

# Medicinal Plants- Significance, Status and Scope for Seed Sector – A Review

V SANKARAN

Formerly NSC-New Delhi and Krishidhan Seeds, Jalna, Maharashtra  
sankaran510@gmail.com

(Received September 2022; Revised November 2022, December 2022)

## Historical Background

India has a rich heritage of plant-based drugs for use both as preventive and curative medicines. Nature has bestowed India with an enormous wealth of medicinal plants, due to which the country is also referred as 'Medicinal Garden' of the world [1]. The nation has a long history of classical healing systems, many of which are based on plants. In India, out of the 17,000 species of higher plants, 7500 are known for medicinal value /uses [2]. This proportion of medicinal plants is the highest known in any country for the flora existing in that country. *Ayurveda*, the oldest medical system in the Indian sub-continent refers to approximately 2000 medicinal plant species, followed by *Siddha*-1121, *Unani*-751 and *Homeopathy*-482 species [3]. More than 90% of their formulations are typically plant based. The efficacy of herbs-based systems mainly depends upon the use of genuine raw materials of good quality and standardized ingredients in the manufacture of medicines of these systems.

The *Charak Samhita*, an age-old document of 700 BC on herbal therapy, have reports on 340 herbal drugs and their indigenous uses [4] and *Sushruta Samhita* [600 BC] served as the historically important medical compendia for the early detection and treatment of several ailments affecting not only humans but also a wide range of animals. The '*Materia Medica*' of 100 AD authored by the Greek physician Pedanius Dioscorides described 600 medicinal plants with pictures of 400 species [5]. So also, "*Hortus Malabaricus*," the 17th-century latin botanical treatise on Indian medicinal plants, deals with the medicinal properties of the flora of the Malabar region along with the Western Ghats stretch in Kerala, Karnataka, and Goa.

South Asia is home to many valuable Traditional Systems of Medicine (TSM). Ayurvedic system dates back to 5000

BC. Along with the Unani, Siddha and Tibetan systems, these TSMs remain important for everyday health and livelihood for millions of people. Himalayan sage scholars of Traditional Medicine have said "*Nanaushadhi Bhootam Jagat Kinchit*" i.e. there is no plant in the world, which does not have medicinal properties [6]. However, for better focus and attention, those plants/ species which possess high degree of therapeutic value and are of exclusive practical use in herbal medicines-formulations are designated as 'Medicinal Plants'.

## Importance of Medicinal Plants and Herbal Medicines

Ayurvedic herbs are time tested for their health and other benefits. Known to have no side effects, they bring about a balanced harmony between mind and body. They rejuvenate the whole system instead of focusing on one specific organ or body part; and have a holistic approach aiding in proper absorption and digestion. They are not necessarily disease specific but act as preventive medicine that positively impacts the overall health and well-being by boosting the immune system. They are known to be effective in treating a wide range of ailments including cancer and autoimmune diseases.

Medicinal plants are the natures' gift for the mankind and are accessible, affordable and culturally appropriate sources of primary health care for more than 80% of Asia's population. Poor and marginalized, who cannot afford or access formal health care systems, are especially dependent on these culturally familiar, technically simple, financially affordable and generally effective traditional medicines. As such, there is widespread interest in promoting traditional health systems to meet the primary health care needs of the population. According to the World Health Organization [WHO], 80% of the world population, especially from developing countries depend mainly on plant-based drugs for primary health care [6].

Throughout South Asia, the use of medicinal plants in meeting family's primary health care and nutrition needs is traditional and embedded in all cultures—a practice dating back to at least four thousand years in many countries [7]. The age-old traditional values attached with the various forest types and the varieties of forest products (i.e. medicinal plants) have gained tremendous importance in the present century [8,9]. Furthermore, the cosmetic industries are increasingly using natural ingredients in their products, and these natural ingredients include extracts of several medicinal plants [10].

Medicinal plants have significance in religious purposes too. *Origanum vulgare*, *Saussurea obvallata*, *Ocimum sanctum*, *Calotropis gigantia*, *Cedrus deodara*, *Cynodon dactylon*, *Aegle marmelos*, *Juniperus communis*, *Musa paradisiaca*, *Nardostachys grandiflora*, *Zanthoxylum armatum*, *Ficus benghalensis*, *Terminalia chebula* and *Ficus religiosa* are some examples of the plants used for both medicinal as well as religious purposes. The Buddhist community in northern India regards *Terminalia chebula* as an important medicine as well as sacred fruit [11].

There are physical ailments in humans, which are cured by different species of the same genus. For example, the malarial fever is controlled by many species of *Swertia* (e.g. *Swertia chiraiyta*, *S. angustifolia*, and *S. cordata*). Similarly, different species of *Berberis* (e.g. *Berberis aristata*, *B. asiatica*, *B. lycium*, *B. chitria* and *B. jaeschkeana*) are used as a source for *berberidine* to cure certain eye diseases. Many medicinal plant species are used for curing more than one disease and as a result, these species are under pressure due to over collection from the wild. For example, *Hemidesmus indicus* is used to cure 34 types of diseases; *Aegle marmelos*- 31, *Phyllanthus emblica*- 29, and *Gloriosa superba*- 28 diseases types [9,12].

An exhaustive account has brought out 121 Indian plants species showing “positive anti-fertility activity” and 64 with “negative activity” relating to both the males and females in animals in general and humans in particular. So also, is the listing of the particulars of 75 species found to have ‘anti-diabetic properties’ to varying degrees [13].

The indigenous communities use some medicinal plant species as a source of food, fodder, timber as well as various other ethnobotanical purposes. For example, apart from the use of *Myrica esculenta* and *Terminalia bellirica* as medicines, the fruits of these species are

edible, the leaves are used for fodder and the wood is used for fuel [14].

Apart from health care, medicinal plants are the main alternate income-generating source for the underprivileged communities and therefore, strengthening this sector may benefit and improve the living standard of poor people [15, 16].

