medicinal plant cultivation for Ayruvedic and Pharmaceutical Companies was undertaken. Information on the requirement of raw materials (medicinal plants) by the pharmaceuticals based in the State was gathered by a questionnaire and personal visits. Accordingly, a comprehensive list of medicinal plants used by the Pharma companies, based in Gujarat, is being compiled.

Recommendations:

There is a need to identify plants and tree species, which can be cultivated easily in Gujarat's agro-climate conditions and generate employment and revenue. Further, tree species which are capable of multiple uses, such a wood production as well as alternate products such as medicines should be identified and planted. This would promote recognition of the value of particular species and results in their inclusion and consideration in forest management planning.

NGO's can also play a prominent role by creating awareness among masses about the need of conserving natural resources and about the economic prospects of cultivating the medicinal plants. GSFC Science Foundation emphasizes on cultivation of medicinal plants. The Foundation has also started works on mass propagation of many medicinal plants through tissue culture and is on the way of developing a live museum of plants. Awareness programs for farmers are conducted at their research station, Dakor. The tissue culture section of the M. S. University of Baroda has already developed protocols for multiplication of Commiphora, Vitex, Gmelina, Anola, Gymnema, Curculigo, Datura, Craeteva, Sapindus etc.

Collaborations between Department of Agriculture of Gujarat Government, Gujarat Agriculture University, semi government, NGOs, producers, pharmaceuticals and farmers are highly essential and important to fulfill the gap between farmers and industries. Small-scale industries for extraction and processing of the harvested plant material need further development. Agricultural and other universities need to make more sincere and more efforts for selection of improved planting material and standardization of agronomic practices for the eventual benefits to the farmer. In short, there is an urgent need for cultivation of medicinal plant and improvement in the marketing network and its management. The cultivation of medicinal plants would be one of the best and powerful mean for rural setups of Gujarat and even Our Country.

Hope, a day will come, when like milk cooperatives, there could be collection booths for raw materials and marketing of medicinal plants all over the State.

References:

Anonymous 1995 Non wood forest products for rural income and sustainable development, FAO, Rome.

Bannerman RH 1982 Traditional medicine in modern health care, World Health Forum 3: 8-13.

Duke JA and Ayensu ES 1985 Medicinal Plants of China, Vol. 1 & 2, Algonac, USA.

Krishnamurthy KV 2001 Botanical correlations of the medicinal plants from Athervana Veda, Amruth 3:6.

Shah GL 1978 Flora of Gujarat State. Sardar Patel University, Vallabh Vidyanagar, India.

Singh U, Wadhwani AM and Johri BM 1996 Dictionary of Economic Plants in India. Indian Council of Agricultural Research, New Delhi, India.

Srivastava JJ, Lambert N and Vietmeyer 1995 Medicinal Plants: A Growing Role in Development, The World Bank, Washington, DC.

Swaminathan MS 2002 A global perspective in Indian traditional knowledge, Proceedings on Medicinal Plant, Spices Exports: Patents, Voluntary Health Education and Rural Development Society, Chennai.

Asian Agri-History Vol. 7, No. 4, 2003 (319–325)

Traditional Knowledge on Plant Conservation Linked to Beliefs and Religious Rites

Yogesh T Jasrai[1] and Binita B Chaplot[2]

1. Department of Botany, Faculty of Science, Maharaja Sayajirao University of Baroda, Vadodara 390 002, Gujarat, India
2. GSFC Science Foundation, Vigyan Bhavan, Fertilizernagar, Vadodara 391 750, Gujarat, India

Ten wells are equal to one pond.
Ten ponds are equal to one lake.
Ten lakes are equal to one son.
Ten sons are equal to one tree.

—Surapala
(c. 1000 AD)
(Source: Vrikshayurveda)

Nature worship was a common phenomenon in the earliest civilizations as these forces fulfilled all the basic necessities. Gradually people realized the importance of some plants to be of great benefit to them. There is evidence of actual worship in the Indian subcontinent around 3000 BC as well as reverence for nature as a source of medicine. This practice has been followed since ancient times before the period when Ayurveda became a serious science.

Ancient texts of India bear evidence of the use of plants for veterinary purpose, for plant health, and also for manufacture of textiles (vegetable dyes), cosmetics, and perfumery. This kind of use is prevalent even today. The All India Ethno-biology Survey carried out by the Ministry of Environment and Forests estimates that over 7,500 species of plants are used by 4,635 ethnic communities for human and veterinary health care across the country.

There is nothing new about the use of medicinal and other useful plants, which promote good health and well-being in a balanced environment. Every culture throughout the world has utilized such useful plants as the basis for its medicine and well-being. The range of plants would vary from area to area depending on the local ecosystem and necessities, but the human problems they deal with were the same. For thousands of years plants have demonstrated their efficiency not only as healing agents but also to take care of the surrounding environment.

Plant biodiversity and religious importance

Biodiversity, an important gift of nature to earth, is under great threat. It is fast depleting as an inevitable consequence of our mad rush towards modern development. Deforestation, wetland losses, habitat loss, environmental pollution, overexploitation, fragmentation, industrialization, and many other factors are endangering our

Plant Tissue Cult. & Biotech. 15(2): 167-175, 2005 (December) PTC&B

Bacopa monnieri (L.) Pennell: A Rapid, Efficient and Cost Effective Micropropagation

B. Chaplot Binita, M. Dave Ashok and T. Jasrai Yogesh[1*]

Agribiotechnology Laboratory, GSFC Science Foundation, Vigyan Bhavan, Vadodara -391750 Gujarat, India

Key words: Bacopa, Brahmi, Leaf culture, Micropropagation, Medicinal plant

Abstract

An efficient and cost effective protocol is described for rapid and large scale *in vitro* propagation of the valuable medicinal herb, *Bacopa monnieri* (L.) Pennell by bud proliferation on nodal segments, young leaves, internodes and shoot tips isolated from field-grown mature plants. This was achieved on MS solid and liquid medium with 1.1 µM BA and 0.2 µM IAA within three weeks of inoculation. Normally, the axillary nodes gave rise to seven - eight shoots. In addition to this, each leaf gave rise to a large number of shoot buds (110 shoots) from all over the surface, while internodes gave rise to a clump of shoots (28 shoots). The solid medium was more effective for bud proliferation from the leaf while the liquid medium proved more suitable for axillary nodes and internode explants. Axillary buds located at middle level nodes (4 - 7 from shoot tip) were found to be more promising and resulted in direct multiplication of about eight shoots. Elongation of shoots and subsequent root induction were achieved on the same proliferation medium only. On an average, within a period of three subcultures, different explants like leaf-, node- and internode explants generated 12100, 49, 784 shoots, respectively thereby favoring the economics of the cost of the materials and time factors. The regenerated plants resembled the mother plants in general habit without any morphological variation. HPLC analysis of the regenerated shoots revealed a phytochemical profile similar to that of the market sample and mother plants. A reproducible, very simple - one step procedure for *in vitro* propagation of *Bacopa monnieri* has been established. This protocol can be used to generate foundation stocks of elite planting material for large scale cultivation.

Introduction

Medicinal plants are of great interest to the researchers in the field of biotechnology as most of the drug industries depend, in part, on plants for the production of pharmaceutical compounds (Chand et al. 1997). Among the World's 25 best selling pharmaceutical medicines, 12 are plant derived (O'Neill

*Present address: Department of Botany, School of Sciences, Gujarat University, Ahmedabad-380009, India. [1]Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara-390002, Gujarat, India.E-mail: yjasrai@yahoo.com

and Lewis 1993). *Bacopa monnieri* (L.) Pennell belonging to the family Scrophulariaceae is an amphibious plant of the tropics and normally found growing on the banks of rivers and lakes. It is commonly known in India as *brahmi* or *jala-brahmi*. It is a small creeping, glabrous and succulent herb with thick, soft, ascending branches and sessile, obovate-oblong or spatulate leaves; flowers are whitish blue with purple veins on long pedicels. It has a great market demand due to its high medicinal values. Moreover, because of the heavy demand and short supply, it is the most adulterated species in *Ayurvedic* formulations. So there is a need to mass-propagate the selected clones. Furthermore, their natural regeneration is hampered by death at two leaf stage and specific habitat requirement. The submerged shoots of *B. monnieri* can hardly ramify to attain the required growth and multiplication. Therefore, it is necessary to develop and standardize the large-scale multiplication through micropropagation.

Brahmi is also known as "Medhya Rasayana" in Ayurveda as it increases mental clarity and brain stimulating action (Bhattacharya and Ghosal 1998). It also possessess anti-inflammatory, analgesic, antipytretic, epilepsy, insanity, anticancer and antioxidant activities (Satyavati et al. 1976; Jain et al. 1994; Elangovan et al. 1995; Tripathi et al. 1996; Vohora et al. 1997). It is also used in the treatment of asthma, hoarseness, water retention and blood cleaning. Moreover, leaf juice of brahmi is given to children for relief in bronchitis and diarrhoea.

The medicinal properties of *Bacopa monnieri* responsible for improving memory-related functions have been attributed to the presence of different types of saponins such as bacosides A, B, C and D which are the active triterpenoid principles and known as "memory chemicals" (Rastogi et al. 1994). These compounds are attributed with the capability to enhance the transmission efficiency of nerve impulses, thereby strengthening memory and cognition (Singh et al. 1997). Two new dammarane type jujubogenin bisdesmosides, bacosaponins E and F of biological interest have also been isolated from this herb (Mahato et al. 2000). The present communication reports an effective, efficient, rapid, cost-effective protocol for large-scale *in vitro* multiplication of *brahmi*.

Materials and Methods

Juvenile shoots were obtained from three-month-old mature plants of *Bacopa monnieri* (L.) Pennell growing in the Botanical Garden of the Maharaja Sayajirao University of Baroda. Axillary nodes, young leaves and internodes were used as explants.

The explants were thoroughly washed under running tap water (30 min) and treated with 0.2% (v/v) aqueous surfactant Teepol (BDH, India) for 15 min

followed by repeated rinsing with distilled water. Subsequently, explants were treated (20 min) with 0.1% (w/v) carbendenzim (BASF, India). Further sterilization was done under aseptic conditions inside a laminar Airflow Hood (Lab Services, India).

