

Sustainable Development and Biodiversity 28

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Jaya Arora *Editors*

# Medicinal Plants

Domestication, Biotechnology and  
Regional Importance

 Springer

# **Sustainable Development and Biodiversity**

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# Preface

Herbal drugs and their preparations are part of all civilizations and evolved with time. With the advent of allopathic modern medicine prepared from pure compounds, decline in practice of herbal medicine was felt. However, because of easy availability of herbal medicine over the counter (OTT), low cost, rarely side effects, and traditional belief resulted in surge in demand all over the world, particularly in developing countries. Traditional medicine in East-Asian countries is very old and herbal based. Several important plants from traditional medicinal plant species of East-Asian and North-American origin have been introduced into official European medicine, followed by their successful cultivation and domestication such as *Schisandra* spp., *Lonicera caerulea*, *Aronia* spp. and *Solidago* spp. With world population nearing 7 billion and spending a US dollar per person on herbal medicine in any form (like tea, decoction, poultice, formulation, or raw plant) will have tremendous impact on economy of several countries. Modern healthcare system is still lacking in rural areas of many developing countries or is not fully equipped. This has become evident in recent pandemic of COVID-19. Therefore, medicinal plants and herbal medicines are backbone of rural healthcare system in traditional system of medicine in several countries and provide nutraceutical for population of the developed countries.

This book is a timely compilation of topics related to medicinal plants as surge in demand has consequently resulted in increased research activities. The demand of medicinal plants and their products cannot meet with increased supply. Still most of the medicinal plants are collected from wild, and pressure on resources makes them vulnerable to extinct. Therefore, this book describes research highlights related to conservation, developing agrotechnology toward domestication for biomass production, conservation through biotechnological methods and incorporation of modern tools of genetic engineering and genome editing. How all these activities can be helpful in rural livelihood improvement is also presented.

This book contains wide spectrum of topics on medicinal plants. Whole contents of 27 chapters are divided into three parts: (I) Domestication and cultivation of medicinal plants, (II) Biotechnology in medicinal plants, and (III) Regional importance of medicinal plants. In these parts, development of agrotechnology and cultivation practices for several important medicinal plant species has been described. Details of productions systems and conservation using biotechnological methods are described

in the second part. Rural livelihood improvement with tourism based on medicinal plants cultivation is discussed in the third part. These chapters are written by various research groups working on these plants and selected from different parts of the world.

This book will be useful for all those dealing with medicinal plants, particularly those working with agrotechnology, biotechnology, herbal drugs and formulations, quality control and policy making. This book is source material for traditional medicine systems of India, China, and other countries. The editors are thankful to all the contributors for their cooperation and patience during the process of book publication. The editors are also grateful to the editorial team of Springer, Dr. Markus Spaeth and Dr. Ineke Ravesloot for their continued professional expertise and support during the book production.

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Prof. Halina Maria Ekiert  
Prof. Kishan Gopal Ramawat  
Dr. Jaya Arora

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# Chapter 1

## Medicinal Plants Domestication, Cultivation, Improvement, and Alternative Technologies for the Production of High Value Therapeutics: An Overview



**Kishan Gopal Ramawat and Jaya Arora**

**Abstract** Medicinal plants are source of several valuable drugs known as natural products or secondary metabolites. Only a handful of medicinal plants are cultivated while most of them are still collected from wild. Due to the high demand for these products, over-exploitation resulted in endangering the species, loss of biodiversity, adulteration of plant materials and products, and the effect on ecosystem. Plants and plant products are used in many traditional medicines for several centuries. To meet the demand of raw plant material for direct use or industrial use, agrotechnologies have been developed for several medicinal plants, alternative biotechnologies (micropropagation, production in cell cultures grown in shake flasks and bioreactor, transfer of gene/s in plant and microbes, modification of biosynthetic pathways, etc.) and microbial production system have been attempted. Understanding seed and floral biology, development of agrotechnologies and introduction into new habitat may improve the availability of raw medicinal plant material associated with the improved downstream process can affect high recovery. Similarly, the use of sophisticated detection methods, high throughput screening methods, genomics and proteomics can through light on genes involved, types of biomolecules, and new sources of known drugs. Biotechnological methods (elicitation, immobilization, cloning of selected strains, hairy root cultures, and gene manipulation) including gene editing can help in improvement in the production system. With ever-increasing population and reliability of herbal medicine, demand for medicinal plants continues to increase; hence, domestication of plants along with new technologies is a demand of time to meet the challenge of supply of uniform raw material. This brief overview presents state of research on medicinal plants and their products.

