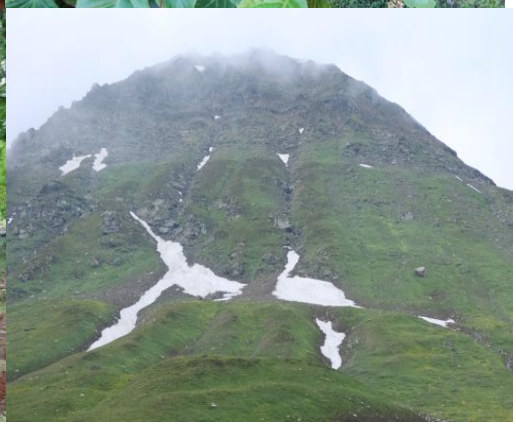
Cluster Level Plan for Conservation, Resource Development and Management of Medicinal & Aromatic plants in Clusters of Kullu & Lahaul & Spiti districts





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Project for Improvement of Himachal Pradesh Forest Ecosystems Management & Livelihoods
Himachal Pradesh Forest Department
Potters Hill, Summer Hill, Shimla-171005, H.P.

Submitted by

G.B. Pant National Institute of Himalayan Environment (NIHE)
Kosi-Katarmal, Almora 263 643, Uttarakhand
and
G.B. Pant National Institute of Himalayan Environment (NIHE)
Himachal Regional Centre, Mohal, Kullu 175 126, Himachal Pradesh

Project Team

Project Coordinator	**:**	**Dr. R.S. Rawal, Director, NIHE, Kosi-Katarmal, Almora, Uttarakhand**
Nodal Person	**:**	**Dr. I.D. Bhatt, Scientist-F & Head CBCM Group, NIHE, Almora, Uttarakhand**
Project PI	**:**	**Dr. K.S. Kanwal, Scientist-D, NIHE, Himachal Regional Centre, Kullu, H.P.**
Project Co- PI	**:**	**Dr. Kishor Kumar, Tech. Gr. IV (2), NIHE, HRC, Kullu, H.P.**

Researchers/
Community Facilitarors : Ms. Sheetal Sharma, Community Facilitator
Dr. Kaushalya Devi, SPF
Mr. Subodh Negi, Community Facilitator
Ms. Shivani Sharma, Community Facilitator
Mr. Kamlesh Kumar, Community Facilitator
Mr. Priydarshan Pandey, JPF

CONTENT

Outcome 2: A cluster level plan for conservation, resource development and management of Medicinal & Aromatic Plants, which will include strategies, methods and interventions for in situ conservation, plantation/enrichment in the forest areas and JFM area, cultivation of medicinal plants on the non-forest land, sustainable harvesting of different Medicinal & Aromatic Plants and strategies for post-harvest management.

Background

As per agreement signed between Himachal Pradesh Forest Department (HPFD) through Society for Improvement of Forest Ecosystems Management and Livelihoods in HP and G.B. Pant National Institute of Himalayan Environment' (NIHP), Kosi-Katarmal, Uttarakhand, India, a cluster level plan for conservation, resource development and management of Medicinal & Aromatic Plants has been developed as per Output 2 of the contract. The plan for Conservation, Resource Development and Sustainable Management of NTFPs and Medicinal Plants have been prepared in consultation with different stakeholders (FD, VFDs members, Right holders and producers, Producers organisation/ societies, local pharmacies/ processing industries, etc.). National medicinal plant board has also been consulted for formulation of MAP development plan. Medicinal plant species have been prioritized for each cluster through wider consultative process, field surveys and review of relevant literature for resource development, value addition and marketing. Package of practice of selected species for each cluster has been provided in the present report. The details of each component is provided in the following sections:

Based on review of literature, field survey of study area, interviews of vaidays/traditional healers, multi stakeholder consultation and discussion with subject experts the following species have been selected in each cluster for cultivation in Kullu and Lahaul & Spiti district (Table 1):

Table 1: species shortlisted for each cluster for cultivation for each cluster

S.No.	Name of Cluster	Prioritized species
1	Kullu	*Picrorhiza kurrooa, Angelica glauca, Berberis aristata, Trillium govanianum, Dactylorhiza hatagirea, Hedychium spicatum*
2	Jari	*Aloe barbadensis, Polygonatum verticillatum, Viola canescens, Bergenia ciliata, Withania somnifera*
3	Larji	*Picorhiza kurooa, Aconitum heterophyllum, Nardostachys jatamansi, Taxus contorta, Jurinea macrocephala, Valeriana jatamansi*
4	Keylong	*Inula racemosa, Sausurea costus, Hippophae rhamnoides, Picrorhiza kurrooa, Bunium persicum, Aconitum heterophyllum*

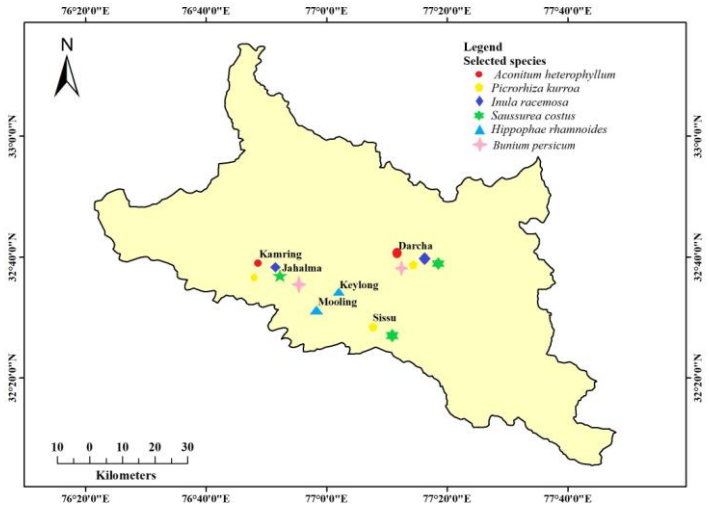

Fig.1: Distribution of selected species of Keylong Cluster of Lahaul & Spiti District