### Status of Medicinal Plants and Herbal Medicines

Many medicinal plants are annuals, some are biennials while many others are perennials; so also, many are herbs in growth habit and others are shrubs or trees. Within these, many are seed propagated and some are vegetatively propagated and some others by both the means. Some are typically temperate types while many belong to tropical agro-ecology. The floral biology, pollination, reproduction, seed development and maturation, seed characteristics – anatomy, physiology etc of medicinal plants exhibit a wide range.

India and China are two of the largest countries in Asia, which have the richest arrays of registered and relatively well-known medicinal plants [17]. According to the Botanical Survey of India, India is gifted with more than 8,000 types of medicinal plants; and is blessed with land, environment and climate in various regions that are favourable for medicinal plants cultivation. It is the 2<sup>nd</sup> largest exporter of medicinal plant products, next only to China, and has > 3lakh herbal medicine preparations / formulations used in ancient healing systems such as *Ayurveda*, *Unani*, *Siddha* and *Homeopathy*.

The Traditional Knowledge Digital Library of the Council of Scientific and Industrial Research [CSIR] has records of > 35,000 herbal medical formulations used in Ayurvedic system of medicine [18]. A great deal of traditional knowledge on the use of various plant species is still intact with the indigenous people, especially in the mountainous areas such as the entire stretch of the Himalayas, Western /Eastern ghats, Vindhya, Aravalli ranges, tribal belts etc. [19].

India has 15 Agro-Climatic zones and medicinal plants are distributed across all bio-geographic regions, diverse habitats and landscapes. Around 70% of India's medicinal plants are found in the tropical areas and around 30% in the temperate and alpine areas. About 6198 species of plants are estimated to be used for human and veterinary health care in the country, out of which about 2,700 plants species are reportedly used in the codified Indian

Systems of Medicine viz. Ayurveda (1800 species), Siddha (500 species) and Unani (400 species). In addition to their use in preparation of traditional medicines, the medicinal plants are being used in the preparation of various pharmaceuticals and health products under the modern system of medicine [20].

It is estimated that about 7,500 plants are used in local health traditions in most of the rural and tribal villages in India [21]. Herbal treatments are the most popular form of traditional medical system. Reviewing the status of medicinal plants species under threat, it was noted that the various codified Indian systems of medicine are complemented by a strong inheritance of non-codified and non-commercial living folk healthcare traditions which are carried through generations and practised by around one million folk practitioners spread across 29 states, 7 union territories, 497 cities, 7,935 towns and 6,49,481 villages and nearly 140 million rural households in the country. Such is the complexity and magnitude of the issue [22].

Apart from the more than 9992 licensed pharmacies with 717319 registered practitioners of Ayurveda, Siddha, Unani and Homeopathy in India, there are many unregistered herbal practitioners who prepare their own traditional herbal formulations for curing various diseases. They all need quality raw material with the required active ingredients from the medicinal plants for the preparations. All such available herbal formulations need to be standardized for their efficacy. Such scientifically prepared medicine will place herbal medicine in a proper perspective and help in getting a broad global market [11]. Bulk of the documentation and research on indigenous uses of Medicinal Plants is focused on the human aspect. But, many of those species have value in curing livestock diseases as well. So also, some of them have pesticidal properties too for plant protection.

The WHO estimated the demand for medicinal plant-based raw materials as approximately US \$14 billion per year; and growing at the rate of 15 to 25% annually, the demand is likely to increase to more than US \$5 trillion in 2050[23]. In India, the medicinal plant related trade is estimated to be approximately US \$1 billion per year [Joshi et al 2004]. The quantity of export of Ayurvedic products from India tripled between two financial years, 2001–2002 and 2002–2003 [9]. The first effort to assess the demand and supply of medicinal plants of selected 162 species in the country was made by the National Medicinal Plant Board (NMPB) during 2001–02, through

the Centre for Research, Planning and Action (CERPA). A total of 1,389 botanical entities corresponding to 960 plant species were enlisted under trade [24].

Reviewing the status of medicinal plants, those ten which have high demand in the indigenous drug industry have been shortlisted in Table 1 [6].

**Table 1**

Species	Common Name	Plant Part
<i>Bacopa monnieri</i>	Jal Brahmi	Whole plant
<i>Centella asiatica</i>	Brahmi/Mandukapaini	Whole plant
<i>Andrographis paniculata</i>	Kalmegh	Whole plant
<i>Withania somnifera</i>	Aswagandha	Root
<i>Asparagus racemosus</i>	Satawar	Tuberous root
<i>Chlorophytum arundinaceum</i>	Safed musli	Tuberous root
<i>Gymnema sylvestre</i>	Gurmar	Leaves
<i>Plumbago zeylanica</i>	Chitrak	Root
<i>Tinospora cordifolia</i>	Guduchi	Stem
<i>Desmodium gangeticum</i>	Salpanni	Root

Examining the herbal trade, it was noted that in a span of ten years (2005–14) the demand and supply of the medicinal plants recorded a tremendous increase. A total of 242 species are enlisted as high commercial demand (> 100 MT/year) during 2014–15; out of which 114 (47%) are collected from forests, 59 (25%) are wild and collected from landscapes outside forests, 54 (22%) are obtained from cultivation and 15 species (6%) are imported. India's domestic herbal industry is represented by 8,610 licensed herbal units (Ayurveda-7,494, Unani-421, Siddha-328 and Homeopathy-367) spread across different states in the country [24].

Indian Medicinal Plants Database developed by the NMPB-Gol and the Foundation for Revitalization of Local Health Traditions [FRLHT]-Bengaluru incorporates 7263 botanical names of Indian medicinal plants and those names have been correlated to more than 1,50,000 vernacular names in ten different languages of India. So is the complexity in identification and limitation in the confidence in usage.