**Keywords** Medicinal plants · Plant biotechnology · Secondary metabolites · Agrotechnology · Domestication

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## 1.1 Introduction

Plants are called medicinal because of the present of certain secondary metabolites in them which impart profound physiological effect on the mammalian system. These compounds impart curative, additive, or synergistic effects on human health. Though these may be present in the whole plant body, higher concentrations may be present in one or many parts such as stem, root, bark, seeds, or leaves. Though secondary metabolites (not involved in metabolism) are considered as waste products of the plant, many evidences are produced to demonstrate them as plant growth modulators or reused by the producer plant as primary metabolites (involved in primary metabolism). Secondary metabolites are also involved in plant defence (Erb and Kliebenstein 2020). In developing countries, most of the medicinal plants are collected from the wild. In Europe, out of 1300 species used, about 80% medicinal plants are collected from wild (Ramawat 2019a; Ramawat and Goyal 2008; Balunas and Kinghorn 2005). Because cheap labour is involved, most of these materials are collected by illiterate labour resulting in problems of identification, deliberate adulteration, inappropriate part collection, and damaging to the plant and ecosystem. The consequence of uncontrolled collection and commercialization is habitat loss, the encroachment of land by alien species, and unavailability of medicinal plants. This puts pressure on the wild population of medicinal plants and the rate of disappearance has accelerated particularly in developing countries like India, China, Nepal, Kenya, Tanzania, and Uganda (Chen et al. 2016). Therefore, the development of cultivation practices, understanding floral and seed biology, improvement of secondary metabolites content in plants, and developing alternative technologies are ways to save medicinal plants from becoming endangered. It is important to introduce and domesticate wild plants for their sustainable utilization and ensure a continuous supply of uniform material for human welfare (Hua et al. 2018; Tanga et al. 2018; Ramawat 2019b).

In developing countries, herbal medicine is the backbone of the traditional systems of medicine like Ayurveda in India (4500–1600 BC), Chinese traditional medicines (3000 BC), Jamu (Indonesia 800 AD), Kampo (Japan 500 AD), Thai medicine (1200 AD) or Unani medicine (Astutik et al. 2019; He 2015; Ramawat and Goyal 2008; Sheehan and Hussain 2002). Most of these countries, where traditional medicine is used by a large number of people, have invested substantially in herbal research. Traditional systems of medicine, whether Indian Ayurveda or Chinese, are based on plant extract whereas allopathic system works on a pure active molecule. Thus, plants of interest to Ayurveda are different than those required for allopathic system (Ramawat and Goyal 2008). Traditional systems of medicine are safe, time tested, and cheap for the people. Traditional systems contain a wealth of information about use of medicinal plants and scientific study of this information has led to new knowledge about medicinal plants and several drug discoveries (Suntar 2019). With increase in living standards in the recent past, consumption of herbal drugs for wellbeing and longevity has increased tremendously. These countries are also major producers of herbal drugs (Vashist et al. 2016) which are further handled by traders, not trained or

educated in knowledge about medicinal plants (Barata et al. 2011). Because of high bulk is involved, now value addition is done by preparing and selling extract or active ingredients which involve good manufacturing practices (GMP), and many of them either not follow them or ignore. It is estimated that about 0.5 million tons of raw material comprising of about 60,000 medicinal, nutraceutical, and aromatic plants have been traded (WHO 2015). The world market for pharma and related compounds in 2022 will be about \$1.12 trillion (Subramani 2018).

In this review, we summarize the importance of medicinal plants, efforts for their cultivation towards availability, alternative technologies for their production, conservation, and improvement. Biotechnological methods (elicitation, immobilization, cloning of selected strains, hairy root cultures, and gene manipulation) including gene editing will not only save the medicinal plants but also improve the quality of human life.

## 1.2 Historical Use of Medicinal Plants

Some of the landmarks in the description and use of medicinal plants are Ayurvedic, Egyptian descriptions, and Chinese medicine system where the time of collection, preparation of herbal medicine and dosage to be given are described in detail. Particular emphasis is given in Ayurveda about the collection and combination of herbs with minerals which is about 5000 years old. Cultivation and/or use of medicinal plants like *Cannabis sativa*, *Papaver somniferum*, and *Conium maculatum* is as old as human civilization. Modern herbal knowledge includes first pharmacopoeia by Greek physician Galen (129–200 AD), isolation of morphine from *P. somniferum*, quinine from *Cinchona* species, and pilocarpine from *Pilocarpus jaborandi* (Ramawat 2019a; Ramawat and Goyal 2008). Details of historical account and old literature describing medicinal plants are given elsewhere (Khan 2018; Petrovska 2012). Several human diseases in the history of human civilization are well documented, and plants are used as curative agents. Not only humans but animals and insects can recognize the presence of secondary metabolites in plants and their biosynthesis in plants or their neutralization by insects/animals, both have co-evolved with the evolution of these species (Ramawat and Goyal 2019). It is evident that old descriptions are about plant morphology and its usage, whereas (see Chap. 25) plant-based drugs were developed with the development of modern scientific tools and a strong base in chemistry. In the last 2–3 decades, metabolomics, molecular markers, high throughput screening, and genetic manipulations added new dimensions in the medicinal plant research.