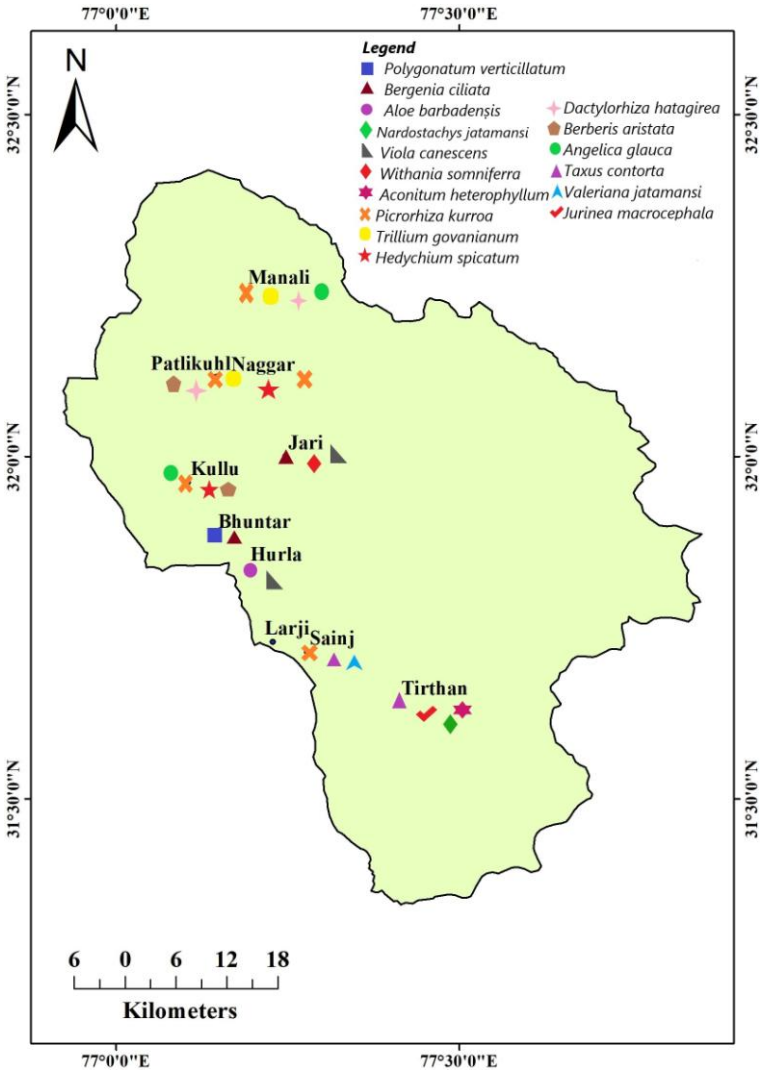

Fig.2: Distribution of selected species of Kullu, Jari & Larji Clusters of Kullu District

Keylong Cluster (Ropsang, Yoche, and Kamring VFDs)

The Keylong cluster falls under Lahaul & Spiti district of Himachal Pradesh. The district is situated between 31°44'57'' - 32°59'57''N latitudes and 76°46'29'' - 78°41'34''E longitudes covering an area of 13,835 sq km, is comprised of two subdivisions, Lahaul with headquarter at Keylong and Spiti subdivision at Kaza. It is located in the north-east of intersection of the Chandra Valley, the Bhaga Valley, and the Chenab Valley on the banks of Bhaga River. Lahaul & Spiti being an essential part of Indian cold desert area of North-western Himalaya located in alpine arid zone of Himachal Pradesh. Lahaul & Spiti area is characterized with sparse vegetation comprising of annual and perennial herbs like *Aconitum, Allium, Aquilegia, Arnebia, Astragalus, Dactylorhiza, Dracocephallum, Epilobium, Gentiana, Geranium, Polygonum, Potentilla, Rheum, Rumex, Saussurea, Taraxacum and Thymus species.* Shrub flora comprises *Lonicera, Caragana, Hippophae, Myricaria, Rosa, Juniperus* and *Salix*. Tree layer is dominated by *Abies, Pinus, Salix, Betula* species in the Lahaul area (Samant et al., 2007). Although the region experiences extreme climate conditions, but the area harbours valuable medicinal plant wealth being used in traditional systems of medicine for ages. Inspite of the fact modern health facilities in the area are available, still people depend on the traditional medicinal system. The herbal healers locally called, Amchis in the region, generally prescribe medicine to the patients. Among the leading systems of medicine, Amchi System of Medicine is one of the native traditional systems of medicine being practiced in Lahaul & Spiti. *Inula racemosa, Sausurea costus, Hippophae rhamnoides, Picrorhiza kurrooa, Bunium persicum, Aconitum heterophyllum* species are proposed for cultivation in the Keylong cluster.

Jari Cluster (Khokan-2, Kapil Muni, Chhman, Upper Jia VFDs)

Jari cluster comprises of Khokan-2, Kapil Muni, Chhman, Upper Jia VFDs of Bhunter, Hurla and Jari forest ranges. Some village of Jari clusters are located in low altitudinal ranges. Jari village is the first sizeable village in Parvati valley near Bhunter town. Jari village is located in Kullu Tehsil of Kullu district in Himachal Pradesh, India. The total geographical area of village is 373 ha. A total of 402 species of medicinal plants belonging to 266 genera and 98 families has been recorded from Parvati valley (Sharma and Samant, 2014). The representative medicinal plants species in the area are *Swertia*, *Berberis, Nepeta, Plantago, Polygonum, Anaphalis, Chenopodium, Erigeron, Impatiens, Rhododendron*, *Thalictrum*, *Allium, Amaranthus, Anemone, Artemisia, Arisaema, Astragalus, Bupleurum, Corydalis, Codonopsis, Delphinium, Geranium, Hypericum, Juniperus, Rheum, Rhamnus, Rumex, Potentilla, Galium, Pedicularis, Scrophularia, Polygonatum, Viola and Urtica*. *The following medicinal plant species Aloe barbadensis, Polygonatum verticillatum, Viola canescens, Bergenia ciliata, Withania somnifera, Pistacia intergerrima* are proposed for cultivation after multi-stakeholder consultation and field survey in Jari cluster.

Larji Cluster (Talara, Kanon, Thatibir, & Chakurtha VFDs)

Larji cluster comprises Talara, Kanon, Thatibir, & Chakurtha VFDs of Sainj and Tirthan forest ranges of Banjar Tehsil of Kullu District. The village of Larji cluster are located around 50km distance from District headquarters Kullu. The notable medicinal plant species of the Larji cluster are *Picrorhiza kurrooa, Valerian jatamansi, Nardostachys jatamansi, Aconitum heterophyllum*, *Dioscorea deltoidea, Plantago ovata, Taxus contorta, Trillium govarianum, Jurinea macrocephala, Bergenia ciliata, Dactylorhiza hatagirea, etc.* Out of which the following species *Picorhiza kurooa, Aconitum heterophyllum, Nardostachys jatamansi, Taxus contorta, Jurinea macrocephala, Valerian jatamansi* are selected for cultivation in the various VFDs of Larji cluster.