The ICAR-NBPGR is conserving 8,071 accessions of Medicinal & Aromatic Plants in seed gene bank, 178 accessions in vitro genebank and 1,041 in cryo genebank [25, 26].

Medicinal and aromatic plants area in India is still small-6.34 lakh ha out of a total agricultural area of 1597 lakh

ha; but, is rising annually @10%. Rajasthan has the highest area under these crops with a share of 56%, followed by UP (25 %). Others are- MP (11%), TN, Kerala, Punjab and Chattisgarh (2%each), and AP and Bihar (1%each). Production-wise, MP ranks 1st with 44% share followed by Rajasthan [19%]. Others- TN, Chattisgarh , NE/Arunachal and Kerala have 16%, 8%, 7% and 1% share respectively. Though Karnataka has < 1% share in area, its production is 2% of total country's production.

In 1983, the National Health Policy recognized that the large treasure of Ayurveda, Siddha, Unani, Homeopathy and Naturopathy had not been adequately utilized; and therefore, steps are needed to move towards a meaningful integration of the indigenous and modern systems of medicine. Since the Indian subcontinent is well known for its diversity of forest products and the age-old healthcare traditions, there is an urgent need to establish these traditional values in both the national and international perspectives, realizing the ongoing developmental trends in traditional knowledge [27].

### Some Issues of Concern that Need Urgent Attention

According to the 'All India Trade Survey of Prioritised Medicinal Plants, 2019', the demand for high-value medicinal plants increased by 50%, while the availability declined by 26%. This led to increased habitat degradation and levels of over-exploitation by pharmaceutical industries resulting in 65 species (i.e. 10% of the total species) falling into the critically endangered, endangered, vulnerable and nearly threatened categories. Urgent action is required to mitigate this looming threat to plant diversity.

More than 95% of the 400 plant species used in preparing herbal medicines by various industries are harvested from wild populations in India. Several of these medicinal plant species have slow growth rates, low population densities, and narrow geographic ranges [28, 29] and therefore, they are more prone to extinction [30]. Furthermore, the indigenous knowledge on the use of lesser-known medicinal plants is also rapidly declining [12]. The continuous exploitation of several medicinal plant species from the wild [31] and substantial loss of their habitats during the past 15 years [32] have resulted in scarcity of many high value medicinal plant species.

Crude collection from the wild/nature by the "raw produce /material trade" without caring / leaving for regeneration /recouping seriously affects the species survival. Also,

the plant material collected from these sources is replete with the problems of adulteration, mis-identification and contamination by other species or parts thereof. The wild genotypes/ varieties also differ for the presence of the active constituents / ingredients between production locations. All such conditions can have adverse consequences.

It is important to note that out of the 242 species in high commercial demand (> 100 MT per year), 72% is sourced largely from wild plants as roots, bark, wood stem or the whole plant. s poses a major concern as it affects the survival of these species. Unsustainable collecting activities coupled with limited or no efforts of replenishment/cultivation, long duration life cycle of plants, climate change and developmental activities have led to rapid decline in the availability of many medicinal plant species in the country during the last three decades. This has culminated into a large number of species falling into threatened group at country as well as global level [22].

The projected escalating demand for medicinal plants has led to the over-harvesting of many plants from the wild resulting in the loss of their existing populations. For example, large quantities of the Himalayan yew (*Taxus baccata*) were gathered from the wild since its extract, Taxol, was found useful in the treatment of ovarian cancer resulting in severe decline in the tree population. *Aconitum heterophyllum*, *Nardostachys grandiflora*, *Dactylophiza hatagirea*, *Polygonatum verticillatum*, *Gloriosa superba*, *Arnebia benthamii* and *Megacarpoea polyandra* are other examples of medicinal plant species which have been overexploited for therapeutic uses and have subsequently been placed today in rare and endangered categories [11].

The instant 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. The continuous exploitation of several medicinal plant species from the wild and substantial loss of their habitats during past 15 years have resulted in population decline of many high value medicinal plant species over the years [33]. In India more than 90% of medicinal plants are facing threat due to excessive and unsustainable collection, utilization, overexploitation or un-skilled harvesting [34].

Based on global rates of plant species threatened with extinction, it is estimated that around 1,000 medicinal

plant species may be under threat in different eco-systems across India [35]. Harvesting shoots and leaves of medicinal plants affect their photosynthetic capacity, and the potential for survival and effective propagation. Medicinal plants' tolerance to harvest varies with climatic / agro-ecological conditions; the temperate herbs being highly vulnerable. Furthermore, rising demand with shrinking habitats leads to the local extinction of many medicinal plant species [36].

The unsustainable collection from the wild not only puts the species at the risk of extinction but also affects the quality of the medicines manufactured due to the absence of standardization in the quality parameters of the raw material. Also, such over-exploitation, indiscriminate harvests and continuous depletion of medicinal plants have not only affected their supply and loss of genetic diversity, but have seriously affected the livelihoods of indigenous people living in the forest margins [37]. Impact is more severe where/when the actual propagating material i.e. seed, rhizome, bulb, tuber, cutting etc., is itself the 'herbal medicine' or the 'raw material' for the final formulation, either as such or after some form of conditioning, processing etc., to get the final herbal formulation.

The medicinal plants sector is also fraught with the perils of substitutes and adulterants traded freely in the market, thus affecting the quality and efficacy of the end product. In addition, issues relating to accurate identification of species and variation in quality plague the sector. The largely unregulated and non-transparent supply chain contributes to the various constraints restricting the growth of the herbal sector in India. The farmers' lack of access to technical knowhow and advisory support for cultivation and management of medicinal plants adds to the issue as they often land up purchasing poor-quality planting materials from various sellers and at a very high price.

### **Need for Cultivation / Farming of Medicinal Plants**

The disturbing trends and issues of serious concern enumerated above point out the urgent need to systematically introduce and promote practical, as well as planned farming / cultivation of medicinal plants in agricultural fields as is practised for the wide range of agricultural and horticultural species/crops. An all-encompassing solution lies in cultivating the medicinal plants outside forest areas and as a part of existing farm

lands. This would also enable farmers to enhance their income through crop diversification with the high-value medicinal plant species.