Explants were surface sterilized with 50% (v/v) ethanol (1 min) followed by a 3 min treatment with 0.01% (w/v) $HgCl_2$. Finally, the explants were washed thoroughly (4 - 5 times) with sterilized distilled water. Throughout the experiments, MS medium with 3% (w/v) sucrose and gelled with 0.8% (w/v) agar (Qualigens, India) was used. The pH of all media was adjusted to 5.8 before autoclaving at 121°C (15 min). The cultures were incubated in a culture room at 25 ± 1°C under 16 h photoperiod (50 $\mu Em^{-2}s^{-1}$) provided by cool white fluorescent tubes (Phillips, India).

For initiation, various explants as described above were inoculated on both agar based semi-solid and liquid MS medium supplemented with different concentrations of BA (0.5 - 4.4 μM) alone and with IAA (0.1 - 0.2 μM). The regenerated shoots were subcultured every three weeks in the same medium. Experiments were also carried out to check the effect of different nodes (2 - 7 nodes) from *in vitro* developed shoots on MS media separately with different concentrations of BA (0.5 - 4.4 μM) alone and in combination with IAA (0.1 - 0.2 μM).

The experiments were performed in replicates of ten for each type of explants and all experiments were repeated three times. The growth responses of the explants were studied at weekly intervals in terms of the initiation and distribution sites of shoots and root regeneration.

Phytochemical evaluation was carried out by HPLC for six-month-old micropropagated plants, market samples and field-grown plants. All the samples were air-dried and crushed to a fine powder form. Optimal extraction was achieved by heating 1 g of fine powdered drug with 20 ml methanol on a hot water-bath under reflux for 5 h. The extract was cooled, transferred to a separating funnel and further extracted with chloroform (30 ml; three times). The combined chloroform layer was collected through sodium sulfate into a beaker. The chloroform was evaporated on a warm water-bath and residue was dissolved in methanol (100 ml).

Separation and determination of Bacoside was performed with HPLC column (250 mm × 4.6 mm) that contained ODS (18) packing (Sigma-Aldrich Hypersil ODs 5mm). The solvent flow-rate was 0.5 ml/min and separated components were monitored by UV (240 nm).

For acclimation, the regenerated plantlets were transferred to small plastic pots containing sand, soil and farmyard manure in the ratio of 1 : 1 : 1. Initially,

high humidity was maintained with water spray at regular intervals (Jasrai et al. 1999) and then transferred to the Botanical Garden of GSFC Science Foundation for further growth.

Results and Discussion

Earlier reports available on *Bacopa monnieri* demonstrated plant regeneration through axillary nodes, internodes and young leaves on media with high concentrations of cytokinin (Tiwari et al. 2001; Shrivastava and Rajni 1999). However, we report here a one-step medium with low concentrations of cytokinin and auxin that were found suitable in all the types of explants for a rapid and large scale multiplication at a cost-effective level.

The nodal segments (Fig. 1A) implanted on MS medium supplemented with only BA (1.1 μM) showed multiple shoot (3 - 4) within two weeks of incubation. Several workers have reported multiple shoot induction with cytokinins in the growth medium (Clog et al. 1990; Stamp et al. 1990). Addition of IAA (0.2 μM) with BA (1.1 μM) enhanced the number of shoots (7 - 8 shoots) from the node (Fig. 1B) and emergence of shoot buds at the base of internodes which later differentiated into shoots in both liquid and solid MS medium. Shoot regeneration potential of IAA has also been reported by Tejavathi and Shailaja (1999) in *Bacopa monneria* with stem and flower buds as explants.

Proliferation of shoot buds and elongation growth of shoots was comparatively higher in the liquid medium than agar-solidified medium. In the liquid medium regeneration response was uniform; a higher biomass with eight shoots from the nodal explants was recorded compared to that in the solid medium with five shoots (Table 1). Further, increase in shoot length was faster in the liquid medium, 5 - 6 cm within 15 - 18 days than that observed in the solid medium (20 - 25 days). This might be due to better uptake of nutrients as large surface areas of explants were in contact with the liquid medium, thereby increasing the growth and multiplication. Furthermore, the liquid medium helps in maintaining O_2 : CO_2 balance (Biondi and Thorpe 1981). The slow growth and fewer shoots on agar solidified medium might be partly due to: (a) the specific habitat needs of this medicinal plant species, (b) a lower diffusion rate of molecules passing through the medium to the regenerant, (c) growth inhibition by an undefined agar-borne inhibitor and (d) reduced availability of water to tissues growing on agar solidified medium (Stevenson and Haris 1980; Kohlenbach and Wernicke 1978; Stoltz 1971). Earlier, suitability of the liquid medium for this plant species has been reported (Shrivastava et al. 1999; Tewari et al. 2000).

Performance of the nodal explants with reference to their position on *in vitro* developed shoots was evaluated in optimal liquid medium. It was observed that

upper nodes (2 - 3) were slower in growth, while lower nodes (4 - 7) were found to be more promising and resulted in multiplication of greater number of shoots (8 shoots). Shoot tip explants were also used; however proliferation response was found to be poor with only a single shoot.

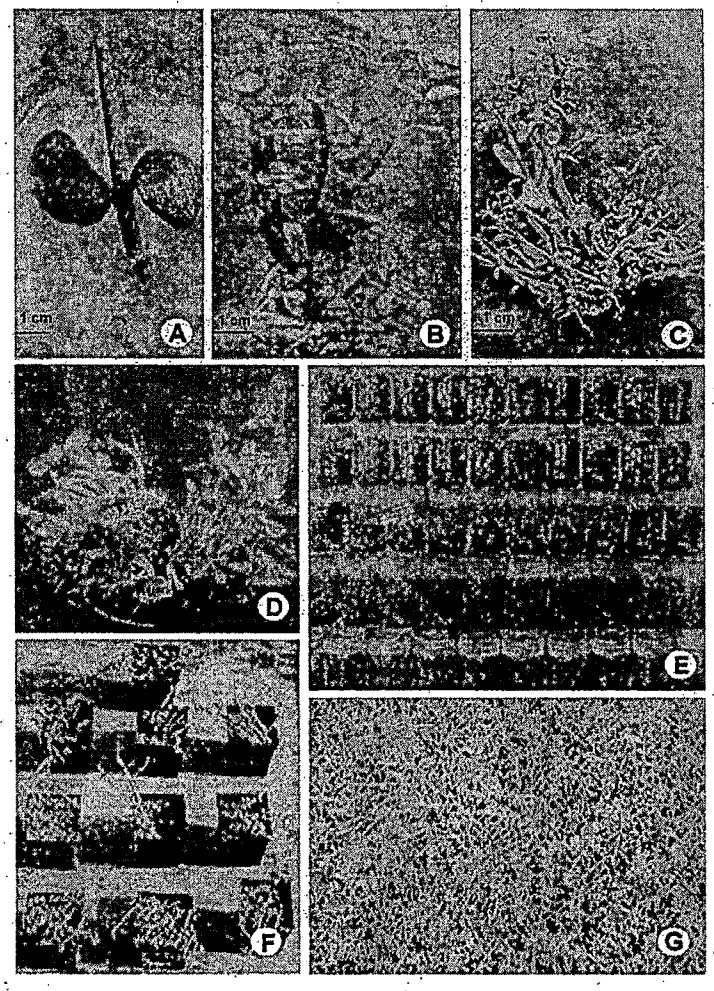


Fig. 1. A. Bud break from nodal explants of *Bacopa monnieri*. B. Multiple shoot formation from nodal explants on MS containing BA (1.1 μM) and IAA (0.2 μM). C. Large number of shoot formation on the internode explants on MS containing BA (1.1μM) and IAA (0.2 μM). D. Multiple shoot regeneration from the leaf surface on optimal medium. E. Shoot regeneration from all the explants during third subculture. F. Hardened regenerated plants maintained in net-house and ready for transplantation. G. A large population of acclimated plants growing in open field (Horizontal bar in the figures indicate increase/decrease in magnification of 1 cm).

The internode explants, when cultured on the optimal solid medium, yielded a large number of shoot (28) regenerants within a period of two and a

half weeks (Fig. 1C). This is in agreement with the results reported by Tiwari et al. (1998) with (23) shoots on a higher concentration of BA (4.4 µM). In contrast, Shrotri and Mukundan (2004) observed fewer shoots (8) from internode explants on a higher concentration of BA (4.44 µM) and IAA (5.71 µM), while Mathur and Kumar (1998) recorded 15 shoots from internode explants after a six-week incubation period but without any growth hormone supplement.

Table 1. Effect of different combinations of BA and IAA in MS medium on shoot formation through nodal explants of *B. monnieri* and % survival rate in the field.

Concentrations (µM)		Number of shoots/explant*	Response (%)	Shoot length (cm)*	Field survival (%)
BA	IAA	Agar based solid medium			
0.0	0.0	3.5 ± 0.26	75	3.1± 0.06	80
0.5	0.2	3.2 ± 2.43	84	2.1 ± 0.29	91
1.1	**0.2**	**6.9 ± 1.15**	**100**	**5.4 ± 0.14**	**100**
2.2	0.2	4.1± 1.20	95	4.1 ± 0.21	98
4.4	0.2	3.1± 0.26	95	3.2± 1.3	98
		Liquid medium (stationary)			
0.0	0.0	1.1± 0.3	76	2.1± 0.6	
0.5	0.2	1.1 ± 0.23	91	3.2 ± 0.32	100
1.1	**0.2**	**7.8 ± 1.13**	**100**	**5.6 ± 1.19**	**100**
2.2	0.2	3.9 ± 0.12	100	3.5 ± 0.12	100
4.4	0.2	3.4 ± 0.43	97	2.1 ± 0.35	100

*Values are mean ± standard error of three replicates with ten cultures per replicate; data scored after three weeks.

Table 2. Effect of different combinations of BA and IAA on direct organogenesis from leaf explants and % survival in the field.

Concentrations (µM)		Number of shoots/explant*	Shoot length (cm)*	Response (%)	Field survival (%)
BA	IAA				
0.0	0.0	1.2 ± 0.45	0.5 ± 1.4	55	64
0.5	0.1	5.4 ± 0.69	2.1 ± 0.22	67	69
0.5	0.2	25 ± 1.32	2.2 ± 0.61	74	81
1.1	**0.2**	**110 ± 2.31**	**3.2 ± 0.25**	**100**	**98**
2.2	0.2	35 ± 0.12	2.9 ± 0.24	**86**	92

*Values are mean ± standard error of three replicates with ten cultures per replicate; data scored after three weeks.

