


Medicinal Plants of the Himalaya

Production Technology and Utilization

Preface by:
Prof. P. Pushpangadan

Dhani Raj Chhetri

ABOUT THE AUTHOR

Dhani Raj Chhetri is the Dean of Students' Welfare and an Associate Professor of Botany, Sikkim University, Sikkim, India. His research interest includes medicinal plants, abiotic stress and plant biochemistry. Dr. Chhetri has research experience in technology development involving Himalayan medicinal plants. He was instrumental in extensive transfer of technology 'from lab to the land' for employment generation in the Eastern Himalayan region. He has undertaken several research projects funded by national and international agencies. Dr. Chhetri has several research papers in peer reviewed international journals and authored two books. He is in the editorial board of two international journals on life sciences and is a recipient of National Merit Scholarship.

ABOUT THE BOOK

This book deals with 29 high value medicinal plants of the Himalayan region. Each plant forms a chapter of the book and the agro-techniques presented are based on academic research and practical experiences of many persons including the author, NGOs, foresters, self-help groups, nurserymen, traditional healers etc. of the Himalayan region. This book is aimed of providing a plethora of information on history, botany, pharmacology, phytochemistry, agronomy and biotechnology of the medicinal plants represented. The agro-techniques have been written in a lucid style so that even a farmer with basic education may undertake cultivation by following the suggestions. In the presentation, a short taxonomic description is followed by chemical constituents of the plant, biological activities and traditional uses. Simple micropropagation techniques on the relevant plants have been incorporated for making mass propagation practicable even by small nurseries. Cost benefit analysis of cultivating the plants have been incorporated to give a projected benefit of cultivation to farmers. References for every species have been included giving scientific validity to the work. In a way, the book is a manual for cultivators and a monograph for the research minded.

At present, cultivation of food grains is not economically sustainable in the Himalayan regions. However, non-availability of cultivation technology packages hinders medicinal plants sector. The present book will serve the cultivators in different zone of the Himalaya, as they will have ready production technology for sufficient number of plants for their respective locations. This book is also aimed at conservation of high value Himalayan medicinal plants and improvement of livelihood in the mountain villages through economy generation while providing a ready reference for research on technology development, scale-up and biotechnology. It is expected that the book would be of assistance to growers of medicinal plants, conservationists, self-help groups, extension workers, students, scientists and exporters.

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Preface

The history of human culture and civilization is all about the management and utilization of the resources around him. Since the dawn of human civilization resources particularly the bioresources has been utilized by diverse human communities. Human beings started their life in the forest as an integral part of the forest ecosystem. Living close to nature, he has acquired unique knowledge about the ambient biodiversity by instinct, trial or error and experimentation and used a variety of plants and animals to meet his essential requirements like food, medicine, fuel, fibre etc. Being an intelligent and innovativce organism, he very soon built a material civilization of his own and carved out a separate habitat for himself utilizing the resources around him. Many human communities later established civilizations and began to live in villages, town and cities built by him. However, a good majority of human communities still continue to live in and around the forest ecosystems. The communities who left the forest and began to live in modern towns and cities gradually lost close touch with nature and forest and lost the precious knowledge about most of the wild plants which their forefathers had. By the turn of 20th century, the peaceful life of the traditional communities who used to live in and around the forest was also disturbed and disrupted and that led to the decline and destabilization of these people causing imminent danger of extinction of the precious/peculiar life style, culture and knowledge system.

As early as 3500 BC, we find a highly advanced and well organized city civilization emerging at Mohan-jo-daro and Harappa in the Indian sub-continent. All these civilization were build by agricultural societies who got more leisure time that stimulated them to build material culture and civilization. But by the turn of 10th century, human communities world over have selected over 10,000 plant species as source of his food. These included many grains, millets, tuber and rhizomes which formed his main energy source and lentils, pulses, nuts, fruits, leaves of many plant species. These plants provided him proteins, fats, vitamins, minerals etc. The nutritional requirements were further supplemented by fish and meat. Many communities selected the best nourishing food items. In fact, the brain development of humans was closely associated with certain specific proteins/amino acids and fatty acids. Communities who settled in particular environment/habitat began to select certain plants and perfected them by trial, error, empirical reasoning or experience which was time and again improved. The innovative and enterprising members of the community went on generating new knowledge and these were passed on to successive generations which are now known as traditional diet or ethnic food items. It was with colonization which started in 16th century that led to globalization of food and diet. During 18th and 19th centuries the colonial powers of the West who reached the biodiversity rich South countries began to make intercontinental exchanage of plants, which predominantly included the edible plants. This globalization of food and nutrition has its advantage as well as disadvantages. Most undesirable out of this globalization of food was the narrowing down of the food basket by the world population. The whole world humans began to be fed by 20 edible plants by the turn of the 19th century against over 7,000 or more species that provided food and nutrition to the humans till the turn of the 18th century. With the increasing scientific knowledge and understanding on the food and nutrition, it is now well known that the location specific and climate specific food are best suited to humans.

It may be mentioned here that the classical systems of medicine (Ayurveda, Siddha, Unani, Amchi etc.) makes use of only 2,500 plants wheras we have a database on 10,000 plants which requires further scientific validation. Out of the 8,000 wild species used by the tribals for medicinal purposes, about 950 are found to be new claims and worthy of scientific scrutiny.

The mighty Himalayas have been a source of life sustaining herbs and medicinal plants from time immemorial. The Himalayas catered to the needs of the people who lived not only in its villages and foothills but also of the people who lived in far away cities and villages.

The Indian Himalaya is divided into three main regions: North Western Himalaya, Western Himalaya and Eastern Himalaya. The North-Western Himalaya (Ladakh plateau and Gilgit district) is characterized by mild summer and severely cold winter. Vegetation is alpine type which is represented by species like *Achillea millefolium, Bunium persicum, Picrorhiza kurroa, Juniperus communis, Ephedra gerardiana* etc. In the Western Himalaya (Jammu & Kashmir, Himachal Pradesh, Garhwal and Kumaon Himalaya), the climate is warm humid during summer and cold humid during winter. The medicinal flora is represented by *Sassurea costus, Colchicum luteum, Atropa acuminata, Physochlaina praelta* etc. In the Eastern Himalaya (Darjeeling, Sikkim, North part of Assam and Arunachal Pradesh), the climate is characterized by warm summer and cool winter. Vegetation is represented by *Aquilaria malaccensis, Coptis teeta, Panax pseudoginseng* etc.