Kullu Cluster (Manali, Naggar, Patlikulh, Bhutti, Kullu ranges)

Kullu district covers an area of 547.71 sq. km, which includes 204 Gram Panchayts. The district comprises of 4 subdivisions; Manali, Kullu, Banjar and Anni. The largest valley in the district is called the Kullu valley, which is also known as the valley of Gods. Kullu district of Himachal Pradesh is well known medicinal plants hot spot in the western Himalaya. Medicinal and Aromatic Plants play significant role in the subsistence economy of the people of Kullu, especially those living in the rugged and impoverished hills, mountains and rural interiors. The following important medicinal plant species *viz. Picrorhiza kurroa, Hedychium spicatum, Zanthoxylum armatum, Aconitum heterophyllum, Podophyllum hexandrum, Polygonatum verticillatum, Morchela esculanta, Hedychium spicatum , Asparagus racemosus, Heracleum candicans, Trillidium govanianum,, Allium humile, Acorus calamus, Viola pilosa, Taxus contorta, Dioscorea deltoidea, Bergenia ligulata, Origanum vulgare* are recorded from the Kullu cluster. After stakeholder consultation workshops held at Patlikul, and Kullu forest department and field survey *Picrorhiza kurrooa, Angelica glauca, Berberis aristata, Trillium govanianum, Dactylorhiza hatagirea, Hedychium spicatum* are proposed for cultivation in the Kullu cluster.

Cluster level development plan for prioritized medicinal plant species

Cluster level development plan for selected/prioritized medicinal plant species of Kullu & Lahaul & Spiti districts have been formulated after multi-stakeholder consultation workshop, field survey, discussion with experts and experience/learning of GBPNIHE ongoing medicinal plant cultivation and conservation projects. The plan is particularly focused on the conservation, resource development and sustainable management of selected species. All practical strategy and activities have been proposed in the formulated plan for successful implementation. The details of various interventions/activities of plan are provided in the following points:

1. **Community mobilization for cultivation of medicinal plants**- Majority of populace living in the study area i.e. Kullu & Lahaul & Spiti are farmers and mainly involved in the cash crop cultivation such as Apple and vegetable cultivation. They are also generating good

income from various tourism activities in Kullu & Lahaul valley. Therefore, it is very essential to create more awareness about importance of medicinal plant cultivation among farmers with the help of local level research institutions. Awareness workshop, consultation meeting, community mobilization programs would be organized to motivate and mobilize community for cultivation of identified medicinal plants species in each cluster. GBPNIHE, HRC,Kullu is currently implementing a DBT funded project on cultivation of *Picrorhiza kurroa* and *Swertia chirayita* medicinal plants in farmers field in the Himachal Pradesh. Therefore, institute may help Jadi Buti Cell of JICA Project for organization of community mobilization programs and cultivation of medicinal plants in the Kullu & Lahaul & Spiti district.

2. **Formation of cluster level MAP farmers association** - Medicinal plant cultivators association needs to be established in each cluster for sustainable management and promotion of medicinal plant cultivation in various clusters. VFDs, BMC members, and medicinal plant cultivators, village heads would be the main members of the farmers association
3. **Strengthening infrastructure facilities for cultivation**: A preliminary survey would be conducted in each cluster with the help of subject experts to assess the status of basic infrastructure facility, land availability, location of cultivation sites, soil quality, field nursery area, irrigation, and other facilities. Afterwards, infrastructure facilities for medicinal plant cultivation such as nurseries, polyhouse, green house, irrigation facilities, procurement of modern nursery tools, implements etc. would be strengthened/developed in each cluster.
4. **Establishment of medicinal plant nurseries:** Cluster level on field medicinal plant nurseries (atleast 2 nurseries in each cluster) needs to be established for providing the quality planting material (QPM) to farmers for cultivation of selected medicinal plants. Procurement of QPM from authentic source will be required. Basic infrastructure like Poly-house/net house, irrigation network needs to be developed for medicinal plant nurseries. Training on nurseries development and raising of QPM will be imparted by the local R&D institution and subject experts to the farmers/cluster members. Medicinal plants having desired Ayurvedic Pharmocopeia of India (API) standards as per herbal industry requirement will be planted at the experimental nursery either through seeds or vegetative cuttings, whichever is suitable for getting enough planting material for on field cultivation.
5. **Cultivation of medicinal plants in the farmers land-** QPM will be distributed among farmers for cultivation in farmers field. Support for land preparation, FYM will also be provided to farmers to encourage medicinal plant cultivation in the farmers field from JICA project. It is also cultivated in the available forest land in consultation with the forest department. Training & capacity building program on cultivation, agro-techniques, pest management, crop monitoring of medicinal plants needs to be organized for farmers & Forest deptt. officials to provide technical support by the local institutions. Good agriculture practice, good collection practice and good post harvest management for selected medicinal plants needs to be followed in each cluster. Arrangement for

medicinal plant crop insurance may also be facilitated to farmers for crop security. Total area of medicinal plant cultivation needs to be finalized in consultation with the local communities and forest department.

6. **Strengthening trade and enterprises development of MAPs sector in the landscape:** There is need to explore opportunity of public-private-community partnerships for medicinal plant cultivation, value addition and marketing of medicinal plant based trade and enterprise. Buy back arrangement with ayurvedic pharmaceutical companies would also be required for direct sale of cultivated medicinal plants. In addition to this, buyer seller meet may also be organized to enhance for trade and enterprise development. This activity could be implemented with the support of medicinal plants boards, research institutions, farmers, industry.
7. **Establishment of medicinal plant collection and processing centre-** There is need to establish medicinal plant collection center at each cluster. These centers would be well equipped with Infrastructure facilities such as storage, drying, processing, packaging facility for each cultivated crops. District level processing facility of medicinal plants may also be established for value addition of different medicinal plants.
8. **Creation of Medicinal Plant Conservation and Development Areas (MPCDAs)-** MPCDAs would be created for in-situ conservation of threatened and important medicinal plants in each cluster. It will help in the conservation of wild genetic resources of medicinal plants species.
9. **Training and capacity building programs-** Regular training and capacity building programs would be organized for diverse range of stakeholders for the conservation, resource development and sustainable management of selected medicinal plant species of Kullu & Lahaul & Spiti district. Training at regular intervals needs to be provided to farmers on standard cultivation practices for growing, harvesting, drying, processing, storage, packaging, marketing, etc. with the support of local research institute.