A large number of shoot buds were also observed on *in vitro* leaf explants on liquid and agar based MS media with BA (1.1 µM) and IAA (0.2 µM) without the intervention of callus. Shoot buds that developed on the leaf did not correlate to somatic embryos. Shoot bud proliferation was observed initially from the base which subsequently extended all over the surface. The results are in agreement

with those reported earlier (Mathur and Kumar 1998). A maximum of 110 shoots was observed (Fig. 1D) within three weeks of incubation in the first sub-cycle (Table 2).

Research is said to be more successful if it is cost effective. The number of shoots per subculture and media quantity per subculture was standardized from the commercial point of view. Within a period of three subcultures, the number of shoots at each subculture generated from young leaves, axillary nodes and internodes were: 12100, 49, 784 shoots, respectively (Fig. E). The system demonstrated a continuous supply of shoots up to ten cycles without any decline in their

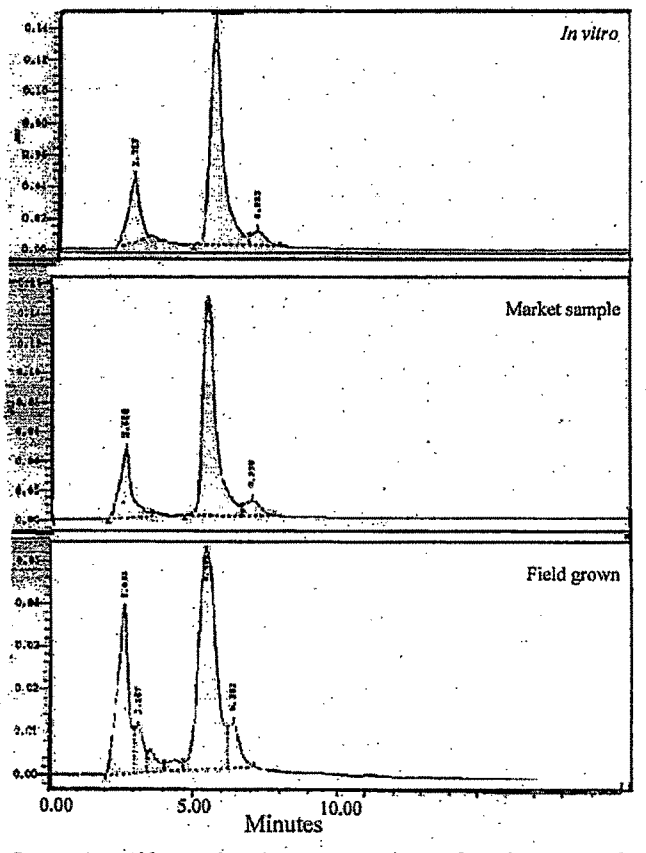


Fig. 2. Separation of bacoside - A present in the methanol extracts of *Bacopa monnieri* by HPLC using mobile phase MeOH-Water (80 : 20) of *in vitro* generated plants, market sample and field-grown plants.

number in subsequent subcultures. Subcultures were performed frequently (3 weeks), as delayed subcultures (more than four weeks) in the liquid medium were found to cause vitrification of shoots similar to that observed in the tissue-

culture-raised carnation plantlets (Ziv et al. 1983). Furthermore, 20 ml of basal media for leaf and 40 ml liquid media for nodal and internode explants with ten explants were found to be optimal.

Well-grown shoots (3 - 4 cm) were isolated and transferred to the basal and the optimal medium for root induction. Root induction was found to be better in the optimal medium as compared to the basal medium. The approximately 5 - 6 cm long shoots with 3 - 4 cm roots were transferred to trays containing sand, soil and farmyard manure in the ratio of 1 : 1 : 1 and kept under shade for hardening. All plants regenerated from different explants were hardened directly in the net-house skipping the greenhouse stage. Initially high humidity was maintained by five sprays of water a day at 5 - 6 h interval. The plantlets so hardened for two weeks in net-house (Fig. 1F) were subsequently transferred to open beds (Fig. 1G) with 100 and 98% survival rate for node/internode and leaf based explants, respectively. No morphological variation of any nature was observed among the *in vitro* raised plants when compared with the mother stock.

For HPLC, different solvent strengths of mobile phase were used; a mixture of methanol and water in the proportion of 80 : 20 was found to be suitable for the separation of bacoside A in *Bacopa monnieri* plant extract. A matching profile of representative chromatograms of *in vitro* generated plants, market sample and field-grown plants of *Bacopa monnieri* was observed (Fig. 2).

We report high level of shoot bud regeneration from various explants with continuous proliferation and elongation of shoot buds and root induction on MS medium supplemented with 1.1 µM BA and 0.2 µM IAA. Thus, a commercially viable protocol has been established for mass micropropagation of Medhya Rasayana - *Bacopa monnieri*. The procedure described here will go a long way to meeting on one hand the ever-increasing demands of the pharmaceutical industries and on the other save this species from extinction.

References

Bhattacharya SK and Ghosal S (1998) Anxiolytic activity of a standardized extracts of *Bacopa monniera* - An experimental study. Phytomed. 5: 77-82.

Biondi S and Thorpe TA (1981) Requirement for a tissue culture facility. *In:* Plant Tissue Culture: Methods and Applications in Agriculture, TA Thorpe Academic Press (Eds), New York, USA, pp. 1-20.

Chand S, Sahrawat AK and Prakash DVSSR (1997) *In vitro* culture of *Pimpinella anisum* L. (Anise) J. Pl. Biochem. Biotech. 6: 1-5.

Clog E, Bass P and Walter B (1990) Plant regeneration by organogenesis in *Vitis* root stock species. Pl. Cell Rep. 8: 726-728.

Elangovan V, Govindasamy S, Ramamoorthy N and Balasubramanian K (1995) *In vitro* studies on the anticancer activity of *Bacopa monnieri*. Fitoterapia 66: 211-215.

Jain P, Khanna NK, Trehan N, Pendse VK and **Godhwani JL** (1994) Anti-inflammatory effects of an Ayurvedic preparation, Brahmi Rasayana, in rodents. Ind. J. Exp. Biol. 32: 633-636.

Jasrai YT, Kannan VR and **George MM** (1999) *Ex vitro* survival of *in vitro* derived banana plants without greenhouse facilities. Plant Tissue Cult. 9: 127-132.

Kohlenbach HW and **Wernicke** (1978) Investigation as the inhibitory effect of agar and the function of active carbon in anther culture. Z. Pflanenphysiol. 86: 463-472.

Mahato SB, Garai S and **Chakravarty AK** (2000) Bacosaponins E and F: two jujubogenin bisdesmosides from *Bacopa monniera*. Phytochem. 53: 711-714.

Mathur S and **Kumar S** (1998) Phytohormone self sufficiency for regeneration in the leaf and stem explants of *Bacopa monnieri*. J. Med. Arom. Plan. Sci. 20: 1056-1059.

'O' Neill M and Lewis A (1993) Human medicinal agents from plants. *In*: Kinghorn AD Balandrin MF, ACS Sysmposium Series 534, Washington, DC. pp. 48.

Rastogi S, Mehrotra BN and **Kulshreshtha DK** (1994) Proceedings of IV International Congress of Ethnobiology. Deep Publications, New Delhi, pp. 93.

Satyavati GV, Raina MK and **Sharma M** (1976) Indian medicinal plants. Vol. 1 Indian Council of Medical Research, New Delhi, pp. 20-35.

Shrivastava N and **Rajni M** (1999) Multiple shoot regeneration and tissue culture studies on *Bacopa monnieri* (L.) Pennell Pl. Cell Rep. 18: 919-923.

Shrotri M and **Mukundan U** (2004) *In vitro* studies of some economically important plants. Ph.D. Thesis, Mumbai University, Mumbai, India.

Singh HK and **Dhawan BN** (1997) Neuropsychopharmacological effects of the Ayurvedic nootropic *Bacopa monniera* Linn. (Brahmi). Ind. J. Pharmacol. 29: 359-365.

Stamp JA, Colby SM and **Meredith CP** (1990) Direct shoot organogenesis and plant regeneration from leaves of grape (*Vitis* sp.) Pl. Cell Tiss. Org. Cult. 22: 127-133.

Stevenson JH and **Harris RE** (1980) *In vitro* plantlet formation from shoot tips of *Fuchsia hybrida* cv *swingtime*. Can. J. Bot. 58: 2190-2192.

Stoltz LP (1971) Agar restriction of the growth of excised mature Tris embryos. J. Amer. Soc. Hortic. Sci. 96: 681-684.

Tejavathi DH and **Shailaja KS** (1999) Regeneration of plants from the cultures of *Bacopa monnieri* (L.) Pennell. Phytomorph. 49: 447-452.

Tiwari V, Singh BR and **Tiwari KN** (1998) Shoot regeneration and somatic embryogenesis from different explants of Brahmi (*Bacopa monniera* L. Wettst). Pl. Cell Rep. 17: 538-543.

Tiwari V, Tiwari KN and **Singh BR** (2000) Suitability of liquid cultures for *in vitro* multiplication of *Bacopa monniera* (L.) WETTST. Phytomorph. 50: 337-342.

Tripathi YB, Chaurasia S. Tripathi E, Upadhaya A and **Dubey GP** (1996) *Bacopa Monniera* Linn as an antioxidant: mechanism of action. Ind. J. Exp. Biol. 34: 521-526.

Vohora SB, Khanna T, Athar M and **Ahmad B** (1997) Anagelesic activity of bacosine, a new tritepene isolated from *Bacopa monniera*. Fitoterapia 68: 361-365.

Ziv M, Meir G and **Halvey AH** (1983) Factors influencing the production of hardened glaucous carnation plantlets *in vitro*. Pl. Cell Tiss. Org. Cult. 2: 55-65.