Demand from pharma sector for medicinal plants from Himalaya region is ever increasing. Of the total medicinal plant species 62 species of medicinal plants are endemic to Himalaya and 208 extend their distribution in the adjacent area and are classified as near endemic species.

Dr. Dhani Raj Chhetri, Associate Professor, Department of Botany, Sikkim University has made a commendable attempt to document the agrotechnologies including micropropagation, traditional medicinal uses, phytoconstituents and biodiversity of 29 Himalayan medicinal plants in this book entitled 'Medicinal plants of the Himalaya: Production technology and utilization.' These monographs will be of immense use to teachers, researchers, students and general public.

I congratulate Dr. Dhani Raj Chhetri for his effort in bringing out this volume which I hope will be welcomed by all those who are interested in the study of Himalayan flora.

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Acknowledgements

Ever since I joined the undergraduate courses in St. Joseph's College and Darjeeling Government College in Darjeeling, I became interested in medicinal plants. Though the rich biodiversity of medicinal plants in the surrounding of Darjeeling Himalaya impressed me, but the rapidly dwindling population of the same concerned me. Poverty is rampant in the mountain countryside and in order to address the problem with our limited resources, I along with some of my friends devised a plan to domesticate wild high value medicinal plants, develop technology for their cultivation, transmit the technology to the field level and provide assistance to the growers in marketing the produce. This was envisaged to save the threatened medicinal plants in their natural habitat, offset the pressure from the wild population and create an alternative source of economy for the mountain villages. However, dearth of propagation protocols for most of the high value medicinal plants necessitated writing such a book. The main inspiration for the book came from the economically and geographically challenged villagers of the Himalayan Mountains who may be uneducated in the conventional sense but harbors invaluable wisdom in their traditional knowledge. I am grateful to all the associations of hill tribals who were instrumental in developing agrotechniques and implementing the same in their cultivation programme. Different funding bodies like Department of Biotechnology, University Grants Commission, MPLADS, B.P. Koirala India-Nepal Foundation are thankfully acknowledged for generously funding my various R & D projects on Himalayan Medicinal plants. My thanks are also due to my teacher Prof. Asok Kumar Mukherjee, Burdwan University for his constant encouragement. Dr. P. C. Lama of Post Graduate Department of Botany, Darjeeling Government College is thankfully acknowledged for his assistance.

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Introduction

INDIAN HIMALAYAS AND ITS MEDICINAL PLANT BIODIVERSITY

India is one of the mega biodiversity centres of the world, having over 45,000 plant species of which about 40% are flowering plants. India harbours 3 of the 34 biodiversity hotspots world-wide including the Himalayas. Interestingly, we are one among the 17 mega diverse countries, where 70% of the world's species occur collectively. At the same time we are rich in our own flora i.e., endemic plant species (Jachak and Saklani, 2007). The Himalayan region extends from Nanga Parbat in the West to Namcha Barwa in the East and includes parts of India, Nepal, Bhutan and South East Tibet. In geographical terms, the Himalaya is a recent creation and it runs from South-East to North-West direction. The richness of the flora is due to the great variation in climate and habitat to be found in this region. Much of the charm of the Himalaya lies in the possibility of seeing very different types of flora within quite a short distance (Polunin and Stainton, 1992). Indian Himalaya is the most beautiful mountain chain in the world. The length is about 2400 km, breadth ranges from 240-320 km and covers a total area of 419871 km^2.

From phytogeographic point of view, the Indian Himalaya is divided into three main regions:

North-Western Himalaya: This area encompasses Ladakh plateau and Gilgit district in Kashmir and is characterized by mild summer and severely cold winter. The mean annual temperature is 8°C and mean annual rainfall is less than 150 mm. The vegetation is alpine type which is represented by species like- *Achillea millefolium, Bunium persicum, Picrorhiza kurrooa, Juniperus communis, Ephedra gerardiana* etc.

Western Himalaya: This region spreads across Jammu & Kashmir, Himachal Pradesh, Garhwal and Kumaon Himalayas. Here the climate is warm humid during the summers and cool humid during winter. The rainfall generally varies between 100-200 mm to 1000-2000 mm from place to place. The natural vegetation comprises of sub-temperate, moist temperate, moist alpine forest, alpine meadows and dry alpine desert type. The medicinal flora is represented by- *Saussurea costus, Colchicum luteum, Atropa acuminata, Physochlaina praealta* etc.

Eastern Himalaya: This zone comprises of Darjeeling, Sikkim, North part of Assam and Arunachal Pradesh. The climate is characterized by warm summer and cool winters and the mean annual rainfall exceeds 200 cm. The natural vegetation comprises of sub-tropical pine forest, temperate wet evergreen forest and wet alpine vegetation which are represented by- *Aquilaria malaccensis, Coptis teeta, Panax pseudoginseng* etc. (Shah, 2002).

Due to ever increasing utilization of land for food crops, devastation of forests and the concurrent indiscriminate exploitation of medicinal crops, their availability from natural resources have declined. On the other hand, the demand for internal use and for export has been increasing, necessitating the production of these crops on a large scale. There is a need to introduce these crops into the cropping systems of the country, which besides meeting the demands of the industry, will also help to maintain standards on quality, potency and chemical composition (Farooqi and Sreeramu, 2001).