   Training will emphasize on primary processing encompassing the immediate post-harvest treatments to medicinal plant material to ensure it is free from foreign matters, untargeted plant materials and other contaminants. Exposure visit of farmers to medicinal plant cultivation areas and herbal industries involved in manufacturing of medicinal plants could also be carried out to give firsthand experience to medicinal plant cultivators of various clusters.
10. **Implementation of Access and Benefit Sharing (ABS) mechanism-** Biological Diversity Act, 2002 regulates access to biological resources for commercial utilization as specified under Section 7 of the Act. Govt. of India has notified Guidelines on Access to Biological Resources and Associated Knowledge and Benefits Sharing Regulations, 2014. ABS mechanism needs to be implemented for access and utilization of medicinal plants resources in each cluster as per ABS regulation, 2014 with the support of HP State Biodiversity Board and State Forest Department.
11. **Institutional support for implementation of cluster level development plan-** Institutional technical support is very essentially required for smooth implementation of various activities of envisaged in cluster level development plan. GBPNIHE, HQ and HRC, Kullu are presently engaged in the conservation and cultivation of medicinal plants in the various districts of Uttarakhand and Himachal Pradesh. Institute has also established

field trials of medicinal plant cultivation, Genetic Resource Center (GRC) for quality planting material, standardized agro-techniques of cultivation of Himalayan medicinal plants. Training and capacity building programs of diverse range of stakeholders in medicinal plant cultivation and setup of marketing linkage of MAP with the help of Zandu Foundation for Health Care (ZFHC) are also being carried out by the institute in the Himachal Pradesh. Therefore, GBPNIHE may be involved as technical/knowledge partner for smooth and successful implementation of cluster development plan in the Kullu & Lahaul & Spiti districts of HP.

12. **Constitutions of District level and Cluster level monitoring committees**: Jadi Buti cell of JICA project may constitute District level and Cluster level monitoring committees for overall supervision and smooth implementation of various activities of proposed cluster level development plan. Grievances of cultivators and other concern stakeholders could be resolved by the above committees. Subject expert may also be included as member of these committees for providing time to time technical inputs to the committees. Meeting/consultation of committee may be organized at regular intervals to discuss the progress of the cluster development plan.

Package of Practice (PoP) for selected prioritized MAP's

Package of practice for medicinal plants comprises good agriculture practice for medicinal plant cultivation, good field collections practice and standard practice for post harvest management of medicinal plants. For large scale cultivation of medicinal plants by farmers, standardization of package of practice is essentially required. However, appropriate agro-techniques and post-harvest technologies for most medicinal plant species of Himalayan region is lacking. Therefore, the standardization of agro-techniques for commercially viable medicinal plants and their large-scale cultivation in farmers' fields are necessary for their conservation and to reduce pressures on natural habitats. Further, the establishment and maintenance of nurseries and herbal gardens in different altitudinal zones with stocks of medicinal plants are required to ensure the availability of quality planting material and to introduce medicinal plants as cash crops.

Package of practice of selected/prioritized species have been documented through review of existing literature, consultation with medicinal plant cultivators and traders, Regional cum Facilitation Center (RCFC), NMPB, subject experts etc. GBPNIHE, NMPB and other universities and research institutes of Himachal Pradesh have developed Package of practice of several high value medicinal plants of the Himalayan region. All the above-mentioned sources have been referred for preparation of Package of practice of prioritized medicinal plants species of clusters of Kullu & Lahaul & Spiti districts. The details of the same is provided in the following sections:

1. ***Saussurea costus*** **(Falc.) Lipsch.**

- **Climate and Soil:** This species require a cool and humid climate and can be cultivated between 2000-4200m. Sandy and porous soils with good depth is suitable for vigorous development of roots.
- **Seed collection, drying and storage:** The fruits should be harvested in September or October and sun-dried for a week before threshing. Seeds should be segregated from the fruits and air-dried for 1-2 weeks. Seeds retain viability for longer period when stored under low temperature (4°C).
- **Field Preparation and Manuring:** The field should be ploughed 2-3 times upto 2 feet deep. About 15 t of FYM or forest humus is required for one hectare of land.
- **Propagation and cultivation:** The propagation and multiplication can be done through seeds or root cuttings. Seeds are generally sown at a distance of 30 cm in the fields or during September and October inside greenhouse. Seedlings can be transplanted after 6-9 months growth. At lower altitudes, seeds becomes mature earlier than that in high altitudes. After flowering, plants continue to grow, but the root quality deteriorates. Root cuttings (2.5cm, collar zone) are be used for vegetative propagation which gives early yield than seeds. About 50,000 seedlings or 3.5-4kg seeds are required for one-hectare land.
- **Irrigation and weeding:** In the initial stage, watering is required every day. After one year, relativity little irrigation is required. During summer months irrigation is required twice a week. Weeding is required 3-4 times in a month during summer and rainy seasons.
- **Harvesting:** Harvesting is done in 2-3 years after seed maturation during late September and October. The plants raised through root cuttings become mature in 1-2 Years. After seed maturation, the root becomes hollow and quality deteriorates. Hence, for higher yield and quality, roots are harvested immediately after seed maturation.
- **Post-harvest management:** After harvesting, roots are washed with running tap water, cut into small pieces and kept in partial shade for drying. After drying, roots are packed in gunny bags for storage in dry chambers or marketed.
- **Cost-Benefit analysis:** About 4.65 ton root material can be obtained from one-hectare land. (NMPB, 2006).

2. ***Inula racemosa*** **Hook.f.**

Climate and soil: The conditions of temperate and sub-alpine regions are most suited for the cultivation of *Inula* species. Well-drained, clay-loam soils are ideal for the crop. It prefers open and sunny locations.

Nursery technique

Raising propagules: The crop can be raised through seeds in nursery in November or early March by sowing the seeds in well-prepared nursery beds. Complete germination

obtained in about 50 days. Seedlings are transplanted in the field after about two months of growth.

Propagule rate and pretreatment: About 1 kg seeds are required to raise about 40,000 seedlings, which is required for 1 ha of land. No specific seed treatment is required before sowing.