Plant Tissue Cult. & Biotech. 16(2): 77-84, 2006 (December)

PTC&B

A Valued Medicinal Plant - Chitrak (*Plumbago zeylanica* Linn.) : Successful Plant Regeneration Through Various Explants and Field Performance

Binita B. Chaplot, Ashok M. Dave and Yogesh T. Jasrai[1*]

Agribiotechnology Laboratory, GSFC Science Foundation, Vigyan Bhavan, Fertilizernagar- 391750, Vadodara, Gujarat, India

Key words: Medicinal plant, Regeneration, Field performance

Abstract

Protocols for plant propagation through axillary bud proliferation and organogenesis were established for Chitrak - *Plumbago zeylanica* Linn. (Plumbaginaceae). MS medium with 4.4 mg/l BA and 1.4 mg/l IAA elicited the maximum number of shoots (12 multiple shoots) from nodal explants. Leaf based callus differentiated into more than 30 shoots on MS with 160 mg/l adenine sulphate. The regenerated shoots were rooted on MS with 1.2 mg/l IBA within ten days. Almost, 96% of the rooted shoots survived hardening when transferred to the field. The regenerated plants did not show any morphological change and variation in levels of secondary metabolite when compared with the mother stock.

Introduction

Plumbago zeylanica Linn. (Chitrak) belongs to Plumbaginaceace. It is an important medicinal plant. It is grown as a perennial herb in most parts of India, but on larger scale in the plains of West Bengal and Southern India. The roots of *P. zeylanica*, *P. rosea* and *P. europaea* have been used extensively in China and other Asian countries for the treatment of cancer, rheumatoid arthritis, dysmenorrhea, and contusion of extremities (Atta-ur-Rahman 1988). Extracts of the root, when given internally or applied to the ostium uteri, causes abortion (Premakumari et al. 1977, Bharghava 1984). The root is pungent, diuretic, germicidal, astringent, vesicant. The roots contain an alkaloid - plumbagin, a natural napthaquinone, possessing various pharmacological activities such as antimalarial, antimicrobial (Didry et al. 1994), anticancer, cardiotonic, antifertility action, antibiotic and

*Author for correspondence and present address: Department of Botany, School of Sciences, Gujarat University, Ahmedabad-388009, India; e-mail: yjasrai@yahoo.com
[1]Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara - 390002, Gujarat, India.

antineoplastic (Kirtikar and Basu 1975; Modi 1961, Krishnaswamy and Purushottamam 1980, Pillai et al. 1981). More than 32 patents involving plumbagin were obtained in the United States and many of these patents involve polymer scale prevention agents (US Patent and Trademark Office 1999). The root stimulates the secretion of sweat urine and bile and has a stimulant action on the nervous system. Roots are specially used in the treatment of rheumatism, skin disease, diarrhoea, piles, anasarca, ulcers, syphilis and carcinoma. It is also used as an appetizer. Milky juice is used as application in scabies and unhealthily ulcers. Its paste is applied externally in leprosy. Coconut oil is processed with the root to a straw yellow colour and is used as a hair tonic, which stimulates hair growth.

Propagation through seed is unreliable due to poor seed quality, erratic germination and seedling mortality as under natural field conditions. Due to the presence of natural nathaquinone, *P. zeylanica* is much sought after in western countries as *Chlorophytum borivilianum* for saponin content (Chaplot et al. 2005). Extensive and destructive harvesting of plants by the pharmaceutical industries for procurement of naturally occurring secondary metabolites (Plumbagin) from the plant and insufficient attempts to either allow its replenishment or its cultivation have led to the depletion of the natural plant population. Very few reports on cultivation, breeding and improvement programmes and *in vitro* studies of *P. zeylanica* are available despite its commercial importance. This paper deals with the standardization of a technique for micropropagation through multiple shoot formation. The protocol provides early bud-break with high frequency of shoot multiplication from axillary bud and leaf explants with comparatively a reduced requirement of plant growth hormones and successful acclimatization of plants in the soil. The performance of regenerated plants was also evaluated in the field.

Materials and Methods

The nodal explants and leaves of *P. zeylanica* from one-year-old plants were collected from the Botanical Garden of the Maharaja Sayajirao University of Baroda. They were washed first under running tap water (30 min) and treated with 0.2 % (v/v) aqueous surfactant Teepol (BDH, India) for 10 min followed by repeated rinsing with distilled water. Subsequently, explants were treated (20 min) with 0.1 % (w/v) carbendenzim (BASF, India). Further sterilization was done under aseptic conditions in a Laminar Airflow Hood (Lab Services, India). Explants were surface sterilized with 50 % (v/v) ethanol (1 min) and followed by 0.07 % (w/v) $HgCl_2$ (3 min). Finally, the explants were washed thoroughly (three - five times) with sterilized distilled water. The nodal explants were cut into appropriate size (0.8 cm) and young leaf lamina with mid rib (0.7 cm) was cut and cultured on MS medium.

Throughout the experiments full strength MS with 3 % (w/v) sucrose and gelled with 0.8 % (w/v) agar (Qualigens, India) was used. The pH of all media was adjusted to 5.8 prior to autoclaving (15 min). The cultures were incubated in a culture room with 25 ± 1°C and 16 hr photoperiod (50 $\mu E/m^2/s$) provided by cool white fluorescent tubes (Phillips, India).

The basal medium was supplemented with BA (0.0 - 8.8 mg/l) and IAA (0.0 - 2.88 mg/l) at different concentrations, either alone or in combinations. Initiation of callus formation from the base of leaf lamina was observed on MS supplemented with BA, IAA and AdS. Root induction on shoots was achieved on full strength MS with IAA/IBA at different concentrations. Well developed rooted shoots were removed from the culture vessels, washed gently under running tap water and planted in plastic bags containing a potting mixture of sand, soil and farmyard manure in the ratio of 1 : 1 : 1. The plantlets were kept in the net house for acclimation (two - three weeks) before their subsequent transfer to the field. Humidity was maintained by sprinkling water regularly throughout the day (Jasrai et al. 1999). Plants were gradually exposed to the normal conditions and transferred to the Medicinal Garden of GSFC Science Foundation.

The experiments were set up in a completely randomized design. Ten cultures were raised for each treatment and all experiments were repeated thrice. Qualitative analysis was carried out through thin layer chromatography. The shade-dried roots of *in vitro* raised plants and mother plants were crushed into powder form and were subjected to phytochemical analysis (Harborne 1964).

Results and Discussion

Bud break on the nodal segments was achieved on MS with 6.7 mg/l BA and 1.4 mg/l IAA (Fig. 1A). When MS supplemented with different concentrations of BA and IAA was used, multiple shoots emerged from the nodal explants within two weeks of incubation (Fig. 1B). Among different concentrations of growth hormones tested, 4.4 mg/l BA and 1.4 mg/l IAA elicited the maximum number of shoots (12 multiple shoots) from nodal explants (Table 1). Direct shoot regeneration from nodal explants have been reported earlier (Selvakumar et al. 2001) on MS medium with 27.2 mg/l AdS + 2.46 mg/l IBA. Similarly, Verma et al. (2002) reported rapid propagation of *P. zeylanica* with maximum of four multiple shoots per nodal segment with 8.87 mg/l BA and 0.49 mg/l IBA. The present study exemplifies a positive modification of shoot induction efficacy on MS with low concentrations of auxin and cytokinin. Excision and culture of the nodal segments from *in vitro* derived shoots facilitated the development of increased number of shoots. The elongation of shoots (4 - 5 cm) was observed on the same proliferation medium within two weeks of incubation (Fig. 1D). On an average within three subcultures, single node explant generated 36 shoots in

presence of 4.4 mg/l BA and 1.44 mg/l IAA. The shoot multiplication at this enhanced pace was also achieved in subsequent cultures up to six - eight cycles (Data not presented).

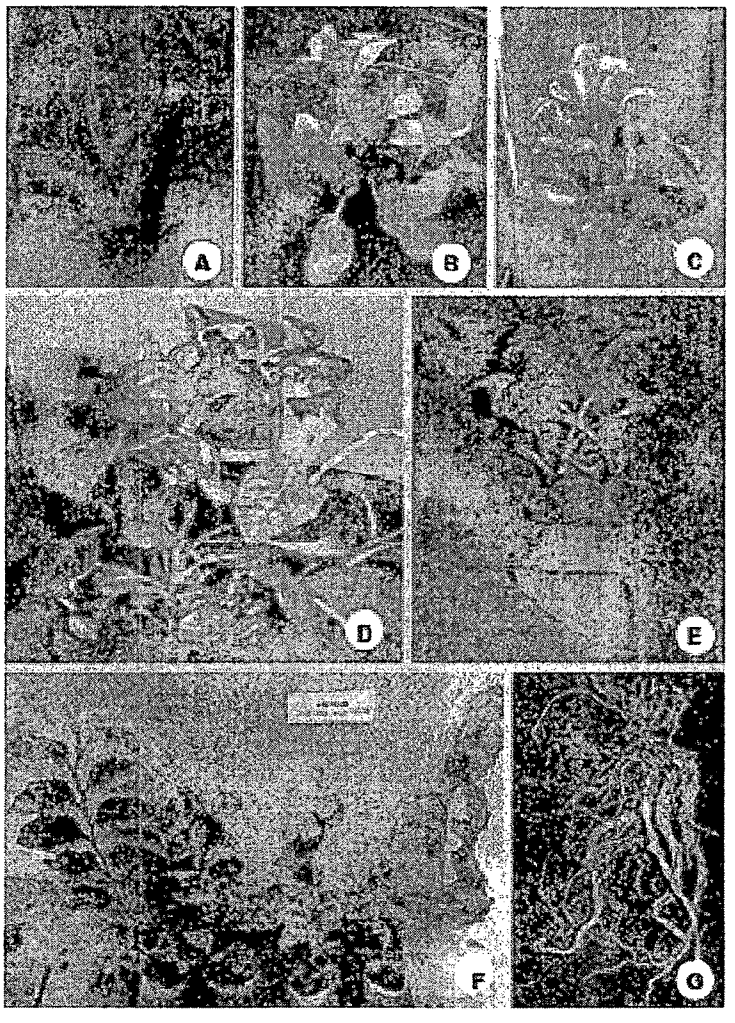


Fig. 1. Micropropagation through axillary bud proliferation and leaf callus of *P. zeylanica*. (A) Bud break from nodal explants of *P. zeylanica*. (B) Multiple shoots formation on MS containing BA (4.4 mg/l) and IAA (1.4 mg/l). (C) Shoot formation from callus on MS with BA (4.4 mg/l), IAA (1.4 mg/l) and AdS (160 mg/l). (D) Elongation growth of shoots. (E) Induction of roots on regenerated shoots on MS containing IBA (1.2 mg/l). (F) Hardened plants ready for transplantation to field in potting mixture in sand, soil and FYM in the ratio of 1:1:1. (G) The harvested roots of *in vitro* raised plants in the process of drying.