The Himalayan region is a bio-geographically unique zone in the world and has the maximum degree of endemism in the Asian region. Unfortunately, many of these species are critically endangered today by both anthropogenic impacts and climate change. Some examples of the endangered Himalayan medicinal plant species include: *Aconitum balfourii, A. deinorrhizum, Acorus calamus, Angelica glauca, Atropa belladonna, Berberis kashmiriana, Coptis teeta, Dioscorea deltoidea, Gentiana kurrooa, Nardostachys grandiflora, Picrorhiza kurrooa, Podophyllum hexandrum, Saussurea costus, Sweria chirayita* and *Taxus baccata* subsp.*wallichiana;* and the sub-tropical/sub-temperate species *Aquilaria malaccensis* (Samant *et al.* 1998). Despite their remoteness and inaccessibility, the high altitude Himalaya has suffered a high level of human & climate change induced biodiversity loss and habitat degradation. The steadily increasing population in the hotspot has led to extensive changes in the land cover and use. Large areas of remaining habitat in the hotspot are highly degraded. Sustenance of the tribes is heavily dependent on the forests, agriculture and livestock supporting only a basic level of food requirement. Firewood constitutes over 90% of fuel in the region; over-extraction of NTFPs and poaching of endangered species has led to some species becoming critically endangered. Biomass demand of communities has grown manifold as a result of population growth and additional livelihood needs. Illegal felling & smuggling of timber is rampant by timber traders. Of late, due to the increased demand in the pharma sector, NTFPs like medicinal plants of the flora of fragile alpine meadows is being overexploited. Other threats such as mining, construction of roads and large dams, pollution due to the use of agrochemicals, unplanned and poorly managed tourism, and political unrest etc. threaten the integrity of the hotspot. Depletion in the forest cover and ecosystem services are interlinked and threaten the sustainable livelihood of not only the hill people but also the much larger population inhabiting the adjoining Indo-Gangetic plains (Hamilton, 1987; Hurni, 1999). Though the Himalaya cover only 18% of India's geographical area, it accounts for more than 50% of the forest cover. Several plant species are endemic to the Himalayan region. Out of total known number of higher plants from India, approximately 46% are endemic to the Himalaya. Of the total medicinal plant species, sixty-two species of medicinal plants are endemic to the Himalaya and 208 extend their distribution to the adjacent areas, and are therefore classified as near endemic (Chatterjee, 1939).

In India, of the 17,000 species of higher plants, 7500 are known for medicinal uses (Shiva, 1996). This proportion of medicinal plants is the highest proportion of plants known for medicinal purposes in any country of the world from the existing flora of that respective country (Table 1). Ayurveda, the oldest medical system in Indian sub-continent, has alone reported approximately 2000 medicinal plant species. The Charak Samhita, an age-old written document on herbal therapy, reports on the production of 340 herbal drugs and their indigenous uses (Prajapati *et al.*, 2003). So far about 8000 species of angiosperms, 44 species of gymnosperms and 600 species of pteridophytes have been reported in the Indian Himalaya (Singh and Hajra, 1996), of these 1748 species are known as medicinal plants (Samant *et al.*, 1998). The maximum medicinal plants (1717 species) have been reported around the 1800 m elevation range.

TRADITIONAL MEDICINAL PLANTS AS NATIONAL ECONOMIC RESOURCE

Countries like Africa, Asia and Latin America use traditional medicine to help meet some of their healthcare needs. In Africa, up to 80% of the population uses traditional medicine for primary healthcare. In industrialized countries, adaptations of traditional medicine are termed complementary and alternative. A huge chunk of humanity is still dependent on herbal medicine for their healthcare needs. In India, traditional health care systems like Ayurveda, Unani and Siddha operate alongside modern healthcare. There are 400,000 registered traditional medicine practitioners in India compared to 332,000 registered doctors. About 70-75% of Indian population is dependent on herbal medicine for primary health care because of better cultural acceptability, better compatibility with the human body and lesser side effects. Availability and cost effectiveness are the other reasons for its popularity. At present, India has about $70 billion worth of herbal medicine market of which 80% comprises crude drugs and not finished products. India is sitting on a gold mine of well-recorded and well-known knowledge of traditional herbal medicines. However, it has not been able to capitalize in this herbal wealth by promoting use and export.

About 25% of modern medicine is of plant origin, a number of which have been derived from Himalayan medicinal plants. For example, Digitalin and Digoxin are heart drugs derived from foxglove, *Digitalis purpurea*. Taxol, a cancer drug, is derived from *Taxus wallichiana* (Raghav, 2003), and many others are synthetic analogues built on prototype compounds isolated from plant species in modern pharmacopoeia (Rao *et al.*, 2004). Many of the important allopathic drugs have been derived from Himalayan medicinal plants (Table-2). It is imperative that economic strategies in the herbal sector should be formulated considering the market forces and global impacts of traditional medicine.

India is one of the few countries that is capable of producing most of the important plants used both in modern and traditional systems of medicine, due to the availability of wide variations of climate, soil, altitude and latitude (Lambert *et al.*, 1997). Most of the plants used by the drug industries, especially from high altitudes are harvested from the wild. This has led to the depletion of resources and extinction of some of the species (Nautiyal and Purohit, 2000). Of the 814 threatened plant species in India, 113 taxa occur on Indian Himalaya (Nautiyal *et al.*, 2001).

Medicinal plants have high potential in creating jobs and pushing economic growth in resource constrained areas suffering from limited educational opportunities, lack of infrastructure and underdeveloped commercial activities. The conversion of socio-cultural traditions and indigenous knowledge into economic opportunities also has the advantage of preserving the vanishing cultural knowledge and practices which are threatened due to globalization. As the Himalayas are recognized as the treasure trove of biological and cultural diversity, there is a need to protect indigenous knowledge and cultural diversity on an urgent basis. The means of achieving this may be by providing economic value to the traditional and indigenous knowledge (Ramakrishnan, 1992).

A number of new drugs derived from plants, including taxol and its derivatives for ovarian and breast cancers have awakened interest in using indigenous knowledge to guide drug discovery. There has been a tension between the modern approach of drug discovery based on combinatorial chemistry, computer modelling, functional genomics and proteomics and the traditional method based on discovery of novel bioactive compounds from plants. At present, western medicine has become more open to alternative approaches of healing and shows a revival of interest in traditional medical practices. Given a remarkable diversity of plants and the diversity of molecules they produce, a cornucopia of important new therapeutic molecules remain to be discovered from plants (Cox, 2005). The traditional medicines are potential sources which provide a short cut for identification of those plants which are of greatest interest for the discovery of modern therapeutic agents (Ved Prakash, 1998).

It has been realized that medicinal plants of the Indian Himalayan region offer advantage in having much greater possibilities of providing new molecules used in drugs due to the extreme condition that they are subjected to (Sharma et al, 1997). For the sake of drug development, instead of random search for medicinal plants, a selective search based on traditional knowledge would be more focused and productive and certainly more economic (Rameswararao et al, 2003).