Planting in the field

- **Land preparation and fertilizer application:** The land should be ploughed lightly in order to loosen the soil and mix organic manure or FYM (farmyard manure). Usually, FYM @ 15 t/ha is applied at the time of land preparation. If inorganic fertilizers are used, half of nitrogen (100 kg/ha) and full dose of phosphorus and potassium at the rate of 100 kg/ha and 50 kg/ha, respectively, can be applied at the time of land preparation.
- **Transplanting and optimum spacing:** The germinated seedlings may be transplanted to the field after about two months. Optimum spacing recommended in the main field is 50 cm × 50 cm. An optimum crop stand of approximately 40 000 plants per ha is accommodated with the above-mentioned plant density.
- **Intercropping system:** Puskarmool is preferred as a sole crop without intercropping.
- **Interculture and maintenance practices:** NPK (nitrogen, phosphorus, potassium) @ 200 kg/ ha, 100 kg/ha, and 50 kg/ha, respectively may be used per year to achieve high biomass yield. Nitrogen is usually applied in two split doses, one as a basal dose and the other (100 kg/ha) as top dressing in six to eight weeks after transplantation. Only manual weeding is recommended twice during the establishment phase of the crop.
- **Irrigation practices:** Light irrigation at an interval of three to four weeks is sufficient to maintain the crop.
- **Disease and pest control:** No serious incidence of disease or pest has been observed in this crop.

Harvest management

- **Crop maturity and harvesting:** The crop is harvested after about one and half years in October–November. Roots are dug after wetting the soil. The roots are cleaned well and soil particles are removed.
- ***Post-harvest management:*** The harvested crop should be cut or sliced into small pieces, dried, and stored in airtight containers. The rootstock and roots should be separated from the aerial portion, chopped into small pieces, and allowed to dry in shade.
- ***Chemical constituents:*** The rootstock and roots contain inulin, alantolactone, β-sitosterol, isoalantolactone, dihydroalantolactone, and its glucosides. Four sesquiterpene lactones have also been isolated from *Inula* sp.
- ***Yield and cost of cultivation:*** The crop is harvested at one and half years of growth. About 80 quintals of dried roots are obtained from 1 hectare cropped area. (NMPB, 2006).

3. *Aconitum heterophyllum* Wall. ex Royle

- **Climate and soil:** Commonly known as Atees/patis, generally prefer sub-alpine and alpine climate, and cultivated between 2000-3000 m altitude in sandy (10 cm deep) soils with rich organic matter. Sandy loam and slightly acidic soil, with pH about 6, has been found to be the best for seed germination, survival, better growth, and yield. Addition of humus or leaf litter to the soil increases survival rate and growth of seedlings at all altitudes. Forest leaf litter also helps in retaining moisture content in the soil. The plant prefers open, sunny sites, and abundant air and soil moisture during summer months.
- **Varieties:** Although no variety has been developed for this plant, yet based on the colour of the tubers, *Aconitum heterophyllum* is classified into white, yellow, red, and black varieties. The white (daughter tuber) variety, with rapid growth and high yield, is considered to be the best. Seeds and tubers collected from alpine meadows (about 3000–4000 m altitude) have better growth, survival, and yield than those collected from alpine pastures between 2500 and 3000 m altitudes
- **Propagation material:** Seeds, tuber segments or young leafy stems can be used as propagules. The fruits (capsules) that turn light brown (before splitting) are collected during late October to mid-November for better germination of seeds. The seeds should preferably be collected during morning hours

Nursery technique

- **Raising propagules:** Seeds have no dormancy period and are sown immediately after collection. They can be sown in sand and FYM (farmyard manure)/compost mixture (1:2) at a depth of 0.5 cm in styrofoam trays in a mist house. Nursery beds of 2 m × 2 m or even smaller size are better for raising seedlings inside the polyhouses. At a depth of 0.5 cm, germination is delayed to some extent, but first true leaf initiation occurs earlier as compared to sowing at other depths. Seeds are sown during October–November or March–April in polyhouses at middle altitudes (1800–2200 m), during February– March in glass houses at lower altitudes (600– 1000 m), and during May–June at alpine sites in open beds or in hot houses. Plants raised from seeds have very slow growth and the cotyledonary phase (pseudomonocotyle) persists for at least one growth season (three to four months). Under polyhouse conditions and sandy textured soil, germination takes about two months to complete. However, temperature (25 °C) and mulching of soil promote germination within 15–25 days.
- The plants can also be propagated through tuber segments. The tuber segments are treated with GA_3 (gibberellic acid) (200 PPM) for maximum rooting percentage and survival. Tuber segments are also planted during the same period as mentioned for seedlings. Propagation using young leafy stems, when inserted in moist soils under scrub

canopy or in soil trenches covered with thin layer of moss, induces rooting at every node. Even the top nodal segment roots within 30–35 days under above conditions during July–August. About two to four plantlets can be produced from one leafy stem.

- **Propagule rate and pretreatment**: Approximately 1.5 kg seeds are required for obtaining seedlings for 1 hectare. However, about 111 000 tuber segments are needed for plantation on 1 hectare. Pretreatment of seeds with GA_3 (200 PPM) results in early germination (9–20 days) and up to 55% germination.

Planting in the field

- **Land preparation and fertilizer application:** During winter, the fields are thoroughly ploughed till fine tilth is obtained. Removal of weeds and addition of manure 10–15 days before transplantation improve the soil quality. A high leaf litter dose (150 quintals/ ha) is added to the soil before transplanting for good seedling growth and survival (up to 56%). In subsequent years, a dose of 60–70 quintals/hectare/ year can be added for maximum yield.
- **Transplanting and optimum spacing:** Propagules/ seedlings are transplanted after three months of the first true leaf initiation during March–April at middle altitudes and during May–August at alpine sites. A spacing of 30 cm × 30 cm in field is considered optimum for better vegetative growth and resultant high tuber yield.
- **Intercropping system:** The plant is grown as a mono crop.
- **Interculture operations and maintenance practices:** Forest leaf litter/ FYM from different sources/leaf compost can be used to provide nutrition to the growing plants. Leaves may turn slightly yellowish and the plants may wither due to waterlogging in beds. To overcome this problem, the crop should be planted in well-drained beds. During the rainy season, weeding is required every week. In other seasons, weeding may be done as and when required. When the crop is cultivated at middle and lower altitudes, weeding is required at an interval of 15–20 days during the entire winter season.
- **Irrigation practices:** Planted beds need irrigation during early summer. The retention of soil moisture is necessary to decrease seedling mortality. Irrigation requirement depends on the texture and porosity of the soil. In dry season, irrigation at least once in a week is necessary to retain soil moisture. However, waterlogging results in withering of plants at lower altitudes. Hence, well-drained beds are recommended for cultivation of the crop.
- **Disease and pest control**: No serious pests or diseases are noticed in this crop.