Callus initiation was observed from young leaves on MS medium supplemented with BA (0.0 - 8.8 mg/l), IAA (0.0 - 2.88 mg/l) and AdS (160 mg/l). Callus formation from the leaf explants of *P. zeylanica* is in agreement with results obtained by Rout et al. (1999) in the same species however varied in hormonal combinations. Best callus (nodular) formation was observed on MS medium containing 6.7 mg/l BA, 1.42 mg/l IAA and 160 mg/l AdS.

Table 1. Effect of different combinations of BA and IAA in MS on shoot formation through nodal explants of *P. zeylanica*.

Concentrations (mg/l)		Response (%)	Number of shoots/node* (Mean ± SD)
BA	IAA		
0.0	0.0	0.0	0.0
2.2	0.5	10	1.5 ± 0.26
4.4	0.5	45	4.5 ± 0.16
4.4	**1.4**	**85**	**12.1 ± 1.34**
4.4	2.8	69	5.5 ± 0.21
6.7	1.4	58	4.8 ± 2.26
8.8	1.4	55	4.1 ± 1.20

*Values are of three repetitions; ten cultures per replicate; scored after three weeks.

Leaf callus developed on MS with 6.7 mg/l BA, 1.42 mg/l IAA and 160 mg/l AdS underwent organogenesis (Fig. 1C) after three weeks of incubation onto various regeneration media containing different concentrations of BA, IAA and AdS. The highest number of shoots from the leaf callus was observed on MS with 4.4 mg/l BA, 1.42 mg/l IAA and 160 mg/l AdS (Table 2). On an average 30 shoots were recorded in callus cultures through organogenesis. Subsequent

Table 2. Effect of different combinations of growth regulators in MS with 160 mg/l AdS on shoot bud regeneration from leaf callus of *P. zeylanica*.

Concentration (μM)		Response (%)	Number of shoots/culture* (Mean ± SD)
BA	IAA		
0.0	0.0	-	-
2.2	1.4	-	-
2.2	2.8	25	2.08 ± 1.75
4.4	1.4	93	30.16 ± 1.43
4.4	2.8	85	22.02 ± 1.02
6.7	1.4	75	15.09 ± 1.02
6.7	2.8	67	9.54 ± 1.12
8.8	1.4	60	6.36 ± 1.43

*Values are of three replicates; ten cultures per replicate; scored after three weeks.

subcultures (up to six cycles) of organogenic callus resulted in an extensive proliferation and an enhanced rate of caulogenesis with more than 35 shoots.

Present results are consistent with the earlier report on Ashwagandha indicating that cytokinin and auxin influenced shoot bud regeneration (Verdia et al. 2006).

Well-developed shoots (4 - 5 cm with three nodes) generated through axillary bud proliferation and leaf callus were excised and cultured on MS medium with different concentrations of auxins for root induction. Root induction was found to be more prominent in the medium containing IAA (0.57 mg/l) and IBA (1.2 mg/l) alone. Roots elongated up to 12 - 13 cm within 15 days of incubation period (Fig. 1E). Earlier workers (Rout et al. 1999, Selvakumar et al. 2001, Verma et al. 2002) had reported smaller number of roots (4 - 5 roots) on half strength MS containing 0.57 mg/l IAA, 4.92 mg/l IBA and 0.49 mg/l IBA respectively. While profuse rooting was observed on full strength MS supplemented with IAA and IBA alone (Table 3), the best result (15 roots) was obtained on MS with IBA (1.2 mg/l) within 10 days.

Table 3. Effect of different auxins in MS medium on root induction from generated shoots.

Concentration (μM)		Number of roots/shoot* (Mean ± SD)	Root length (cm)
IAA	0.0		
	0.57	12.54 ± 1.12	10.2 ± 0.45
	1.42	6.36 ± 1.43	5.36 ± 0.28
IBA	0.0	-	-
	0.49	3.9 ± 0.25	5.05 ± 0.02
	1.2	15.04 ± 1.12	13.41 ± 0.25
	2.46	8.36 ± 1.43	6.12 ± 0.45

*Values are of three replicates; ten cultures per replicate; scored after two weeks.

The potency of IBA in root induction has been reported in many species (Epstein et al. 1993). The slow movement and slow degradation of IBA facilitates its localization near the site of application and thus functions better in inducing roots (Nickell 1982). Maximum frequency (97 %), number of roots/shoot (around 15) and mean root length (13.41 cm) was achieved within ten days when shoots were cultured on MS with IBA.

The ultimate success of *in vitro* propagation lies in successful establishment of plants in the soil. Normally, in absence of greenhouse facilities *in vitro* plantlets loose tremendous amount of water through leaf surfaces with poorly deposited cuticular wax and poorly developed or non-active stomatal system (Wardley et al. 1983). This problem was taken care of by regular sprinkling of water and irrigating the regenerated plantlets twice a day. The rooted shoots demonstrated 100 % survival rate in the net house (Fig. 1F). However, a 96 % transplantation success of *in vitro* hardened plantlets in the field (Table 1) was

observed in comparison to the 65 - 90 % survival of plantlets recorded in the experiments of previous workers (Rout 2002, Selvakumar et al. 2001). The high survival rate of *in vitro* plants of *P. zeylanica* in present studies indicates that this procedure could be easily adopted for large-scale multiplication and cultivation. The *in vitro* propagated plantlets resembled the general growth and morphological characteristics of the donor plants.

The *in vitro* raised- and seed grown plants were uprooted from the field (Fig. 1G) for root harvesting. A significantly higher number of roots (19.0 ± 0.6) per plant were observed compared to the seed generated stock with roots (5.1 ± 1.4). There were a threefold increase in root biomass on fresh weight basis of *in vitro* roots (153.1 ± 2.4 gm) in comparison with seed generated plants (47.3 ± 0.2 g). Similar observations have been reported by Roja and Heble (1996) for *in vitro* generated plants of *Rauwolfia serpentina* with thick root stumps and fresh weight (60.56) compared to long slender root and fresh weight (11.92) per plant in conventionally grown counterparts. Present results are in agreement with earlier report by Satheesh Kumar and Bhavanandan (1988) who obtained a higher number of roots (18.0 ± 0.5) and fresh weight (137.4 ± 3.4 gm) in *in vitro* raised *Plumbago rosea* as compared to what were observed in rooted cuttings (14.0 ± 1.7; 47.9 ± 1.6 g), respectively. Further qualitative analysis through thin layer chromatography, emulated the presence of plumbagin (Yellow spots) on the silica gel plate with R_f 0.76 on mobile phase - petroleum ether: ethylacetate (7 : 3) in both *in vitro* generated and seed-grown plants.

Thus, a reproducible protocol for *P. zeylanica* was established through nodal and leaf explants. This protocol can be exploited for conservation and commercial propagation of this medicinal plant in the Indian subcontinent.

References

Atta-ur-Rahman (1988) Studies in Natural Products Chemistry, Elsevier, Amsterdam, The Netherlands.

Bharghava SK (1984) Effects of plumbagin on reproductive function of male dog, Ind. J. Exp. Biol. **22** : 153-156.

Chaplot BB, Vadawale AV, Jhala JM and **Barve DM** (2005) Clonal Propagation of Value Added Medicinal Plant - Safed Moosli (*Chlorophytum borivilianum*), *In:* Recent Progress in Medicinal Plants, Govil JN and Singh VK (Eds.), Studium Press, LLC : Texas, USA, pg. 383-388.

Didry N, Dubrevil L and **Pinkas M** (1994) Activity of anthraquinonic and naphthoquinonic compounds on oral bacteria, Die Pharmazie **49** : 681-683.

Epstein E, Sagee O and **Zahir A** (1993) Uptake and metabolism of indole-3 acetic acid and indole-3 butyric acid by *Petunia* cell suspension culture. Plant Growth Regul. **13**: 31-40.

Harborne JB (1964) Biochemistry of Phenolic Compounds, Academic Press, London and New York.

Jasrai YT, Kannan VR and **George MM** (1999) *Ex vitro* survival of *in vitro* derived banana plants without greenhouse facilities. Plant Tissue Cult. **9** : 127-132.

Kannan VR and **Jasrai YT** (1998) Micropropagation of medicinal plant *Vitex negundo*, J. Med. Arom. Pl. Sci. **20** : 693-696.

Kiritkar KR and **Basu BD** (1975) Indian Medicinal Plants, Indological and Oriental Publishers, Delhi, India.

Krishnaswamy M and **Purushottamam KK** (1980) Plumbagin, a study of its anticancer, antibacterial and antifungal properties, Ind. J. Exp. Biol. **18** : 876-877.

Modi J (1961) Textbook of Medicinal Jurisprudence and toxicology, Pripati Pvt. Ltd.: Bombay, India.

Nickell GL (1982) Encyclopaedia of Chemical Technology, Wiley, New York, USA.

Pillai NGK, Menon TV, Pillai GB, Rajasekharan S and **Nair CRR** (1981) Effect of plumbagin in Charmakeela (common warts) a case report. J. Res. Ayur. Sidha **2** : 12-126.

Premakumari P, Rathinam K and **Santhakumari G** (1977) Antifertility activity of plumbagin. Ind. J. Med. Res. **65** : 829-838.

Roja G and **Heble MR** (1996) Indole alkaloids in clonal propagules of *Rauwolfia serpentina* benthe ex kurz. Pl. Cell Tiss. Org. Cult. **44** : 111-115.

Rout GR (2002) Direct plant regeneration from leaf explants of *Plumbago* species and its genetic fidelity through RAPD markers. Ann. Appli.Biol.**140** : 305-313.

Rout GR, Saxena C, Das P and **Samantaray S** (1999) Rapid clonal propagation of *Plumbago zeylanica* Linn. Plant Growth Regul. **28** : 1-4.

Rout GR, Saxena C, Samantaray S and **Das P** (1999) Rapid plant regeneration from callus cultures of *Plumbago zeylanica* Pl. Cell Tiss.Org. Cult. **56** : 47-51.

Satheesh Kumar K and **Bhavanandan KV** (1988) Micropropagation of *Plumbago rosea* Linn. Plant Cell Tiss. Org. Cult. **15** : 275- 278.

Selvakumar V, Anbudurai PR and **Balakumar T** (2001) *In vitro* propagation of the medicinal plant *Plumbago zeylanica* L. through nodal explants. In Vit. Cell. Dev. Biol. **37** : 280-284.