Cultivation of genuine, genetically pure, authentic genotypes / varieties of medicinal plants in ideal locations/ seasons adopting proper crop husbandry practices is extremely important for getting the raw material of required quality. This will not only provide the quality raw material required by the herbal-medicines industry but also will leave the plants in the wild to survive in nature and thereby help conserve the wild genetic diversity of the species. Cultivation will ensure the production of uniform material from which standardized products can be consistently obtained. It will also permit better species / genotype identification, improved quality control, and increased prospects for genetic improvements. Planned and enhanced medicinal crop cultivation will give impetus to Crop Improvement and Seed Improvement activities / efforts.

Studies conducted on the agro-forestry component of medicinal plants suggest that since many medicinal plant species prefer to grow under forest cover, agroforestry offers a convenient strategy for their cultivation as well as conservation through: i) integrating shade tolerant medicinal plants as lower strata species in multi strata system, ii) cultivating short cycle medicinal plants as intercrops in existing stands of tree crops, iii) growing medicinal tree as shade providers and boundary markers, and iv) inter-planting medicinal plants with food crops [37].

Medicinal plants of 58 species from 24 botanical families adapted to arid zones/ environments without affecting the pharmacological properties have been elaborated in earlier works [38]. Considering the threats due to 'climate change' and 'global warming', such plants adapted to arid situations is a welcome feature; and such species deserve priority attention.

Information on the propagation of medicinal plants and their agro-technology is available only for a few medicinal plants. Therefore, developing agro-technology should be one of the thrust areas for research.

### **National Medicinal Plants Board (NMPB)**

In order to promote the medicinal plants sector, the Government of India set up the National Medicinal Plants Board (NMPB) on 24th November 2000. Now the Board is under the Ministry of AYUSH (Ayurveda, Yoga &

Naturopathy, Unani, Siddha & Homoeopathy), Gol. The primary mandate of NMPB is to develop an appropriate mechanism for coordination between various ministries/ departments/ organizations and implementation of support policies/programs for overall (conservation, cultivation, trade and export) growth of medicinal plants sector both at the Central /State and International levels. The aim is to encourage cultivation of medicinal plants and its sustainable management across the country and to reduce pressure on the collection from wild habitats in the forests.

The NMPB has developed several policies, strategies and programs for conservation, proper harvesting, cost-effective cultivation, research and development, processing, marketing of raw material to promote and develop medicinal plants sector. It has highlighted the fact that although about 6000 plants are used in the folk and documented systems of medicine in India, less than 50 species of medicinal plants are cultivated to any sizeable extent. Limited knowledge on cultivation practices for such medicinal plants and non-availability of authentic planting material are some of the main constraints

NMPB funding is available for:

1. survey and inventory of medicinal plants
2. in-situ conservation and ex-situ cultivation of selected medicinal plants
3. production of quality seed-planting materials
4. knowledge transfer through education and training
5. strengthening research
6. promotion of global and domestic markets
7. bulk production of medicinal plants and ensuring supply of quality planting materials
8. expansion of selected medicinal plants
9. value addition in harvesting, processing and marketing medicinal plants
10. developing innovative marketing methods.

Recently (2019) NMPB prioritized 32 medicinal plants listed below for conservation: *Aconitum ferox* Wall ex Ser., *Aconitum heterophyllum* Wall., *Aegle marmelos* (L.) Corr., *Andrographis paniculata*, *Asparagus racemosus* (Burm.) Nees, *Bacopa monnieri* (L.) Wettst., *Berberis aristata* DC., *Cassia angustifolia* M Vahl. = *Senna alexandrina* Mill.,

*Chlorophytum borivillianum* Sant., *Coleus barbatus* Benth., *Commiphora wightii* (Arn.) Bhandari, *Crocus sativus* L., *Embelia ribes* Burm.f., *Embllica officinalis* Gaertn. = *Phyllanthus emblica* L, *Garcinia indica* Choisy, *Gloriosa superba* L., *Glycyrrhiza glabra* L., *Gymnema sylvestre* (Retz.) R. Br., *Nardostachys jatamansi* (Retz.) R. Br., *Ocimum sanctum* L., *Phyllanthus amarus* Schum. & Thonn., *Picrorhiza kurroa* Royle ex Benth., *Piper longum* L, *Plantago ovate* Forsk., *Rauvolfia serpentina* Benth. ex Kurz., *Santalum album* L., *Saraca asoca* (Roxb.) De Wilde, *Saussurea costus* (Falc.) Lipsch, *Solanum nigrum* L., *Swertia chirata* Roxb. ex Flem., *Tinospora cordifolia* Miers., *Withania somnifera* Dunal [39].

### Prioritized list of Medicinal Plants for cultivation under the Scheme of NMPB

The NMPB has been promoting cultivation of medicinal plants in a Mission mode under the Centrally Sponsored Scheme of “National Mission on Medicinal Plants (NMMP)” since 2008-09; which is now continuing under National AYUSH Mission. It aims to reduce the collection from wild natural habitat in forests. The Ministry of AYUSH has prioritized 95 medicinal plants species as listed below for subsidizing their cultivation across the nation ie 75% subsidy for highly endangered, 50% for the critically declining and 30% for other therapeutic plants species which need support.