Harvest management

- **Crop maturity and harvesting:** Vegetative growth phase lasts for three to four years and finally leads to the reproductive phase. Flowering at alpine (natural) sites has been recorded in September and fruits mature during late October or November. Harvesting of tubers is recommended after the completion of reproductive phase and ripening of seeds during October–November, when maximum quantitative tuber yield is recorded. However, active content (atisine) and other alkaloid contents have been found to be

maximum when tubers/plants are harvested in July–August at the budding stage. Further, percentage of active contents decreases slightly with the maturity of the plant. Plants raised from tuber cuttings complete their vegetative and reproductive phase within three years. *A. heterophyllum* tubers harvested in May– June contains lower quantity of atisine (0.35%) as compared to those harvested in November and December (0.43%), which also contain traces of aconitine. The tubers harvested in May, however, show higher quantity of aconitine and hypoaconitine as compared to those harvested in other seasons.

- **Post-harvest management**: Tubers are harvested simply by digging the field. Usually, whole tuber is harvested. However, topmost segments of tubers can be used for further multiplication, as they have better survival and growth rates. After harvesting, the whole tubers or the tubers without the top segment should be dried in partial shade or at room temperature. After complete drying, slices of tubers can be stored in wooden boxes or airtight polythene bags.
- **Chemical constituents:** In tubers, atisine content varies from 0.19% to 0.27%. However, 0.79% of total alkaloids of the plant are found in tubers. Other alkaloids found in *A. heterophyllum* are heteratisine (0.3%), histisine, heterophyllisine, heterophylline, heterophyllidine, atidine, and hitidine.
- **Yield and cost of cultivation*:*** The production through seedlings is reported 518 kg/ha and 579 kg/ha through tuber cuttings after third year of cultivation under experimental conditions. Cost of cultivation is nearly Rs 304500 for three years for 1 ha of land. This includes cost of land preparation, irrigation facilities, low-cost polyhouse for the seedling establishment, manure, labour charges, and harvesting cost.

4. *Picrorhiza kurrooa* Royle ex Benth.

Climate and soil: The plant grows well in cool and moist climate. Sandy clay textured soil is the best for its growth. It needs porous soil layers, which facilitate horizontal spreading of the rhizomes underneath, that produce aerial sprouts from the nodes. The plant prefers sufficiently moist and shaded locations. *Picrorhiza kurrooa* is a long-duration high-altitude plant and suffers heavy mortality during prolonged and intense rains.

Propagation material: The planting stock can initially be raised through seedlings, but can also be propagated through rhizomes/stolons/offsets. Seeds may be collected in August–September for raising nursery. Viability of seeds is more than 60% for a period of about six months.

Agro-technique

Nursery technique

- **Raising propagules**: The nursery beds are planted using rhizomes/stolons/ offsets in October–November. The planting stock may be raised in polybags, styrofoam trays or mother beds. However, sunken beds should be prepared in the nursery to conserve moisture during the period of water scarcity. Each offset or fragment of rhizome must have two to three intact nodes for better establishment in the field. Stolons and offsets are also suitable for multiplication under controlled cultivation conditions with or without hormonal treatment. Seeds can also be planted in mother beds or polybags for germination. Seeds do not show any dormancy and germinate without any pre-treatment. However, seeds treated with 100 PPM and 200 PPM of GA_3 (gibberellic acid) for 24 hours have 95% and 90% survival rate, respectively. When the soil surface is covered with moss, germination percentage is maximized.
- **Propagule rate and optimum spacing**: About 165000 seedlings/ha are needed, which means 1–1.5 kg seeds are required for raising saplings for 1 ha of land. Rhizomes planted at a spacing of 30 cm × 20 cm have been found to give best results in terms of yield.

Planting in the field

- **Land preparation and fertilizer application:** The land should be tilled, and made friable and porous by repeated ploughing so as to facilitate horizontal spreading of the rhizomes underneath. Field is left open for a week for solarization. Forest leaf litter or well-decomposed FYM (farmyard manure) is mixed with the soil at the rate of 6 t/ha at least 15 days before transplanting.
- **Transplanting and optimum spacing**: Approximately 110000 plants are required at the time of transplantation that is done at a spacing of 20 cm × 30 or 30 cm × 30 cm.
- **Intercropping system**: Intercropping of *P. kurroa* with *Foeniculum vulgare* (saunf), potato, and *Digitalis purpurea* is quite successful, as these plants provide microclimate for better growth. They retain moisture for longer time and provide shade for the better growth. However, intercropping with potato needs special care at the time of potato harvesting, as plants may be uprooted during the process. While intercropping with *F. vulgare* and *D. purpurea*, planting distance should be about 60 cm.
- **Interculture and maintenance practices:** In the absence of FYM, urea should be sprayed at a concentration of 1.5% in July and August to fulfil the fertilizer needs of the plants. In case of heavy rains, the plots should be drained by digging channels across the fields.
- **Irrigation practices***:* Field should be irrigated on alternate days during summer and as and when required during winter. The field should be kept sufficiently moist at all the times.
- **Weed control***:* Manual weeding must take place frequently at an interval of five to seven days during the first growing season. At later stages, weeding along with hoeing at an interval of one month is recommended.
- **Disease and pest control:** At lower altitudes (1800–2500 m), plants are infected by powdery mildew during early growth period (March–May), which can be controlled by spraying Topsin-M (thiophinate methyle 0.1%) about 15–20 days after initiation, followed by another spray after 15 days. Powdery mildew also appears after excess manuring. At the time of flowering and seed formation, spraying of insecticide (ecalux,

0.5%) twice at 10-day interval prevents seed loss due to insects and aphids. In the middle ranges, generally, there is no incidence of insect/pest/nematode or fungal diseases. However, there is every possibility of mortality due to heavy rains during rainy season.

Harvest management

- **Crop maturity and harvesting**: This crop has a life cycle of three years. After the completion of flowering, the fruiting starts in August and continues up to September. The plant needs one year for complete maturity of the seed. The roots and rhizomes are manually harvested in September when the shoots or the aerial parts begin to wither and dry. Plants raised through stem cuttings mature almost a year earlier than those raised from the seedlings. However, to get higher active contents, plants must be collected before flowering occurs.
- **Post-harvest management**: The roots and rhizomes should be dried in shade, and after proper drying, the material should be packed in polythene-lined jute bags to ensure protection from moisture.
- **Chemical constituents**: Rhizome contains a brown resinous glucoside, picrorhizin, and a glycone, picrorhizetin. Root contains bitter principle kutkin, a non-bitter product kurrin, vanillic acid, and kutkoli in varied quantities.
- **Yield and cost of cultivation:** The plant gives about 11 quintals/ha of dry roots and rhizomes in the third year when the crop is raised through rhizomes; however, 10–11 quintals/ha dry weight of roots and rhizomes are obtained in lesser period when the plant is propagated using stolons. Yield is reduced to about 6 quintals/ha when seeds are used as propagation material. Yield proportionally increases with elevation. The cost of cultivation is high due to high maintenance costs at higher elevation. It is estimated to be Rs 327280/ha including the seedling cost.