US Patent and **Trademark Office** (1999) [http://www.uspto.gov/patft/index.html] 23 March 2002.

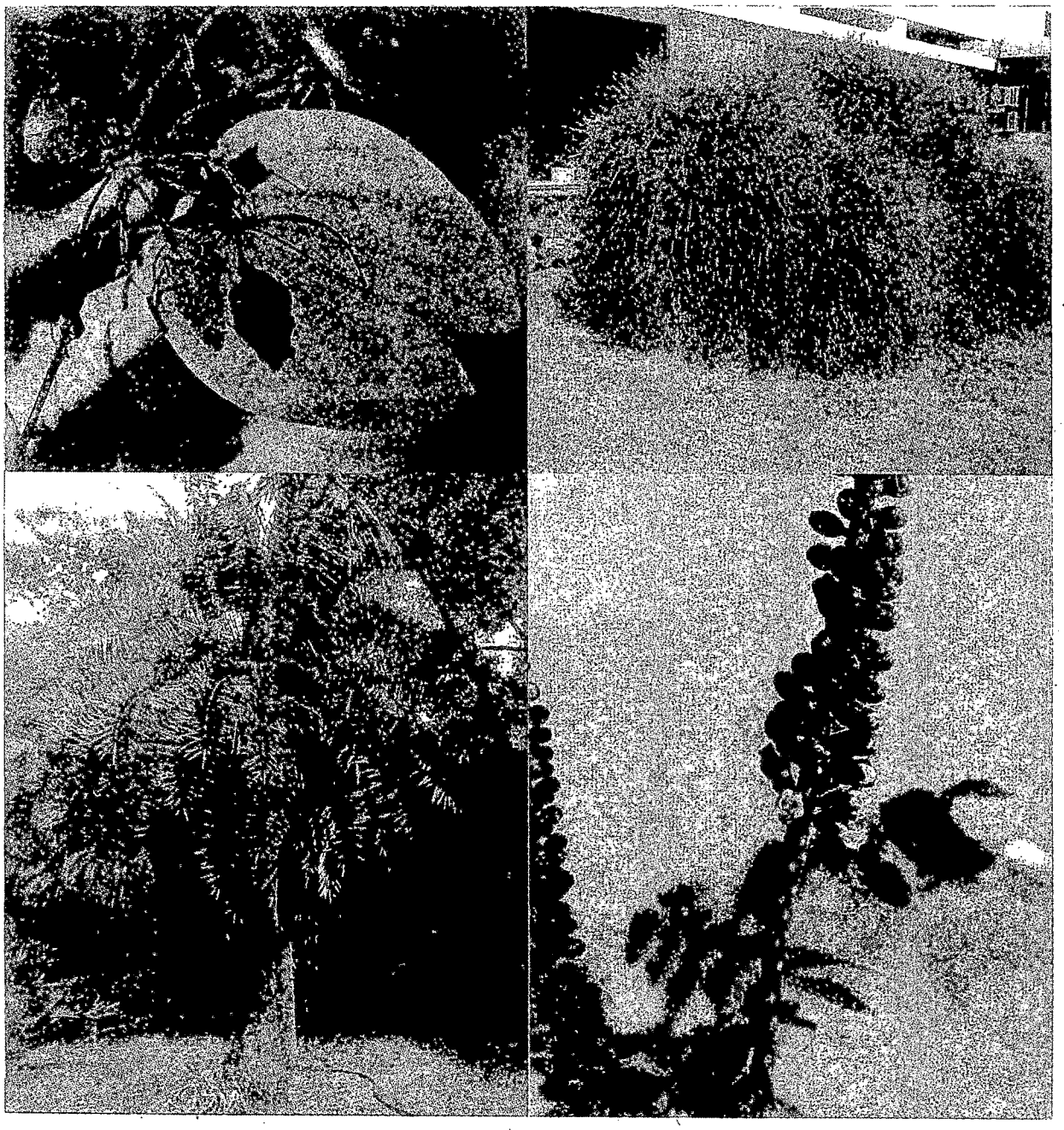
Verdia BG, Dave AM and **Jasrai YT** (2006) *In vitro* rapid propagation of *Withania somnifera* (Indian ginseng), a high valued medicinal plant through axillary bud proliferation and internodal callus (under publication).

Verma PC, Singh D, Rahman L, Gupta MM and **Banerjee S** (2002) *In vitro* studies in *Plumbago zeylanica*: rapid micropropagation and establishment of higher plumbagin yielding hairy root cultures. J. Pl. Physiol. **159** : 547-552.

Wardley K, Dobbs EB and **Short KC** (1983) *In vitro* acclimatization of aseptically cultured plantlets to humidity. J.Amer. Soc. Hort. **108** : 386-389.

National Seminar
on
Herbal Technology

28-29th January 2005



SOUVENIR CUM ABSTRACTS

Department of Botany
Faculty of Science
The Maharaja Sayajirao University of Baroda
Vadodara 390 002, Gujarat

09

Technology for cloning of medicinal plants

B. B. Chaplot[1], Y. T. Jasrai[2] and A. M. Dave[1]

[1]GSFC Science Foundation, Vigyan Bhavan, Agribiotechnology Laboratory, Fertilizernagar, Vadodara 391750, Gujarat, India.

[2]Department of Botany, Faculty of Science, The M. S. University of Baroda, Vadodara 390002,

Medicinal plants are moving from fringe to mainstream use with a greater number of people seeking remedies and health approaches free from side effects caused by synthetic chemicals. The efficacy of many of drugs is fading because of the adultered, dried raw material profusely available in indigenous market. Due to this adulteration and altered efficacy, the faith in crude drug promotion has declined. The problem mainly is due insufficient availability of raw material, quality raw material, awareness of knowledge regarding storage of material and cost factor. Desire for quick returns by the pharmaceutical firms by not processing the herbal materials in proper way, is the major cause of decline of use of medicinal plants in India.

Further low seed set, poor seed viability, high dormancy and low percentage of seed germination are some of the problems in propagation of some medicinal plants. There are various technologies available for cloning of medicinal plants to above mention problems. Plant tissue culture plays a major role in this area. Techniques such as micropropagation, somatic embryogenesis, direct and indirect organogenesis, anther and pollen culture, meristem culture, genetic engineering and many more can provides us the quality planting material. Some of these techniques can also facilitate rapid and high frequency propagation of the valuable medicinal plant, which can be used to provide planting material for mass propagation and conservation to meet the pharmaceutical demand.

We have already developed the clonal propagation of various medicinal plants from commercial point of view for plants such as *Chlorophytum borivilianum, Plumbago zeylanica, Centella asiatica, Withania somnifera, Aloe vera and Bacopa monnieri.*

The experiments for biomass generation were also carried out for selected medicinal plants generated *in vitro* and *in vivo*. Plants selected were *Withania somnifera and Bacopa monnieri.* The fresh weight and dry weight with respect to days were taken into consideration.

Thus, cloning technology can provide the foundation stocks of planting material of elite genotypes for large-scale cultivation.

ગુજરાત રાજ્યમાં ઔષધિય પાકો અંગેની જાગૃતિ, જરૂરિયાત અને પ્રાપ્ત જથ્થા અંગેની મોજણી

૧. **વ્યક્તિગત માહિતિ :**

ખેડૂતનું નામ : _____

ઉંમર : _____ પુરુષ/સ્ત્રી : _____

સરનામું : _____

તાલુકો : _____ જિલ્લો : _____

પીનકોડ નં. : _____ ફોન નં. : _____

ઇ.મેઇલ : _____

૨. **શૈક્ષણિક લાયકાત :**

☐ અલ્પશિક્ષિત ☐ પ્રાથમિક શિક્ષણ ☐ કૃષિ વિષયક ડિપ્લોમા/ડિગ્રી

☐ સ્નાતક ☐ સ્નાતકોત્તર

કોઇ કૃષિ સંલગ્ન સંસ્થાના સભ્ય હો તો તેનું નામ : _____

(લાગુ પડતું હોય ત્યાં ✓ કરો)

૩. **વાવેતર :**

❋ **હાલમાં શેની ખેતી કરો છો ?**

☐ ધાન્ય પાકો ☐ શાકભાજી ☐ કઠોળ પાકો

☐ ઔષધિય પાકો ☐ તેલીબીયાં પાકો ☐ અન્ય

વિગતો લખો : _____

❋ **ખાતર નો ઉપયોગ :**

☐ રાસાયણિક ખાતર ☐ છાણીયું ખાતર ☐ બંને ☐ અન્ય

વિગતો લખો : _____

❋ **પિયત :**

☐ ધોરિયા પદ્ધતિ ☐ ટપક પદ્ધતિ ☐ ફુવારા પદ્ધતિ ☐ ચોમાસા આધારિત

૪. **જાગૃકતા :**

૧) વિશ્વ વ્યાપાર સંગઠન (WTO) અંગે કશું જાણો છો ? ☐ હા ☐ ના

જો હા, તો વિગત જણાવો. _____

૨) આઇ.પી.આર. એક્ટ (ઇન્ટેલેક્ચ્યુઅલ પ્રોપર્ટી રાઇટ એક્ટ) વિશે જાણો છે ? ☐ હા ☐ ના

જો હા, તો વિગત જણાવો. _____

૩) પી.વી.પી. (પ્લાન્ટ વેરાયટી પ્રોટેક્શન) એક્ટ વિશે જાણો છો ? ☐ હા ☐ ના

જો હા, તો વિગત જણાવો. _____

૪) પી.બી.આર. (પ્લાન્ટ બ્રીડર રાઇટ) એક્ટ વિશે કશું જાણો છો ? ☐ હા ☐ ના

જો હા, તો વિગત જણાવો. _____

૫) ઔષધિય પાકોનું વાવેતર કરો છો ? ☐ હા ☐ ના

ઔષધિય પાકોનું નામ	વિસ્તાર	બીજ/ધરૂ	બીજની જરૂરિયાત	સરેરાશ કિંમત/કિલો	ઉત્પાદકનું નામ અને સરનામું

૫. **વેચાણ :**

☐ બીજ ☐ ધરૂ ☐ ઔષધિય અર્ક

૬. **વેચાણ પદ્ધતિ :**

☐ સ્વયં વિપણન ☐ દલાલ મારફત ☐ વિક્રેતા મારફત ☐ અન્ય

૭. **ઔષધિય પાકો ન વાવવાના કારણો :**

☐ ઔષધિય પાકોની ખેતી પદ્ધતિ વિશે જાણકારી નથી.
☐ માહિતીનો સ્ત્રોત જાણતા નથી.
☐ વાવેતર કરવામાં મુશ્કેલીઓ પડે છે.
☐ જાણકારીની જરૂરિયાત.
☐ આ યોજના પોષણક્ષમ હોય તેવું લાગતું નથી.
☐ વેચાણ કરવાની મુશ્કેલી છે.
☐ આ ઉપરાંત અન્ય કોઇ કારણો.