[a] Plants eligible for 30% subsidy: 55 species :*Neem, Brahmi, Tulsi, Pippali, Isabgol, Ghritkumari, Dalchini, Tejpat, Kapoor, Chirmati, Vach, Adusa, Smaller Galanga, Kalmegh, Artemisia, Shatavari, Pashnabheda, Pinarnava, Senna, Patang, Sadabahar, Malkagani, Mandookparni, ShwetMusali, Arni, Aparajita, Patherchur, Shankhpushpi, Krsnasariva, Rotalu, Bringaraj, Amla, Kokum, Vai Vidang, Gudmar, Kapurkachari, Anantmool, Kurchi, Trivrit, Indian Crocus, Chandrasur, Konch, Bhumiamlaki, Bakuchi, Manjishha, Flannel Weed, Kathel-badhi, Makoy, Madhukari, Pawad, Arjuba, Bahera, Harad, Giloy, Nirgundi, and Aswagandha.*

[b] Plants eligible for 50% subsidy :27 species: *Katha, Beal, Mulethi, Shirish, Varun, Gambhari, Chitrak, Agnimanth, Beejasar, Ashok, Timoor, Patala, Rohitak, Sarp Gandha, Indian Valerian, Prishnaparni, Hrdhatri, Archa, Vidarikand, Nagakeshar, Jivanti, Pushkarmool, Kalihari, Sarivan, Atropa, and Satvin.*

[c] Plants eligible for 75% subsidy:13 species: *Chandan, Jatamansi, Atees, Agar, Guggal, Kutki, Raktachandan,*

*Bankakri, Syonaka, Vatsnabh, Daruhaldi, Kuth, and Chirata.*

### **Voluntary Certification Scheme for Medicinal Plants**

To ensure Good Agricultural Practices (GAP) and Good Field Collection Practices (GFPC) in therapeutic plants and improve their quality and well-being, the NMPB and Quality Council of India (QCI), jointly propelled in 2017 a Voluntary Certification Scheme for Medicinal Plant Produce (VCSMPP). The Scheme is designed to enhance the availability of certified quality medicinal plants and raw materials in the country and also boost exports. The seeds chosen for cultivation purposes must meet the botanical and varietal purity requirements. This is the critical issue.

This scheme will benefit medicinal plant producers, collectors, traders, societies, manufacturers of herbal medicines and consumers as well because of the assured quality of the medicinal plants and herbs. It will also reduce the risk of recall and rejection, increase buyers' confidence and will provide assured legal compliance and sustainable collection as well.

Recognising the significance of 'Product Quality', the NMPB in collaboration with the WHO Country Office for India, developed a set of guidelines and standards for Good Agricultural Practices (GAP) and Good Field Collection Practices (GFPC) in 2009. Those guidelines and standards targeted specifically the medicinal plant producers in the Indian subcontinent. Soon thereafter an initiative by the FAO resulted in the publication "Good Agricultural & Collection Practices for Medicinal Plants" [40] which further simplified the standards into a format for easier comprehension and adoption by farmers and collectors.

Attempts are being made by different organizations to cultivate various medicinal plant species, including the rare and endangered categories. Agro-technology for about 20 species of rare and endangered medicinal plants of the northern India has been developed by different organizations [41]. The Ministry of AYUSH supports studies for development of agro-techniques under the 'Central scheme for development of agro-techniques and cultivation of medicinal plants', specifically for those plants that are used in AYUSH systems of medicine.

Projects to study 115 medicinal plants were given to 33 specialized scientific organizations among agriculture/

horticulture universities and the R&D institutions of CSIR, ICAR, and ICFRE (Indian Council of Forestry Research and Education). The Project envisaged experimental cultivation of selected species for three to four years specifically for the development of agro-techniques. Based on the studies under the Project, the NMPB published the recommended agro-techniques [crop husbandry practices and harvest /post-harvest management] for 50 plant species in volume -1 [42] and for another 32 in volume -2 [20]. This set of 82 publications on agro-techniques serves as authentic guidelines for medicinal plants cultivation.

Based on the multiple ranges of usage of medicinal plants [43] and reviewing the wide range of issues relating to medicinal plants, [11] 50 important medicinal plants listed in Table-1 were found to be in short supply and need to be prioritized for R&D including seed research.

### **Seed Technology Research in Medicinal Plants**

A critical review of the seed technology research studies on Medicinal Plant species shows that bulk of them relate to seed dormancy -its kind, nature, duration and breaking methods, viability /germination / vigour potential, seed testing specifications for pre-treatment, media/ substratum, light, temperature and days to count. A few studies touched about seed longevity, storability, environment influence, processing etc. From among the research information located, 120 results based on the studies on 75 Medicinal Plants are summarised in Table-2 to give a broad idea of the issues and species covered and to bring out the vast areas yet to be studied.

According to [20, 42] Anon [2008/2014], no specific treatment is required to enhance seed germination in *Phyllanthus amarus*, *Psoralea corylifolia* and *Rheum emodi*. Harvest indices for seed maturity were identified and used for harvesting three medicinal crops viz Ashwagandha [44], Isabgol [45] and Ocimum [46].

In the seed production studies at the Medicinal and Aromatic Plants Research Station, Rajendranagar, Hyderabad, protection from contamination by foreign pollen was ensured by providing space isolation as follows: Ashwagandha: 200m; Senna: 50m; Kalmegh: 100m; Velvet Bean: 50m; Isabgol: 200m; Palmarosa: 200m; Sweet basil: 200m; and Sacred basil: 200m. This space isolation was supplemented by time isolation of 15-20 days and barrier isolation of 5-6 ft height 4 ft height around Basil, Ashwagandha and Senna [47].

Seed extraction procedures for *Solanum nigrum* especially for long term conservation have been elaborated by [48].

Developing Field and Seed Standards for Seed Propagated-*Ashwagandha*, Isabgol, Makoi [*Solanum nigrum*], Opium and *Sarpagandha* and vegetatively propagated-*Giloe* and *Safed Muesli* is a part of the research projects undertaken by the ICAR-DM&APR, Anand.