A tremendous scope of research is foreseen on the biochemical, pharmacological and pharmaceutical aspects of folk medicine and its related plants in the Himalaya. The rich medicinal plant biodiversity of the area and a rich traditional medicine system could be understood from the single fact that for a single disease there are multiple remedies in the Himalayas, for example, there are 31 species of plants used separately as antipyretic agents and 23 species used as hepatoprotective agents (Chhetri, 2005).

The international trade in Medicinal Plants has been estimated at over US $60 billion and growing at a rate of 7 % annually. India's export share in this global market is about 9% with China (24%) being the leader in this sector (Vasisht and Kumar, 2002). The planning commission, Govt. of India had envisaged an increase in the trade of medicinal plants extract to rupees 10,000 crore by the year 2010 (Kumar, 2006).

CULTIVATION OF MEDICINAL PLANTS IN THE HIMALAYAN REGION

Mountains are magnificent ecosystems offering a wide array of services to its inhabitants, but they are as fragile as any other ecosystems of the world (Biju Kumar, 2002). Of late, the subsistence level farming practiced is this area has been severely jeopardized due to fragmentation of land share, damage of roads & crop fields due to land-slips, scarcity of water, and lack of communication and absence of any marketing assistance.

Cultivation of medicinal plants is a specialized task and the local communities who have for generations nurtured the resources in their habitat are best equipped for this task (Anon.,1997). A great deal of traditional knowledge of the use of various plant species is still intact with the indigenous people, and this fact is especially relevant with the mountainous areas such as the Himalaya due to less accessibility of terrain and comparatively slow rate of development (Kala, 2002; Farooquee *et al.*, 2004). With the demand for medicinal plant extracts skyrocketing, this will provide them a steady source of income while giving them an incentive to conserve. Apart from health care, medicinal plants are mainly the alternate income-generating source of underprivileged communities (Myers, 1991). The cosmetic industries are increasingly using natural ingredients in their products, and these natural ingredients include extracts of several medicinal plants (Anon., 2003). Therefore, strengthening this sector may benefit and improve the living standard of poor people.

Cultivation of medicinal plants in the Himalayan region has some advantages like:

1. It can be cultivated in fallow and barren land
2. These plants require almost zero maintenance
3. These plants are less susceptible to diseases and pests.
4. Chance of damage by wild animals is negligible.
5. Promises a high economic return
6. Completely based on local resources
7. Convenient for packaging, storage and transportation
8. Limited global competition
9. Incubation period is short for most of the plants
10. Can be cultivated organically

In the sectors of medicinal plants cultivation, there is serious lack of awareness among the people regarding its scopes and importance (Haridasan *et al.*, 2003). To popularize the matter some steps like workshops, seminars, exhibitions, field demonstrations etc. should be organized involving all the stake-holders in this region. Govt. agencies, NGOs and community based organisations could play active role in this direction. Once the farmers becomes ready for the alternative farming, they should be provided with the initial seed money through Banks, Co-operatives, Financial institutions and other Govt. Agencies in the form of grants or soft loans. The forest rules should be implemented in a more stringent but people friendly manner. Transit passes required for transporting the NTFPs should only be given to the genuine cultivators of medicinal plants but not to the people who illegally extract them from the wild.

Information on the propagation of medicinal plants is available for less than 10% and agro-technology is available only for 1% of the total known plants globally (Lozoya 1984, Khan and Khanum, 2000). This trend shows that developing agro-technology should be one of the thrust areas for research. Furthermore, in order to meet the escalating demand of medicinal plants, farming of these plant species is imperative. Apart from meeting the present demand, farming may conserve the wild genetic diversity of medicinal plants. Farming permits the production of uniform material, from which standardized products can be consistently obtained. Cultivation also permits better species identification, improved quality control, and increased prospects for genetic improvements. Selection of planting material for large-scale farming is also an important task. The planting material therefore should be of good quality, rich in active ingredients, pest and disease-resistant and stress-environment tolerant. For the large scale farming, one has to find out whether monoculture is the right way to cultivate all medicinal plants or one has to promote polyculture model for better production of medicinal plants. Continuous research is a must for developing propagation technologies for the suitable alternative crops in a particular area. After a sizable number of farmers take up the alternative agriculture, industries could be set up in the nearby areas for primary processing of the product and ultimately to manufacture the finished products. Such a situation will go a long way towards making each of the mountain village free of hunger, disease and poverty.

When considered with respect to food security, there is no scope to commit agricultural land for medicinal plants cultivation. However, there is an important case for encouraging village tribals, small and marginal farmers etc. to grow medicinal plants in their household garden, waste land, fallow land etc. instead for encouraging the big farmers. Such a strategy can invigorate the growth and development of medicinal plant sector by linking it to the economy of the rural and tribal people (Saini, 2002). It is often argued that the small farmers in the hills need to be secure in their cereal cropping in order to specialize in the alternative farming. It is at least important in the initial years, because they can at least secure cereal grains for their consumption even if the new trial fails. It seems wise to incorporate alternative crops in multiple cropping systems with cereal crops or in agro-forestry on sloping land (Banskota, 1989).

The rising demand for plant-based drugs is unfortunately creating heavy pressure on some selected high-value medicinal plant populations in the wild due to over-harvesting. Several of these medicinal plant species have slow growth rates, low population densities, and narrow geographic ranges; therefore they are more prone to extinction (Jablonski, 2004). The other constraints in the medicinal plants sector are: i) slow rate of production of many medicinal plants, ii) long gestation period, iii) shortage of suitable cultivation technology, iv) production of small quantity, v) unscientific harvesting, vi) paucity of research on the high yielding varieties, vii) inefficient processing techniques, viii) fluctuation in demand and supply, ix) poor quality control procedures, x) scarcity of good manufacturers, xi) poor marketing infrastructure, and xii) poor coordination among different stakeholders (Kala *et al.*, 2006).

In order to address the concerned issues, the National Medicinal Plants Board has been established under the ministry of health and family welfare (by a notification dated 24th November, 2000). The objectives of the board are to formulate strategies for conservation, cultivation, proper harvesting, processing, marketing and Research & Development related to medicinal plants. The Board has been implementing contractual farming schemes under which financial assistance is provided to growers for cultivation of identified medicinal plants. The board had so far identified 32 medicinal plants for commercial cultivation. However, as per Operational Guidelines, projects for cultivation of other commercially important plants can also be considered for which assured market exists. The Board has since revised the list of prioritized plants to include 80 plant species for cultivation and development. Of these, more than 63% plants are found in the Himalaya, indicating the richness of medicinal plant biodiversity in the region (Table-3).