_____

_____

૮. **કયા ઔષધિય પાકોની ખેતી કરવા રસ ધરાવો છો ?**

_____

_____

_____

૯. **જાણકારીની જરૂરિયાત :**

❁ ઔષધિય પાકોની ખેતી કરવા માટે જાણકારીની જરૂર છે ? ☐ હા ☐ ના

❁ જો સ્ત્રોત અને પુનઃખરીદીની યોજના હોય તો તમે ઔષધિય પાકોની ખેતી કરવા ઇચ્છો છો ? ☐ હા ☐ ના

❁ ઔષધિય પાકોની ખેતી માટે કોમ્પ્યુટર ઉપર વિશ્લેષણ આપી ઉપયોગમાં લીધું છે ? ☐ હા ☐ ના

❁ આઇ.પી.આર. અને પી.વી.પી. અંગે વધુ માહિતીઓ જોઇએ છે ? ☐ હા ☐ ના

૧૦. **તમારા ઔષધિય પાકોની ખેતી અંગેના અભિપ્રાયો :**

_____

_____

આ બધી જ માહિતીઓ ભરીને સાથે બીડેલ કવરમાં મૂકી તરત પરત કરવા વિનંતી.

તારીખ : _____ સહી : _____

ટીકિટ લગાડવી જરૂરી.

Assessing the Present & Future requirement & Promotion of Medicinal Plants for Ayurvedic and Pharmaceutical Companies for their cultivation

Department of Botany
Faculty of Science
Maharaja Sayajirao University of Baroda
Vadodara, Gujarat

Medicinal plants represent not only the valuable part of India's biodiversity but also the traditional knowledge. The latest thrust is on the use of natural products and in particular the medicinal plant as an alternate and safe system of medicine because of side effects of antibiotics and other synthetic drugs. Thus there is a spurt in the demand for these natural products. With availability of seeding material and known agronomic practices for some of the medicinal plants, have encouraged the small and marginal farmers of the State to undertake cultivation of medicinal plant.

We have undertaken a research work on ***Status Survey for Medicinal Plant in Our State ----- Gujarat.*** As a part of this research work, we would like to seek some data from your organization.

This survey would help in assessing the demand and supply of medicinal plants for future in Gujarat. Further depending on the requirement, specific plants can be cultivated on a large scale in the State. The data collected under the study are primarily intended for research purpose. Your data will be treated confidentially.

You may send the required information in the given format.

Prof. Y. T. Jasrai
Guide

Dr. A. M. Dave
Co-Guide

B. B. Chaplot
Research Student

Year of establishment: _____

Name of Pharmacy : _____

Address : _____

_____ Tel. No: _____

_____ Fax No.: _____

Email : _____

Authorized Person: _____ Designation: _____

Sr. No.	Botanical Plants	Vernacular Name	Used		Total Qty required annually	Appro Price Rs/Kg	Plac Age of proc eme
			Part	Extract			
1	*Abies Spectabilis*	Talispatra					
2	*Abroma augusta*	Ulat kambal					
3	*Abrus precatorius.*	Chanothi					
4	*Abutilon indicum*	Atibala					
5	*Acacia catechu*	Kher					
6	*Acacia concina*	Shikakai					
7	*Acacia nilotica*	Baval					
8	*Achyraanthus aspers*	Adhedo					
9	*Aconitum heterophyllum*	Ativish					
10	*Acorus calamus*	Safed bach					
11	*Adansonia digitata*	Gorakh amli					
12	*Adhatoda vasica*	Basak, Arusa,					
13	*Aegle marmelos*	Bilva					
14	*Agave americana*	Ketki					
15	*Ailanthus excelsa*	Arduso					
16	*Alangium salvifolium*	Ankol					
17	*Albizzia lebbeck*	Siris					
18	*Alhagi maurorum*	Javaso					
19	*Allium cepa*	Kanda					
20	*Allium sativum*	Lasan					
21	*Aloe vera*	Guvar pattu					
22	*Alstonia scholaris*	Sataparni					
23	*Amaranthus lividus*						
24	*Amomum subulatum*	Elcho					
25	*Amorphallus campanulatus*	Suran					
26	*Anacylus pyrethrum*	Akalkaro					
27	*Andrographis paniculatas*	Lilu kariyatu (kalmegh)					
28	*Annona squamosa*	Sitafal					
29	*Anogeissus latifolia*	Dhavdo					
30	*Apium graveolens*	Ajamo					
31	*Aquilaria agallocha*	Kala agar					
32	*Areca catechu*	Sopari					
33	*Argemone mexicana*	Darudi					
34	*Argyreia speciosa*	Samudrashosh					
35	*Aristolochia bracteolate*	Kidamari					
36	*Artocarpus integrifolia*						
37	*Asparagus racemosus*	Shatavar					
38	*Asteracantha longiifolia*	Akhro					
39	*Azadiracta indica*	Neem					
40	*Bacopa monnieri*	Brahmi					
41	*Baliospermum montanum*	Dantimool					
42	*Bambusa arundinacea*	Katris bans					

43	*Barleria sepiaria*	Kanta					
44	*Bauhina racemosa*	Asitro					
45	*Bauhina variegata*	Kachnar					
46	*Berberis aristata*	Daru-haldi					
47	*Bergenia ligulata*	Pashanbad					
48	*Boerhaavia diffusa*	Punarnava					
49	*Bombax ceiba*	Simlo					
50	*Boswelia serrata*	Saledo,					
51	*Brassica nigra*	Sarsav					
52	*Buchanania lanzan*	Charoli					
53	*Butea monosperma*	Keshudo					
54	*Callicarpa macrophylla*	Priyanguful					
55	*Calotropis gigantean*	Akado					
56	*Calotropis procera*	Akada, Rato					
57	*Cannabis sativa*	Bhang					
58	*Capparis sepiaria*	Kanthar					
59	*Careya arborea*	Kumbhi					
60	*Carica papaya*	Papaiya					
61	*Carum carvi*	Shahjiru					
62	*Carum copticum*	Ajmod					
63	*Carum roxburghii*	Bodi ajmod					
64	*Casearia esculenta*	Saptarangi					
65	*Cassia angustifolia*	Senna, Sonmukhi					
66	*Cassia auriculata*	Aval					
67	*Cassia fistula*	Garmalo					
68	*Cassia occidentalis*	Kasundro					
69	*Cassia tora*	Kuvadio					
70	*Cedrus deodara*	Devdar					
71	*Celastrus paniculata*	Malkagni					
72	*Centella asiatica*	Jal Brahmi					
73	*Chlorophytum borivilianum*	Safed moosli					
74	*Chlorophytum tuberosum*	Moosli					
75	*Cichorium intybus*	Kasani					
76	*Cinchona officinalis*	Cinchona					
77	*Cinnamomum camphor*	Kapur					
78	*Cinnamomum zeylanica*	Tamal Patra					
79	*Cissus quandrangularis*	Hadsankal					
80	*Citrullus colocynthis*	Indrayanmool					
81	*Citrus acidus*	Limbu					
82	*Citrus aurantifolia*	Santra					
83	*Citrus medica*	Bijoru					
84	*Clematis triloba*	Morvel					
85	*Clerodendrum phlomodies*	Arni					
86	*Clerodendrum serratum*	Bharangimool					

87	*Clitoria ternatea*	Garni					
88	*Coccinia indica*	Kadva ghiloda					
89	*Cocus nucifera*	Nariyeli					
90	*Colchium luteum*	Suranjan					
91	*Commiphora myrrha*	Hirabol					
92	*Commiphora wightii*	Guggul					
93	*Convolvulus microphyllus*	Shankhavali					
94	*Corriandrum sativum*	Dhana					
95	*Crateava nervala*	Vai varano					
96	*Crocus sativus*	Keshar					
97	*Croton tiglium*	jamalgota					
98	*Cucumis sativus*	Kakdi					
99	*Cuminum cyminum*	Jiru					
100	*Curculigo orchioides*	Kali musli					
101	*Curcuma aromatica*	Amba haldar					
102	*Curcuma longum*	Haldar					
103	*Curcuma zedearia*	Kachuro					
104	*Cyclea peltata*	Patha					
105	*Cymbopogan martinii*	Rosaghas					
106	*Cynodon dactylon*	Dharo					
107	*Cyperus rotundus*	Nagarmoth					
108	*Dalbergia latifolia*	Sisum					
109	*Datura innoxia*	Dhaturo					
110	*Daucus carota*	Gajar					
111	*Desmodium gangeticum*	Salavan, shaliparni					
112	*Desmostachya bipinata*	Darbh					
113	*Dioscorea bulbifera*	Varahikand					
114	*Diosypros malabarica*	Timru					
115	*Dolichandrone falcata*	Mattarsingi					
116	*Dryobalanopsis aromatica*	Bhimsenikapur					
117	*Eclipta alba*	Bhiringraj					
118	*Eclipta prostrata*	Bhangaro					
119	*Elaeocarpus ganitrus*	Rudraksha					
120	*Ellataria cardamomum*	Elaichi					
121	*Emblica officinalis*	Amla					
122	*Emblica ribes*	Vavding					
123	*Enicostema littorale*	Mamejavo					
124	*Eucalyptus spp.*	Nilgiri					
125	*Eugenia caryophllata*	Laving (Clove)					
126	*Eugenia jaambolana*	Jambu					
127	*Eulopia campestris*	Salampanjo					
128	*Euphorbia hirta*	Lal dudhi					
129	*Europia nuda*	Amarkand					
130	*Evolvulus alsinoides*	Shankhavali					
131	*Fagonia cretica*	Dhamaso					
132	*Feronia limonia*	Kotha					
133	*Ferula narthrex*	hing					
134	*Ficus benghalensis*	Vad					