In terms of the prescribed Seed Testing Procedures, the Hand Book of Seed Testing [July 1993] published by the Dept of Agriculture, Gol or the ISTA Rules for Seed Testing do not cover the Medicinal Plant species to any significant extent. Similarly, seed quality standards and quality verification procedures applicable for field [seed crop] and seed stages ie Seed Certification Standards and Procedures for Medicinal Plants are yet to be formulated. However, taking into account the studies carried out at three different centres, viz. IARI, DMAPR and IIHR and reported in [49] a set of seed testing protocols for Germination Test for 25 important medicinal plants in terms of the medium, temperature, days to first / final counts and pre-treatment have been brought out [50]. The said protocols are summarized in Table-3. For the same 25 species the suggested seed standards ranged as follows depending upon the crop:

- [a] Pure Seed [minimum]- from 96.0 to 99.0 % and conversely the Inert Matter [maximum] ranged between 1.0 to 4.0%;
- [b] Other Crop Seeds[maximum]-None or 5/kg or 10/kg;
- [c] Total Weed Seeds[maximum]-None or 5/kg or 10/kg;
- [d] Objectionable Weed Seeds[maximum]-None; and
- [e] Germination [ minimum]: as low as 35% for *Rauvolfia serpentina* and 50% for *Carum carvi*. For the remaining 23 species the suggested germination minimum ranged among 60, 65,70 75, 80 and 85 depending on the germination potential under optimum test conditions.

The gap in seed technology research in medicinal plants is thus evident. Research on almost every branch of Seed Science and Technology is required.

### Seed Production Techniques/ Procedures

The agro-techniques for medicinal plants production already available for 82 species [Anon, 2008 / Anon,2014] will need to be suitably modified/ elaborated to include

those precise agronomic-cultural-production practices / techniques relevant for quality seed crop production and handling, harvest / post-harvest management, seed processing-conditioning-treatment, storage and packaging specifications. Further, ideal locations need to be identified by arranging seed production trials / studies for producing the required quantities of quality seed, in time, economically etc for each medicinal plant variety chosen by the seed sector for seed production.

### Seed Sector's Attention to Medicinal Plants

Seed sector cannot remain a silent spectator any more. A moderate beginning should be made soon for quality seed production / availability of at least some selected medicinal plants. Production and supply of quality seed of medicinal plant species in required/sizeable volumes on commercial scales is totally an unexplored, untouched area available for the Indian Seed Sector to attend to immediately. Despite the significant growth / development of the Indian Seed Industry, there is no visible organized effort for a planned seed program devoted to Medicinal Plants in the country. Neither the Public nor Private seed sector has so far made any attempt worth mentioning.

The standard Seed Chain ie BS-FS-CS has not been established as yet in the medicinal plants varieties; and no BS indent is figuring for any variety in this Group. On the other hand, the ICAR- NARS in general and the ICAR-Dte of Medicinal &Aromatic Plants Research [DMAPR], Anand in particular have excellent knowledge base on the subject; and an array of superior varieties with known 'pharmacognosy' properties are available in this large group. Superior varieties developed by public research and formally released by the system are listed in Table-4. The Annual Reports of the ICAR-DMAPR, Anand have elaborate information on the wide range of issues relating to medicinal plants.

Non-availability of Quality Seed of superior varieties of medicinal plants is a serious constraint. *Thus, in the absence of comprehensive Seed Improvement Programs in medicinal plants, the benefits of Crop Improvement in this group have not reached the commercial crop production stage in full.* Regular availability and use of quality seed of superior varieties/ proven genotypes will help the herbal medicines industry to get the raw material / produce from the medicinal plants in conformity to the required specifications /concentration of the active components-ingredients so as to ensure the technical quality of the final herbal formulation. For making a

beginning with quality seed from authentic sources, the Centres for Quality Planting Materials of Medicinal Plants listed in Annexure 1 may help.

Comprehensive all-inclusive Seed Plans/ Schemes for medicinal plants are needed at the National / State levels; as was and is adopted for many other crops under HYVP, TMOP, ISOPOM, NFSM, AFDP, MIDH etc. To start with, 'Seed Propagated' species, soon followed by the 'Vegetatively Propagated' kinds / species should be considered for launching the seed program. Growing/ maintaining perennial tree type medicinal plants in institutional farms / lands will not only yield quality raw material for supplying to the herbal industry but also provide the propagating material for farmers to grow those medicinal trees in their location.

### Way Forward

In the light of the details brought out in the preceding Sections, 20 Action Point as listed below are suggested for facilitating the seed sector to contribute to the growth and development of the Medicinal Plants industry:

- i. The seed sector should explore suitable interactions- tie ups with reliable factories/firms producing herbal formulations- medicines etc; and assess the status of commercial crop production of medicinal plants in terms of Area, Production, Productivity, Production Locations, etc leading to a dispassionate SWOT of the herbal industry in general and medicinal plant seed program in particular;
- ii. An in-depth study of the item/ product wise, market segment wise annual seed requirement and the ideal seed production seasons/locations is needed for launching the program in a phased manner.
- iii. Detailed consultations with the Govt's NMPB, AYUSH, CSIR-CIMAP- Lucknow, ICAR-NRCMAP- Anand, ICAR-NBPGR-New Delhi, National Institute of Siddha-Chennai, PPV&FRA, Central/ State Forest Depts, GI Authorities, herbal -pharmaceutical industry etc will help in formulating / implementing the seed program.
- iv. Choice of medicinal plant species / varieties from among those released by the National Agricultural Research System and time-tested traditional genotypes in nature and their identification characteristics for roguing, inspection etc during seed production;
- v. Estimates of the total quantity of seed sown [ie total area x average seed rate], Seed Replacement Rate [if any known], net seed requirement for the crop / variety;
- vi. Assessment of the likely scope available for the Seed Sector to take up seed production and marketing as a commercial activity;
- vii. Estimates of the net seed demand to be met ie to be produced / marketed by the Seed Sector; crop variety / genotype wise quantity required, seed market locations, pricing issues, economic viability of the venture;
- viii. BS Sources for the varieties/genotypes identified for the seed program;
- ix. Identification of ideal locations for producing the required quantities of quality seed, in time, economically etc for each variety chosen by the seed sector for seed production;
- x. Seed Production Techniques / seed crop husbandry practices for the species selected / identified for Quality Seed Production /Handling- including precautions/ challenges, if any; basic essential botanical and agronomical aspects of the species.
- xi. Seed quality specifications- for field / seed stages and precise verification procedures and arrangements thereof;
- xii. Seed processing-conditioning, storage and packaging specifications and procedures for the species taken up for the seed program;
- xiii. Seed production economics, seed pricing issues / policies – for seed production-procurement / sales;
- xiv. Need oriented training to all concerned- officials, personnel, seed growers, dealers, farmers-etc on the various relevant issues involved in seed production and handling and commercial crop production.
- xv. Consolidation of research-based information on medicinal plants with special reference to Seed Science & Technology aspects;
- xvi. Developing precise syllabus for post-graduation studies in MPs Seed Science & Technology and implementing the same through Term Papers, Projects, Thesis / Dissertation etc.