It is well known that the cultivation of food grains in the hills is not economically viable, and thus immediate diversification from agriculture to economically viable and sustainable alternatives is needed. The cultivation of wild and important medicinal plants seems to be such an option (Nautiyal and Nautiyal, 2004). Medicinal plants should be cultivated to save the forests in the Himalayan regions and at the same time to meet the rising demand of herbs to improve the livelihoods of hill people. As per the law of comparative advantage, different regions should specialize in producing and exporting goods that they produce at a lower relative cost than other regions. Thus it is quite natural to think that the comparative advantage of the mountains lies in their climatic characteristics such as low temperature, high humidity, heavy precipitation etc. which enables the hills to produce certain medicinal crops at a lower cost. Such comparative advantage over the traditional crops in terms of monetary returns is palpable. India has already established a reputation as a low-cost manufacturer of high quality drugs in the global market. It is expected that India's aim to build a golden triangle between traditional medicine, modern medicine, and modern science will be a boon for developing the traditional herbal medicine and the medicinal plants sector (Mashelkar, 2005).

This book deals with 29 high value medicinal plants of the Himalayan region. A couple of exotic plants have been incorporated in the list keeping economy in mind. Each plant forms a chapter of the book and available literature and studies on the theme of the book have been referred for each. The agro techniques presented are based on academic research and practical experiences of many persons including the author, NGOs, foresters, self-help groups, CBOs, local nurserymen, traditional healers, environmentalists etc. of the Himalayan region.

In the presentation, both scientific name and common name along with family of the plant is given for each plant, which follows the vernacular name in Sanskrit, Hindi and some languages spoken in the Himalayan region. Distribution of plants in the Himalayan region along with altitudinal zone has been mentioned. A short taxonomic description of the plant has been incorporated along with a color photograph wherever available for easy identification of the species. Chemical constituents of the plant, biological and pharmacological activities follow the traditional uses. Agrotechniques have been written in a systematic manner starting from soil type, land preparation, seed sowing, plantation, vegetative propagation, irrigation, manuring, and harvesting so that even a farmer with basic education may undertake cultivation following the suggestions. Simple micropropagation techniques on the relevant plants have been incorporated, so that mass propagation may be practiced even by small nurseries or the forest departments.

Medicinal plants should be cultivated to save the forests in the fragile Himalayan mountain regions, to meet the rising demand for medicinal herbs across the globe and to improve the livelihood of Himalayan people. The cultivation of wild, rare and high value medicinal plants may be the appropriate vehicle for transferring technology from 'lab to the land.' At present cultivation of food grains is not economically sustainable in the Himalayan regions. MAP cultivation may be the effective alternative, but non-availability of cultivation technology packages and planting material hinders the sector. The present book will serve the cultivators in the different zones of the Himalaya, be that in the sub-temperate, temperate and alpine regions or the Eastern and Western Himalaya, as they will have sufficient species to choose from for each of their specific zone. It is always advisable to start MAP cultivation in unused fallow land without replacing the main crops until sufficient confidence is gained. For starters, annual herbs are the best bet from which they may graduate to perennial plants. The cost benefit analysis provided is merely a projection based on idealized situation which is likely to vary due to environmental and market conditions. Moreover, in the perennials, the maintenance cost during the intervening years has not been included in order to maintain lucidity of the text.

This small book would be a success if it could be of assistance even in a minuscule way in conserving the high value Himalayan medicinal plants and in economy-generation in the mountain villages, while providing a ready reference for further research in technology development, scale-up and biotechnology.

TABLE 1: Distribution of medicinal plants.

Geographical area	Total number of plant species in flora	No of medicinal plant species reported	% of medicinal plants	Reference
World	297000	52885	10	Schippmann *et al.*, 2002
India	17000	7500	44	Shiva, 1996
Indian Himalayas	8000	1748	22	Samant *et al.*, 1998

TABLE 2: Allopathic drugs originating from medicinal plants found in Himalayan region.

Botanical name	Common name (in English)	Part used	Medicinal compound	Usage / disease
Artemisia annua Linn.	*Sweet wormwood*	Plant	Artemisinin	Anti malarial
Asparagus racemosus Willd.	*Asparagus*	Root	L-asparginase, Rutin	Anti cancer
Atropa belladonna Linn.	*Belladona*	Roots, inflorescsense	Atropine	Anti-cholinergic
Berberis asiatica Roxb. ex DC.	*Tree turmeric*	Root bark	Berberine	Anti-diarrhoeal
Camellia sinensis (L.) Kuntze	*Tea*	Leaf	Caffeine	CNS-stimulant
Cephaelis ipecacuanha (Brot.) A. Rich.	*Ipecac*	Bark	Emetine	Emetic, expectorant
Cinchona officinalis Linn. f.	*Cinchona*	Bark	Quinine	Anti malarial
Colchicum luteum Baker	*Colchicine*	Tuber	Colchicine	Anti-gout
Digitalis purpurea Linn.	*Foxglove*	Leaf	Digoxin, gitalin digitoxin	Cardiotonic
Dioscorea deltoidea Wall. *Dioscorea prazeri* Prain & Burkil.	*Dioscorea*	Tuber	Diosgenin	Contraceptive
Ephedra gerardiana Wall.	*Stem, Roots*	Plant	Ephedrine	Bronchodilator
Gloriosa superba Linn.	*Glory lily*	Tuber	Colchicine	Gout, cancer

Botanical name	Common name (in English)	Part used	Medicinal compound	Usage / disease
Hyocyamus niger Linn.	*Henbane*	Leaves	Hyoscyamine	Anti-cholinergic Anti-spasmodic
Panax pseudoginseng.Wall.	*Indian ginseng*	Root	Ginsenosides	Tonic, antioxidant
Picrorhiza kurroa Royle ex Benth.	*Kutki*	Root	Kutkin	Stomachic, cathartic
Papavar somniferum Linn.	*Poppy*	Latex	Morphine, codeine, papaverine	Analgesic, anti-tussive
Podophyllum hexandrum Royle	*May apple*	Root	Podophyllotoxin	Anti cancer
Silybium marianum (Linn.) Gaertn.	*Holy Thistle*	Leaf	Silymarine	Anti-hepatotoxic
Taxus baccata Linn.	*Himalayan Yew*	Leaf	Taxol	Anti cancer
Urginea indica Kunth	*Indian Squill*	Bulb	Scillaren A, B	Cardiotonic
Valeriana wallichii DC.	*Valerian*	Roots	Valpotriates	Tranquilizer

TABLE 3: Revised list of prioritized plants suggested for development and cultivation by National Medicinal Plants Board (NMPB). Species prefixed with asterisk (*) are found in the Himalayas.