5. *Hippophae rhamnoides* L.

Climate and Soil: The habitat of the species is characterized by extreme climatic conditions, with atmospheric temperature ranging between 30 to 35^{0}C, rainfall between 50 to 700 mm and winter snowfall of 100 to 400 cm. It is mostly found growing on the hill slopes, riverbeds, water logged and marshy areas and as a bio-fence around agricultural fields and orchards. It also grows as dense stands in scattered patches on moist areas.s

Propagation by seeds

- **Seed Maturity Index:** To confirm whether the seeds are fully matured or not, various phenological as well as physical parameters are standardized and a simple thumb rule for the same was formulated. It was observed that after the fruit is plucked softly and its peduncle separated and if there is oozing of the fruit juice without the application of any pressure, then we can say that seed has

not matured fully. On the other hand, if there is oozing of fruit juice only with the application of some finger can be harvested safely.

- **Raising of Seedlings:** Seeds should be collected during October and November, when the fruits are ripe. Fruits should be dried in open shade and the seeds be separated from the pulp. Seeds can be stored in dry muslin cloth bags or paper bags. Seeds can also be stored under cold storage conditions in paper or cotton bags at 4^{o}C for one year. Freshly collected seeds should be used for nursery seedling production to obtain higher germination. *H. rhamnoides* seeds should be soaked in cold water for six days (changing water daily) and sown at a depth of 1.5 cm in furrows during May in soil mixture of sand + soil + FYM (2:1:1) in well prepared sunken nursery beds with grass mulch to obtain 94 per cent germination. Partial shed should be provided on the seed beds. The ideal time for sowing seeds is mid May in Cod Desert Area. For *H. rhamnoides*, line to line spacing of 20 cm and seed to seed of 5 cm is kept in the nursery beds. Seedlings can also be raised in poly bags containing sand + soil + FYM (5:3:1) with two to three seeds per bag. Irrigation should be done twice a week, preferably in early morning or evening hours through rose can. Damping off of seedlings in nursery (if any) can be avoided by drenching the soil with fungicide like bavistine (0.1%).
- **Propagation by Stem cuttings:** Stem cuttings (9 cm long) collected during February and March from two years old shoots with top bud and planted in soil media of sand + soil + FYM (1:1:1), 20 cm apart give rooting of 68 percent in *H. rhamnoides*. Survival percentage reduces to nearly 60 per cent during the second year. Lower part of one-year old shoots and top part of three-year-old shoots can also be used for propagation. Weeding be carried out after one month or as and when required. Nursery raised plants through cuttings are ready for plantation in the fields after two years, while those raised from seeds after three years.
- **Propagation by Root Suckers:** Root suckers (10 cm long) can be directly planted in the field, while smaller ones (up to 5 cm) can be used to raise nursery plants.
- **Micro-propagation:** Micropropagation or tissue culture is a convenient, fast technique for production high quality, clonally uniform and genetically identical axenic plantlets of many desirable tree species. The technique facilitates year-round production capability and requires less space. It has immense potential in mass propagation in a genetic improvement programme of Seabuckthorn, particularly, where the number of plus trees selected are limited for raising large plantation. The present study aims to standardize the protocol of Indian Seabuckthorn (*Hippophae rhamnoides* ssp. *turkestanica*), which grows in high altitude Indian Himalayas.
- **Cost of Nursery/Plants**: The cost of plantable sapling raised in nursery through seeds or cuttings comes out to Rs. 15/plant; while its plantation in field costs Rs. 22/plant or we can say Rs 56,000/ ha as a pure crop (DIHAR, 2013).

Agro-technique

- **Planting:** Seabuckthorn is one of those plants for which autumn is not a suitable planting period because of the constraining feature of the roots. It has been proven that the survival rate of seedling planted in autumn is much lower than of those planted in spring. A high survival rate is ensured only when the seedling is dug out and immediately planted in the field during early spring before the seedling start sprouting. Pits (30 x 30 cm) should be dug well in advance (September and October) and while planting be filled with and FYM (2:1) with immediate irrigation. Regular irrigation (once a week) should be provided after planting for at least the first growing season. When saplings are planted, the tap root should be cut and lateral roots be also pruned as per the pit size. Grass mulching helps in retaining the soil moisture during summer months. *Hippophae rhamnoides* can be planted as single row plantation (160 plants/ha) as boundary with a spacing or 2.5 m as multiple row plantation (4x2 m) having 1250 plants/ha and as close plantation with spacing of 2x2 m (2500 plants/ha). Seabuckthorn is a typical dioecious plant. The number and disposition of pollinisers directly influence the yield of the plantation. Male and Female plant ratio of 1:8 should be maintained in plantation, so as to ensure optimum fruit set. Dead and malformed branches (if any) should be pruned at the time of plantation.
- **Manuring and Fertilizer Application:** Manure or compost supplies plant food over a period of time, cow and poultry manures are commonly used. Maximum application rates of dairy manure should be about 45 tonnes/ha and poultry manure should be applied at no more than 20 tonnes/ha on cropped land. The exact nutrient levels required for seabuckthorn have not been established. However, seabuckthorn, just like any other crops, requires adequate soil nutrients for a high yield of good quality fruit. Seabuckthorn is capable of fixing nitrogen with its roots; however, some slow released nitrogen applied just after planting is beneficial. It also responds well to phosphorus fertilizer. Fertilizers are better to be mixed with the soil around the plant. The use of nitrogen fertilizer is recommended only when the Seabuckthorn is planted on poor soils.
- **Irrigation:** Seabuckthorn is well adapted to withstand drought. However, during establishment and for maximum fruit production, irrigation is beneficial. Irrigating during the first two years following planting will significantly improve establishment especially in dry regions or during drought. Irrigation is also beneficial during bud formation and fruit development.
- **Weed Control:** Weed control or vegetation management is very important in seabuckthorn plantings. Proper weed control promotes growth of newly planted seedlings. Only low concentration of herbicides should be used. Black plastic may be used to control weeds during orchard establishment, also to retain standards for organic production.
- **Pruning:** The purpose of pruning seabuckthorn is to train branches, promote growth and facilitate harvesting. Seabuckthorn may grow up to 23 m in four years. In an orchard - type planting, the tree should be pruned annually to remove overlapping branches and

long branches should be headed to encourage development of lateral shoots. Mature, fruiting plants should be pruned to allow more light penetration if the bush is dense. To prevent sea buckthorn from premature senescence, three-year-old branches should be pruned in the early winter for rejuvenation.