- xvii. National / State Level short, medium and long term plans for cultivation of selected species/varieties that will generate seed requirement;
- xviii. Seed Plans/Schemes to make available required quantities of quality seed of those species/ varieties included in the 'Area Coverage Programs ';
- xix. Strong linkages between the Seed Sector and Herbal Industry to facilitate seed program planning and implementation, assured off take of quality seed produced and production of quality raw products for the herbal industry; and
- xx. Explore ways and means of contributing to enhanced herbal industry's export market by producing and making available high quality seed of those species / varieties involved in the herbal product export so as to facilitate growing 'export oriented commercial crop production'.

## REFERENCES

1. AHMADULLAH M, AND NAYAR MP (1999). Red data book of Indian Plants (Peninsular India): Botanical Survey of India.
2. SHIVA MP (1996). Inventory of Forestry Resources for Sustainable Management and Biodiversity Conservation: Indus Publishing Company, New Delhi.
3. ANON (2004). Herbals in India: Opportunities, Challenges and Initiatives by NABARD. National Bank for Agriculture and Rural Development, India.
4. PRAJAPATI ND, PUROHIT SS, SHARMA AK, KUMAR T (2003). A Handbook of Medicinal Plants. *Agrobios*, Jodhpur.
5. VANANGAMUDI K, V ANBUKKARASI AND M PRABHU (2019). Medicinal Seeds and Plants. Pub. Scientific Publishers [India], Jodhpur-342001, pp 372.
6. NARESH BABU, SK SRIVASTAVA, M PRUSTY AND TAPASWINI SAHOO (2019). Medicinal and Aromatic Plant Production Technologies —a step towards farmwomen prosperity. *Technical Bulletin No. 28*. ICAR- Central Institute for Women in Agriculture, Bhubaneswar, 751 003, Odisha.
7. FRANSWORTH, NR. AND DD SOEJARTO (1991). Global Importance of Medicinal Plants. In: Akerely, O. V. Heywood and H. Synge (Eds.) Conservation of Medicinal Plants. Cambridge University Press, Cambridge.
8. STEIN R (2004). Alternative remedies gaining popularity. The Washington Post. Friday, May 28.
9. KALA CP (2004). Revitalizing traditional herbal therapy by exploring medicinal plants: A case study of Uttaranchal State in India. In *Indigenous Knowledges: Transforming the Academy, Proceedings of an International Conference*-Pennsylvania State University, 15-21.
10. KIT (2003). Cultivating a Healthy Enterprise. In Bulletin 350 Royal Tropical Institute, Amsterdam, The Netherlands, 2003.
11. KALA CP, PP DHYANI AND BS SAJWAN (2006). Developing the medicinal plants sector in northern India: challenges and opportunities. *Journal of Ethnobiology and Ethnomedicine*, **2**: 32.
12. KALA CP (2005). Current status of medicinal plants used by traditional *Vaidyas* in Uttaranchal state of India. *Ethnobotany Research and Applications*, **3**: 267-278.
13. NAGARAJAN S, HC JAIN AND GS AULAKH (1982). Indigenous plants used in fertility control. Cultivation and Utilization of Senna in India. In Cultivation & Utilisation of Medicinal Plants, Pub by Regional Research Lab-CSIR, Jammu, 558-583.
14. DHYANI PP AND DHAR U (1994). *Myrica esculenta* Box myrtle *Kaphal*: A promising underexploited tree crop of the Himalaya: G.B. Pant Institute of Himalayan Environment and Development. Almora
15. MYERS N (1991). The world's forests and human population: the environmental interconnections. *Population and Development Review*, **16**: 1-15.
16. LACUNA-RICHMAN C (2002). The socio-economic significance of subsistence non-wood forest products in Leyte, Philippines. *Environmental Conservation*, **29**: 253-262.
17. RAVEN PH (1998). Medicinal plants and global sustainability: The canary in the coal mine. In *Medicinal Plants: A Global Heritage, Proceedings of the International conference on medicinal plants for survival*: International Development Research Center: New Delhi, 14-18.
18. PUSHPANGADAN P AND KUMAR B (2005). Ethnobotany, CBD, WTO and the Biodiversity Act of India. *Ethnobotany*, **17**: 2-12.
19. FAROOQI, NA, MAJILA BS, AND KALA CP (2004). Indigenous knowledge systems and sustainable management of natural resources in a high-altitude society in Kumaun Himalaya, India. *Journal of Human Ecology*, **16**: 33-42.
20. ANON (2014). Agro-techniques of selected medicinal plants: Volume-II. National Medicinal Plants Board -Department of AYUSH, Ministry of Health and Family Welfare, GoI, 131.
21. SHAKYA, AK (2016). Medicinal plants: future source of new drugs. *Int J Herb Med*, **4**: 59-64.
22. GOWTHAMI, R, NEELAM SHARMA, RUCHIRA PANDEY AND ANURADHA AGRAWAL (2021). Status and consolidated list of threatened medicinal plants of India. *Genet Resour. Crop Evol*, **68**(6): 2235-2263.
23. SHARMA AB (2004). Global Medicinal Plants Demand May Touch \$5 Trillion By 2050. *Indian Express-Monday March 29, 2004*.
24. GORAYA GS AND DK VED (2017). Medicinal plants in India: an assessment of their demand and supply. National Medicinal Plants Board, Ministry of AYUSH, Government of India. New Delhi and Indian Council of Forestry Research and Education, Dehradun.
25. SINGH N AND S PANDEY (2019). Conservation of plant genetic resources. In: Pandey CD, Koul AK, Vimala Devi S, Singh N, Radhamani J, Pandey S, Jacob SR, Aravind J, Gore PG, Gupta V, editors. International training programme on management of plant genetic resources for officers from directorate of seed testing and certification ministry of agriculture, Baghdad, Republic of Iraq. ICAR-NBPGR, New Delhi, p. 27.
26. SHARMA N, R PANDEY AND R GOWTHAMI R(2020). *In vitro* conservation and cryopreservation of threatened medicinal plants of India. In: Rajasekharan P.E, Wani S.H (eds) *Conservation and utilization of threatened medicinal plants*. Springer, India, 181-228.