Sl. No.	Species	Common name
1	**Aconitum ferox* Wall	Vatsnabh
2	**Aconitum heterophyllum* Wall.ex.Royle	Atees
3	**Aconitum palmatum* D. Don	Prativisa
4	**Acorus calamus* Linn.	Vach
5	*Aegle marmelos* (Linn) Corr.	Beal
6	*Albizzia lebbeck* Benth	Shirish
7	**Aloe vera* Tourn ex Linn.	Ghritkumari
8	**Alstonia scholaris* R. Br.	Satvin
9	*Altingia excelsa* Noronha	Silarasa
10	*Andrographis paniculata* Wall.ex.Nees	Kalmegh
11	**Aquilaria agallocha* Roxb.	Agar
12	**Artemisia annua* Linn.	Artemisia
13	**Asparagus racemosus* Willd.	Shatavari
14	*Azadirachta indica* A. Juss	Neem
15	*Bacopa monnieri* (L.) Pennell	Brahmi
16	**Berberis aristata* DC	Daruhaldi
17	*Boerhaavia diffusa* Linn.	Punarnava
18	*Carum carvi* Linn.	Kala jeera
19	Cassia *angustifolia* Vahl.	Senna
20	**Centella asiatica* Linn.	Mandookparni

Sl. No.	Species	Common name
21	*Chlorophytum borivillianum* Sant.	Shwet Musali
22	**Cinnamomum* (*C. zeylanicum*, *C. tamala*, *C. camphora*)	(Dalchini, Tejpat,Kafoor)
23	**Coleus barbatus* Benth	Pather Chur
24	*Coleus vettiveroides* K.C. Jacob	Hrivera
25	*Commiphora whightii* (Arn.) Bhandari	Guggul
26	**Convolvulus microphyllus*	Shankhpushpi
27	*Crataeva nurvala* Buch.-Ham	Varun
28	**Crocus sativus* Linn.	Kesar
29	*Cryptolepis buchanani* Roem & schult	Krsna sariva
30	**Digitalis purpurea* Linn.	Foxglove
31	**Dioscorea floribunda*	Dioscorea
32	**Embelia ribes* Burm. F	Vai Vidang
33	**Emblica officinalis* Gaertn.	Amla
34	**Ferula foetida* Regel	Hing
35	*Garcinia indica* Chois	Kokum
36	**Gentiana kurroo* Royle	Trayamana
37	**Ginkgo biloba*	Ginkgo
38	**Gloriosa superba* Linn.	Kalihari
39	*Glycyrrhiza glabra* Linn.	Liquorice
40	**Gmelina arborea* Linn.	Gambhari
41	*Gymnema sylvestre* R. Br.	Gudmar
42	**Hedychium spicatum* Ham.	Kapur kachari
43	*Hemidesmus indicus* R. Br.	Anantmool
44	**Hippophae rhamnoides* Linn.	Seabuckthorn
45	**Holarrhena antidysentrica* Wall.	Kurchi/Kutaj
46	*Ipomoea petaloidea* Choisy	Vrddhadaruka
47	*Ipomoea turpethum* R. Br.	Trivrit
48	*Litsea glutinosa*	Listea
49	**Mesua ferrea* Linn.	Nagakeshar
50	**Mucuna pruriens* Bak.	Konch
51	**Nardostachys jatamansi* DC.	Jatamansi
52	**Ocimum sanctum* Linn.	Tulsi
53	**Orchis latifolia* Linn.	Salampanja
54	**Oroxylum indicum* vent.	Syonaka
55	**Panax pseudo-ginseng*	Ginseng
56	**Parmelia perlata* Ach.	Saileya
57	**Phyllanthus amarus* Sch. & Th.	Bhumi amlaki
58	**Picrorhiza kurrooa* Benthex Royle	Kutki
59	**Piper longum* Linn.	Pippali
60	**Plantago ovata* Forsk.	Isabgol
61	**Podophyllum hexandrum* Royle	Bankakri

Sl. No.	Species	Common name
62	*Premna integrifolia* Linn.	Agnimanth
63	*Pterocarpus santalinus* Linn. f.	Raktachandan
64	**Rauwolfia serpentina* Benth. ex Kurz	Sarpgandha
65	*Salacia reticulata, S. oblongata*	Saptachakra
66	*Santalum album* Linn.	Chandan
67	**Saraca asoca* (Roxb.) de Wilde	Ashok
68	**Saussurea lappa/S. costus* C.B. Clarke	Kuth, Kustha
69	*Smilax china* Linn.	Chob Chini
70	**Solanum nigrum* Linn.	Makoy
71	*Stereospermum suaveolens* DC.	Patala
72	*Stevia rebaudiana*	Madhukari
73	**Swertia chirata* Buch-Ham	Chirata
74	**Taxus baccata* Linn.	Talispatra
75	*Terminalia arjuna* W. &. A.	Arjuna
76	**Terminalia belerica* Roxb.	Behera
77	**Terminalia chebula* Retz.	Harad
78	**Tinospora cordifolia* Miers	Giloe
79	**Withania somnifera* (Linn.) Dunal	Ashwagandha
80	**Woodfordia fruticosa* Lurz	Dhataki

1

Aconitum ferox Wall. ex Ser. (Ranunculaceae)

Syn:	*Aconitum virosum* D. Don *Aconitum napellus* var. *rigidum* Hook. f. Th. *Aconitum dissectum* St.
English	Monkshood / Indian aconite
Sanskrit	Vatsanabha
Assamese	Bish
Hindi	Mithazahar
Kashmiri	Mohri
Nepali	Bikh
Lepcha	Nyine