135	*Ficus glomerata*	Umbro					
136	*Ficus religiosa*	pipalo					
137	*Foeniculum vulgare*	Variyali					
138	*Fritillaria roylei*	Kakoli					
139	*Fumaria indica*	pittapapado					
140	*Garcinia indica*	Kokam					
141	*Garcinia morella*	Revanchini					
142	*Garcinia pendulata*	Amalvetas					
143	*Gardenia resinifera*	Dikamari					
144	*Gloriosa superba*	Vachnnag					
145	*Glycyrrhiza glabra*	Jethi madh					
146	*Gmelina arborea*	Sewan					
147	*Grewia asiatica*	Falsa					
148	*Gymnema sylvestre*	Madhunashini					
149	*Haldinia cordifolia*						
150	*Hedychium spicatum*	Kapur kachali					
151	*Helicteres isora*	Mardasing					
152	*Hemidesmus hirta*						
153	*Hemidesmus indicus*	Anantmool					
154	*Hibiscus rosasinesis*	Jasud, jasvanti					
155	*Holarhena antidysenterica*	Kutaja, Kudo, indrajav					
156	*Hordeum vulgare*	Jav					
157	*Hygrophila auriculata*	Aekharo					
158	*Hyoscyanus niger*	Khursaniajamo					
159	*Ichnocarpus frutescens*						
160	*Indigofera tinctoria*	Gali indigo					
161	*Inula racemosa*	Puskarmool					
162	*Ipomoea digitata*	kshirvidarikand					
163	*Ixora parviflora*						
164	*Jasminum auriculatum*	Jui, Champa					
165	*Jatropha gossypifolia*	Safed Arandos					
166	*Juglans regia*	Akharot					
167	*Justicia adhatoda*	ardusi					
168	*Laucas indica*						
169	*Lawsonia inermis*	Mehndi					
170	*Lepidium sativum*	Asariyo					
171	*Leptadenia reticulata*	Jivanti, dodi					
172	*Leucas cephalotes*	Kudo					
173	*Lilium polyphylum*	Kshirkakoli					
174	*Limonia acidum*	Kothi					
175	*Lindernia ciliata*						
176	*Lubunga scandens*	Sugandhkokla					
177	*Ludwigia adscendens*						
178	*Luffa echinata*	Kukadvel					
179	*Madhuca indica*	Mahudo					
180	*Malaxis acuminata*	Jivak					
181	*Malaxis muscifera*	Rushbhak					
182	*Mallotus philippensis*	Kampilak, kapilo					
183	*Mangifera indica*	Aambo					

184	*Melia azedarach*	Bakam limado					
185	*Mentha viridis*	Fudino					
186	*Merremia tridentata*	Prasarini					
187	*Meusa ferrea*	Nagkeshar, nagpushpa					
188	*Mimosa pudica*	Lajamni, lajjalu					
189	*Mimusops elengi*	Borsalli					
190	*Mollugo spergula*						
191	*Momardica charantia*	Karela					
192	*Moringa concanensis*	Kadvo sargavo					
193	*Moringa oleifera*	Mitho sargavo					
194	*Mucuna prurita*	Kaucha					
195	*Murraya paniculata*						
196	*Myrica nagi*	Kaifal					
197	*Myristica fragrans*	Jaifal					
198	*Nardostachya jatamansi*	Jatamansi					
199	*Nelumbo nucifera*	Kamal					
200	*Nerium indicum*	Karen					
201	*Nigella sativa*	Kalonji					
202	*Nyctanthes arbortristis*	Parijat					
203	*Nymphaea stellata*	Uplata, Poyna					
204	*Ocimum basilicum*	Dhamro					
205	*Ocimum canum*						
206	*Ocimum sanctum*	Tulsi					
207	*Oldenlandia corymbosa*						
208	*Operculina turpetum*	Nashotar					
209	*Oroxylum indicum*	Tetu					
210	*Oxalis corniculata*						
211	*Paederia scandens*						
212	*Papaver somniferum*	Khaskhas					
213	*Parmelia perfoliata*	Shaileyak					
214	*Pedalium murex*	Gokharu					
215	*Pergularia daemia*						
216	*Peristrophe bicalyculata*	Anghedi					
217	*Peristrophe paniculata*						
218	*Phaseolus trilobus*	Moongparni					
219	*Phoenix dactylifera*	kharek					
220	*Phyla nodiflora*	Ratveliyo					
221	*Phyllantus embelica*	Bhoi amli					
222	*Phyllantus fraternus*	Bhoi amli					
223	*Picrorhiza kurroa*	Kadu-kutaki					
224	*Piper betel*	Nagarvel					
225	*Piper chaba*	Chavak					
226	*Piper longum*	Lindi piper					
227	*Piper nigrum*	kalimari					
228	*Pistacia integerrima*	Kakadashingi					
229	*Pistacia lentiscus*	Rumimastaki					
230	*Plantago ovata*	Isaphgul					
231	*Pluchea lanceolata*	Rasna					

232	*Plumbago zeylanica*	Chitrak					
233	*Polygonatum cirrhifolium*	menda					
234	*Polygonatum verticillatum*	Mahamenda					
235	*Pongamia pinnata*	Karanj					
236	*Prunus cerasoides*	Padam kast					
237	*Psoralea coryfolia*	Bawachi					
238	*Pterocarpus santalinus*	Rakta chandan					
239	*Pterospermum acerifolium*						
240	*Puereria tuberosa*	Viharikand					
241	*Punica granatum*	Dadam					
242	*Raphanus sativus*	Mula					
243	*Rauvolfia serpentina*	Sarapgandha					
244	*Rosa centifolia*	Gulab					
245	*Rubia cordifolia*	Majistha					
246	*Saccharum officinarum*	Sheradi					
247	*Salamalia malbarica*	Shimlo					
248	*Salvadora persica*	Khara pilu					
249	*Santalum album*	Chandan					
250	*Sapindus laurifolius*	Aritha					
251	*Saraca indica*	Ashok					
252	*Sarcostema acidum*	somlata					
253	*Saussurea lappa*	Kath, Uplet					
254	*Scindapsus officinalis*	Gajpiper					
255	*Semecarpus anacardium*	Bhilamo					
256	*Sesamum inicum*	Tal					
257	*Shorea robusta*	Sal, Ralgum					
258	*Sida cordifolia*	Bala, Khareti					
259	*Sida veronicaefolia*	Nagbala					
260	*Solanum indicum*	Ubhi bhoiringani					
261	*Solanum nigrum*	Kakamasi					
262	*Solanum surattense*	Bhairingani					
263	*Solanum xanthocarpum*	Bethi bhoiringni					
264	*Sphaeranthus indicus*	Gorakhmundi					
265	*Spilanthes acmella*	Marethi					
266	*Stephania japonica*						
267	*Sterculia urens*	kadaya					
268	*Stereospermum personatum*	Patala					
269	*Streblus asper*						
270	*Strychnos nuxvomica*	Zerkochala					
271	*Strychnos potatorum*	Nirmali					
272	*Swertia chirata*	kariyatu					
273	*Symplocos racemosa*	Lodra					
274	*Syzgium cumini*	Jambu					
275	*Tamarindus indicus*	Khati Amli					

276	*Taraxacum officinale*	Dulal burau					
277	*Tecomella undulata*	Rohido					
278	*Tectona grandis*	Sag					
279	*Tephrosia purpurea*	Sharpunkho					
280	*Teramnus labialis*	Mash parni					
281	*Terminalia arjuna*	Arjun					
282	*Terminalia bellerica*	Baheda					
283	*Terminalia chebula*	Harade					
284	*Terminalia indica*	Aamali					
285	*Thespesia populnea*	Paraspiplo					
286	*Thevetia nerifolia*						
287	*Tiliacora acuminata*						
288	*Tinospora cordifolia*	Gaddo, guduchi					
289	*Trachyspermum roxburghiianum*	Ajmo					
290	*Tragia involucrate*						
291	*Trapa bispinosa*	Singoda					
292	*Trema orientalis*						
293	*Trewia nodiflora*						
294	*Tribulus terrestris*	Gokharu					
295	*Trichosanthus cucumerina*	Patol patra					
296	*Trichosanthus dioica*	Patol					
297	*Trichosanthus tricuspidata*	Kakanahsa					
298	*Tridax procumbens*						
299	*Trigonella foenumgraceum*	Methi					
300	*Tylophora indica*	Antamul					
301	*Uraria picta*	Prushnaparni					
302	*Urena lobata*						
303	*Valeriana jatamansi*	Tagargantha					
304	*Ventilago denticulata*						
305	*Veronia anthelmintica*	kalijiri					
306	*Vetiveria zizanioides*	Khas valo					
307	*Viola odorato*	Banfasa					
308	*Vitex negundo*	Nagod					
309	*Vitis vinifera*	Kali draksh					
310	*Withania coagulence*	Kaknaj					
311	*Withania somnifera*	Ashwagandha					
312	*Woodfordia furticosa*	Dhavdi					
313	*Wrightia tinctoria*	Kadi kutij					
314	*Xeromphis spinosa*	Mindhal					
315	*Zingiber officinale*	Aadu, Shunth					
316	*Ziziphus jujuba*	Bor					

Plants in short supply

Common name	Botanical Name	Quantity required Annually	Since when the supp got reduced

Plants obtained from your cultivated source				
Common name	Botanical Name	Quantity Annually	Sale Price (Rs / kg)	Place of Cultivation

Raw drug material imported to India (Gujarat)					
Plant Name	Country Plant	Part	Quantity annually	Price (Rs./ kg)	Total Cost (Rs. in lac.)

Raw material exported					
	Country Plant	Part	Quantity annually	Price (Rs./ Kg)	Total Cost (Rs.)

Drugs produced from medicinal plants exported annually				
Plant Name	Export to which Country	Quantity annually	Price (Rs./Kg)	Total Cost (Rs.)

Drugs produced from medicinal plants imported annually:				
Plant Name	Import from which Country	Quantity annually	Price (Rs./ Kg)	Total Cost (Rs.)

- **Packaging of the drug in the form of**

  ☐ Crude
  ☐ Powder
  ☐ Extract

  Specify which part: _____

- **Packaging Quantity:** ☐ Bulk packaging ☐ Individual
- **Any patent taken:** ☐ Yes ☐ No

Specify if yes:

_____

_____

- **Expected implications of WTO implementations:**

_____

_____

_____

- **Any steps planned for this**

_____

_____

_____

Date:_____ **Signature:** _____

Thanks for sparing your valuable time!!