27. ANON (1983). National Health Policy. New Delhi: Ministry of Health and Family Welfare, Government of India.
28. KALA CP (1998). Ethnobotanical Survey and Propagation of Rare Medicinal Herbs in the Buffer Zone of the Valley of Flowers National Park, Garhwal Himalaya. International Centre for Integrated Mountain Development, Kathmandu.
29. NAUTIYAL S, KS RAO, RK MAIKHURI, KS NEGI AND CP KALA (2002). Status of medicinal plants on way to Vashuki Tal in Mandakini Valley, Garhwal, Uttaranchal. *Journal of Non-Timber Forest Products*, **9**: 124-131.
30. JABLONSKI D (2004). Extinction: past and present. *Nature*, **427**: 589.
31. KALA CP (2003). Commercial exploitation and conservation status of high value medicinal plants across the borderline of India and Nepal in Pithoragarh. *The Indian Forester*, **129**: 80-84.
32. FAO (2003). State of the World's Forests: Food and Agricultural Organization, Rome.
33. UNIYAL RC, MR UNIYAL AND P JAIN (2000). Cultivation of Medicinal Plants in India: A Reference Book. TRAFFIC India and WWF India, New Delhi.
34. KUMARI GP, C JOSHI AND LM TEWARI (2011). Diversity and status of ethno-medicinal plants of Almora district in Uttarakhand India. *Int J Biodivers Conserv*, **3**: 298-326.
35. FRLH TENVIS (2016). Centre on Medicinal Plants. Medicinal plants under threat. <http://envis.frlht.org/overview.html>. Accessed on 6.4.2020.
36. TICKTIN T (2004). The ecological implications of harvesting non-timber forest products. *Journal of Applied Ecology*, **41**: 11-21.
37. RAO MR, MC PALADA AND BN BECKER (2004). Medicinal and aromatic plants in agro-forestry systems. *Agroforestry Systems*, **61**: 107-122.
38. ZOHARA YANIV AND DAN PALEVITCH (1982). Effect of Drought on the Secondary Metabolites of Medicinal and Aromatic Plants - A Review. In Cultivation & Utilisation of Medicinal Plants, Pub by Regional Research Lab-CSIR, Jammu, 1-12.
39. NMPB (2020b) National Medicinal Plants Board (NMPB). <https://www.nmpb.nic.in/> (accessed on 31.1.2020).
40. BEN HERON (2010). [Rev/Ed. Satyabrata Maiti ]: Good Agricultural & Collection Practices for Medicinal Plants. FAO, New Delhi, pp.46.
41. ANON (2003). Conservation Assessment and Management Prioritization for the Medicinal Plants of Jammu-Kashmir, Himachal Pradesh and Uttaranchal. *Foundation for Revitalization of Local Health Traditions*. Bangalore.
42. ANON (2008). Agro-techniques of selected medicinal plants: Volume-I. National Medicinal Plants Board -Department of AYUSH, Ministry of Health and Family Welfare, Gol, pp 262.
43. JAIN SK (1991). Dictionary of Indian Folk Medicine and Ethnobotany. Deep Publications, New Delhi.
44. RAJESHWARA R, ER RAKUT, G NAGARAJU AND G ADINARAYANAM (2012). Opportunities and challenges in the cultivation of *Ashwagandha (Withania somnifera (L.) Dunal)*. *Journal of Pharmacognosy*, **3**(2): 88-91.
45. MEENA VD, ML DOTANIA, BP MEENA, H DAS AND BEENA (2015). Isabgol (*Plantago ovata* Forsk.) – Medicinal Herb: Good source of Income Generation in water scarcity Regions, Popular *Kheti*, **3**(4): 2-5.
46. JITENDRA K (2014). Cultivation of *Ocimum* Technical Report. Directorate of Medicinal and Aromatic Plants Research, ICAR.
47. PADMA M (2019). Quality Seed Production in Medicinal and Aromatic Crops. *Int. J. Curr. Microbiol. App. Sci.* **8**(7): 604-611.
48. AGONG SG (1993). Seed extraction procedures for long term conservation of *Solanum nigrum*. *Seed Sci & Technol*, **21**(2): 447-451.
49. PARIHAR SS, M DADLANI , DAS MANISH AND K BHANUPRAKASH (2013). Seed Standards and Seed Testing Protocols for Medicinal Plants. Technical Bulletin No. TB-ICN: 117/2013, 63p.
50. MANISH DAS AND AP TRIVEDI (2021). Essentiality of seed standards for cultivation of medicinal plants — a review. *Current Horticulture*, **9**(2): 9-16, July-December 2021.