The Indian aconite plant is a common site at lower alpine regions during July-August. The root of the plant is used in the Eastern Himalaya after proper curing as an antidote for herbal poisoning. It is also used for fever and remaining body pain (Rai and Sharma, 1994). Various poisonous properties have been ascribed to this root, which is supposed to have been commonly used in poisoning arrows in various manners (Biswas, 1956). The symptoms of poisoning by aconite are numbness of tongue and mouth, nausea, giddiness etc. Various species of aconite possesses the same narcotic properties, but none of them equal in energy to that of *A. ferox*. Aconite poisoning of drinking-water wells by using *A. ferox* has been carried out by native Indians to stop the progress of an advancing army. It is believed that the Roman Emperor, Claudius was poisoned with aconitine derived from *A. ferox* by his wife, Agrippina (Moog and Karenberg, 2002). Over the centuries aconite was variously called as Leopard killer, Woman killer, Brute killer, Dog killer, Wolfsbane, Blue rocket, Friar's cap, and Monkshood. According to Dioscorides, the term Wolfsbane originated because the roots of the plant were mixed with raw flesh and used to kill wolves. The term Monkshood, on the other hand, is derived from the hooded flower which resembles the cloak worn by monks (Haller, 1984). *A.*

ferox is the most powerful and deadly of all the species of aconites, as well as most familiar among the poisonous plants called *bikh* or *bish* in the Himalayan region. So much so that the word 'bikh' or 'bish', which literally means a poison, has come to be the vernacular name of *A. ferox* (Cullimore, 1884).

The ferox variety of Indian aconite of commerce has often been found to be substituted with *A. deinorrhizum* Stapf, *A. balfoureii* Stapf, *A. spicatum* Stapf and *A. laciniatum* Stapf. 'Aconite' of homoeopathic medicine is obtained from *A. ferox*. The potent diterpene alkaloids have given the monkshood a reputation since antiquity. The importance of this plant extends from its use in medicine to ornamentals. Conventionally, propagation of this plant takes place by seeds, but seeds may not store for long in dry condition. Alternative germination rate could be enhanced if care is taken to over winter the seeds in imbibed condition to provide development of rudimentary embryo prior to germination (Cervelli, 1992).

THE PLANT

Perennial 50-100 cm tall herb with slender hollow stem. Roots tuberous, biennial, paired, with dark brown root fibres. Leaves scattered, distant leaf blade rounded or oval, 5-lobed, which are further dissected, ultimate segments or the teeth acute. Petioles slender, the lower upto 24 cm long and much dilated at the base. Uppermost blades sessile or sub-sessile, much smaller and less dissected. Inflorescence loose, 15-30 cm long terminal spike like cluster of few flowers, simple or sparingly branched below. Lower bracts pinnately lobed, upper entire. Sepals dull blue, uppermost helmet shaped, helmet semiorbicular in profile, shortly beaked. Filaments glabrous, narrowly winged, wings attenuate. Carpels 5, contiguous, gradually passing into the style. Fruit follicles, dorsally sub-convex, glabrous or loosely tomentose, conspicuously reticulate. Seeds obovid 2.5-3.0 mm long, winged along the raphe.

Part used: Tuberous roots
Flowering season: July-August

DISTRIBUTION

Jammu and Kashmir, Garhwal, Kumaon, Darjeeling, Sikkim, Arunachal and other parts of Eastern Himalayas between 2400-4000 m. Also found in the mountains of Nepal, Bhutan and Myanmar.

TRADITIONAL USES

The root is antiperiodic, antidiabetic, antipyretic, anodyne and diuretic. It is also considered narcotic and sedative. Preparations of *A. ferox* are employed externally to the skin to treat neuralgia, lumbago, rheumatism and boils. It is also used in different stages of pneumonia, pleurisy and cardiac failure. If taken frequently or in overdose, it acts as a deadly poison. The roots are generally used after mitigation by soaking them in cow's milk or urine. It is believed that by mitigation the active principles lose their depressant action on the heart and instead become stimulant with mild cardiotonic property. The root after mitigation is used externally in the form of paste or liniment in cases of muscular rheumatism and inflammatory joint afflictions. Internally, it is administered in nasal catarrh, tonsillitis, sore throat, gastric disorders, debility and fevers of inflammatory origin.

PHYTOCONSTITUENTS

The roots of *A. ferox* contain 0.5 to 0.15% alkaloids. The principal alkaloid is aconitine. Alongside aconitine are found small quantities of compounds of related structure viz., pseudaconitine, hypaconitine, mesaconitine, jesaconitine, lycaconitine, neopalline, napelline etc. (Bruneton, 1999). Nine unknown norditerpenoid alkaloids viz., chasmaconitine, crassicauline A, falconericine, bikhakonine, pseudaconine, neoline, senbusine A, isotalatizidine and columbianine were obtained from the processed and unprocessed roots of *A. ferox* (Hanuman and Katz, 1994a,b). Other norditerpenoid alkaloids found in the roots are bikhaconitine, pseudaconitine, eratroylbikbaconine, and veratroyl pseudaconine (Hanuman and Katz, 1993). In addition, four new lipoalkaloids- lipopseudoaconitine, lipopolyunaconitine, lipoindaconitine and lipobikhaconitine were isolated from the root tubers of the plant (Rastogi and Mehrotra, 2005).

BIOLOGICAL ACTIVITY

Aconitum roots possess a number of pharmacological activities, some of which may be rationalized by the constituent aconitine (Hikino *et al.* 1979). The aconite alkaloids are neurotoxins. The molecule binds well to the nerve cell membrane and prevents normal closing of sodium channel. Aconite preparations have been used as sedatives, analgesics and cardiotonics. Aconitine first stimulates and then paralyzes the sensory nerves. Both internally and externally it depresses the activity of the peripheral terminations of the nervous system. In small doses, the heart is unaffected, but with large quantities it acts as a cardiac irritant and slows down the heart and pulse rate (Anonymous, 1985).

Aconite tuber is used in the form of aconite tincture. As a decongestant, it is an ingredient of medications, generally syrups, used to relieve unproductive cough (Bruneton, 1999). Hexane and chloroform soluble extracts of Indian aconite shows antipyretic activity in rabbits receiving subcutaneous yeast injections (Ikram *et al.*, 1987). It is also used as analgesics (Murayama *et al.*, 1984), anti-inflammatory (Tang *et al.*, 1984) and anti-arrhythmic (Chen *et al.*, 1983) agent.

AGROTECHNIQUES

Soil and climate: *A. ferox* prefers a soil slightly retentive of moisture, such as moist loam and flourishes best in shade. It also grows well in loam soil rich in humus and organic carbon. The plant prefers sub-alpine areas around 2000 to 3000 m near the snow line with a cool moist weather. It grows luxuriantly in moist open woods or alpine meadows. The plant also grows well in sloping land.

Land preparation: The soil should be hoed or pulverized thoroughly by ploughing 3-4 times. The land should be prepared into raised beds and furrows as that for potato cultivation. Land preparation should start in early winter.

Seed sowing: Seeds are sown during February-March about 1-2 cm deep in the raised nursery bed. At this stage a sowing distance of approximately 10 x 10 cm is maintained. Seeds may be better germinated under greenhouse conditions during March-April in sand textured soils mixed with decomposed forest litter. The sprouting seeds should be protected from rain-splash and frost. Seedlings could be raised in greenhouse at lower altitude and transferred to its site of plantation in higher altitude to reduce the growing phase of the plants. About 250-300 g seed is sufficient for cultivation in 1 acre area.

Vegetative propagation: Vegetative propagation is usually done by division of roots in autumn. Apical tuber segments with shoot buds are the best for vegetative propagation for vigorous plants, although it can also be propagated by middle and basal segments with buds. The tuber segment should be 2.5-3.0 cm long for vegetative propagation.

The underground portion of the plants is dug out after the aerial portion has died out and the smaller daughter roots that have developed at the sides of old roots are selected for replanting in December-January to form new stock. Vegetative propagation reduces the reproductive cycle of the plant by at least 6 months.

Planting: After about 3-4 months of growth, the seedling (5-10 cm tall) becomes suitable for transfer to the field. Transplanting the seedlings or tuber segments should be done in June-July of the following season in raised beds. The young roots or the root segments should be planted in 10 x 10 x 10 cm pits at 30 x 45 cm spacing. In case of seed raised plants also, similar spacing is maintained. Straw roofing should be provided to protect the plants from excessive rains. Vegetative growth phase lasts 3-4 years before leading to reproductive phase. About 30,000 plants are required for covering 1 acre area.

Irrigation: Frequent watering is required till the plants are 6 months old. No irrigation is required during monsoon but a good drainage system should be established to prevent waterlogging. Weekly irrigation is essential during the winter and during dry seasons.

Manuring: During land preparation, the soil should be treated with 6 *tonnes* of leaf litter per acre. During the winter a mulch of decomposed leaf is preferred to keep nutrition and to maintain moisture content of the soil.

Intercultural practices: Immediately after germination the plant around the roots should not be disturbed. Weeding should be performed during monsoon in 1-2 weeks interval. During the winters 1-2 weeding is sufficient.

Harvesting: Harvesting is done in October-November after the completion of their reproductive phase when the aerial parts dies down, but before the bud that is to produce the next years stem has begun to develop. Plants raised from tuber segments complete their reproductive phase by the end of third year. The roots are dug up, sorted over, the smaller ones laid aside for replanting and the plumper ones reserved for drying. The apical portions of the mature tubers are also removed for planting. Upon digging out, the roots are washed in cold water, trimmed of all rootlets and then dried. The roots may be longitudinally sliced to hasten drying. Drying may at first be done in open air spread thinly or they may be spread on clean floors or wooden shelves in a warm place. The roots may also be dried quickly by artificial heat in a drying room. When dried, the roots should be brittle and snap when bent.

Yield: The yield of *A. ferox* tuber is very low under natural conditions. However, under standardized cultivation practices, the tuber raised plants grown in greenhouses and transferred to the field at high altitudes yields about 350 kg of tubers and roots per acre land.

ECONOMICS OF CULTIVATION OF A. FEROX /ACRE LAND AREA:

Inputs			Output			Net income (Rs.)	Cost-benefit ratio
Particulars	Cost (Rs.)	Total input (Rs.)	Items	Yield (Kg.)	Income (Rs.)		
Planting material	10,000	31,000	Tubers, rootlets (dried)	350	1,40,000	1,09,000	4.51
Land preparation	5,000						
Fertilizers	6,000						
Maintenance inter-cultural practices	5,000						
Harvesting & packaging	5,000						

IN VITRO PROPAGATION

Micropropagation of Monkshood has been successfully carried out using nodal segment axillary buds and apical segments etc. The explants were sterilized successively in 70% ethanol for 1 min, 0.5% NaOCl (having 2 drops Tween-20/100 ml) for 20 mins followed by two rinses in sterile distilled water. Optimum shoot multiplication in the form of basal rosettes occurred from the explants, when cultured on MS medium containing 1mg/l BA. Phenolic exudation in the medium is controlled by adding 25 mg/l citric acid and 500mg/l PVPP. Rooting of rosettes and shoots took place *In-vitro* after 6 weeks on basal MS medium lacking hormones or supplemented with 0.5 mg/l IAA. Rosettes could also be rooted by transferring directly to peat plugs. The plant produces thick tuberous roots which appear to be functional whether plantlets are rooted *In-vitro* or directly in peat plugs. The rooted plants acclimatize best after keeping at 20°C at high humidity for 4 weeks (Cervelli, 1992).

A balfourii, is one of the common substitutes of *A. ferox* in the Indian market (Nautuyal and Nautiyal, 2004). This plant was micropropagated through callus culture derived from small leaf segments obtained from *In-vitro* sprouted axillary buds. Callus was induced on MS medium containing 4.5 μM BA and 26.9 μM NAA. Shoot induction from the callus was sustained on MS medium containing 4.5 μM BA and 1.4 μM NAA. When transferred to the same medium containing 1.1 μM BA only, the shoots showed profuse proliferation. The shoots were then separated and transferred to MS medium containing 12.3 μM IBA for efficient rooting. After *In-vitro* hardening in the culture room, the plantlets were transferred to a greenhouse where the growth of plants was normal (Pandey *et al.*, 2004). Formation of callus and their growth response was greater when the callus was induced from leaf segments on MS medium containing 0.8 mg/l each of NAA and BAP alongwith 10% coconut milk. Such callus also showed direct organogenesis (Singh *et al.*, 1998, Kuniyal, 1999).