- **Intercropping:** Normal agriculture crop can be raised without any difficulty underneath the SBT plantation as single or multiple row plantations.
- **Harvesting and Yield:** Flowering generally occurs in May June and ripening started by late August and September. Harvesting of Seabuckthorn (SBT) fruit is quite difficult and only nearly 25 kg of fruit can be harvested by one person in a day as care is taken not to damage the vegetation. Before sunrise fruits can be harvested without causing damage to plant. Like any other crop, yield of sea buckthorn is affected by various factors such as genotype, soil condition, annual precipitation, temperature, crop management, numbers of fruit bearing branches, and time and methods of harvesting. Yield data for sea buckthorn is scarce, since most fruit collection is from natural habitats, plantations for controlling soil and water erosion, and field shelter belts. In Germany, it was reported yield of 5 t/ha from an orchard plantation. In Saskatchewan, fruit production in shelter belts yields 4– 5 t/ha. It was estimated that an orchard with 4,000 trees/ha and a 1:6 male and F ration, should yield approximately 10 t/ha. Detailed study is underway in Canada on the effects of crop management on yield.
- **Fruit Harvesting Technique:** Due to the thorny nature of the plant, the harvesting of fruits is a major problem. It has been observed that in case of Seabuckthorn, before the day break, if we tie a simple rope to the shrub, shake it vigorously, then nearly 80 per cent of the fruits fall down very easily on the ground. On the contrary, if the same is repeated after sunrise, then this technique does not work out that efficiently.
- **Postharvest Management and Storage:** Seabuckthorn berries when overripe carry a strong musky odor with rancid taste, detectable even in the field. Washing may reduce or change the odor. To avoid this problem, berries must be harvested at the correct stage, quickly transported to the processing plant and be cooled immediately to temperatures around 4° to 6°C to retard growth of microorganisms. If the berries are to be stored more than a few days, they should be frozen, preferably by individual quick-freezing techniques. The berries are thawed and processed to products as required on demand. Juice extracted by pressing or centrifugal techniques must be stored under refrigeration and requires pasteurization and freezing for long term storage. Alternatively, fruit may be processed into pasteurized or sterilized finished products and stored in that form at room temperature. The shelf life even of sterilized product is limited but improved in refrigerated storage. Maximum containment in cooler of ten days is recommended before shipment in cooler transport, to the processing plant. Shipment should be contained (once fruit is cooled) in plastic wrapping, and then placed in cold storage at the processing plant at a temperature below freezing (1 to 2 °C) if processed within 30 days. Fruit can be frozen to 18 °C for long term storage (1 year) without further loss of ingredients.

6. ***Bunium persicum*** **(Boiss.) B.Fedtsch.**

- **Climate and Soil:** It requires dry temperate climate. It thrives in well-tilled and humus rich sandy loam soil.
- **Field preparation and Manuring:** The land is dug up to 30 cm and soil is finely crushed and properly mixed with organic matter. Farm Yard Manure is mixed with soil at the rate of 20qt/acre.
- **Propagation and Cultivation:** It is propagated through seeds. About1.5-2 kg seed is required for cultivation in one acre of land. Seeds are sown by broadcasting in a well-prepared land in the month of April. Germination starts after one week of sowing. Often, it is sown with other traditional crops.
- **Irrigation and Weeding:** Normally, irrigation is not required. However, for good germination and growth of the plants, periodic irrigation is required at an interval of 10 days. Two times weeding is essential for the better growth. Monthly weeding is required during May, June and July.
- **Harvesting (Seed Collection, Drying and Storage):** Seeds are collected every year for cultivation. Harvesting is done in the month of October when seeds are fully ripened. The plant is harvested with green stem and left for drying in sun for 2-3 days. After collection, this material is kept in shade and after 9-10 days, it is kept in sunlight. Further, threshing and winnowing is done to segregate seeds. The separated seeds are then collected in bags and stored in cold and dry rooms.
- **Yield, Post-harvesting Techniques and Income Generation:** Approximately, 5qt/acre yield of seeds is obtained after one year of cultivation and a net return of Rs. 9300/- can be earned. The well sun-dried seeds are packed in the cotton bags and kept in cool and dry places (Samant *et al*., 2008).

7. ***Dactylorhiza hatagirea*** **(D.Don) Soo**

- **Climate and Soil**: Plants grow in the alpine climate of Central and Western Himalayas where average summer temperature ranges between 15- 0 18 C and winters are very harsh generally below the freezing point. Plants grow best in moist meadow soils. These soils are usually dark grey, granular, sandy loam, micaceous sandy soils at greater depth.
- **Propagation Material**: The materials for propagation are seeds and tuber cuttings. Plants can be grown by splitting the sprouting tubers. Collected seeds did not show germination at controlled temperature and moisture 0 (temp. 10-15 C; humidity 90+5%) conditions. It probably requires thawing

under the snow for about 4-5 months and mycorrhizal association for germination. It is reported to be an inherently slow growing and poorly regenerating species because of pollinator specificity.

Nursery Propagules

- **Raising Propagules:** Vegetative propagation through tuber cutting is quite successful in this plant. Small slices of tuber of 4.0 mm size, with meristematic tissues are reported to develop plantlets when transplanted at 5.0cm -7.0cm depth at a spacing of 15cm X 15cm. Plant raised from tuber cutting develops tubers and roots after one year and it becomes about 4. 0-8.0 cm tall.
- **Propagule Rate and Pretreatment:** Multiplication through seeds is very low and no fruitful results have been obtained so far. In natural habitat, seed germination was found to be between 20 to 30%. Seed sowing in soil collected from its natural habitat at lower altitudes gives better results. Collection of immature and fresh seeds from nature enhanced germination percentage. Approximately 1,11,150 tubers or tuber segments are required for one hectare of land and are transplanted at spacing of 30 cm apart.
- **Land Preparation and Manure Application:** Land should be ploughed and cross ploughed to have a fine tilth. The field should be well prepared and made free from weeds before transplanting. Livestock manure and forest litter treatment increase survival, growth and yield. Approximately 5 t manure is required for one hectare of land. Manure requirement increases at lower altitudes and at 1800-2000 m approximately 10.0 - 15.0 t/ha manure is required depending upon soil fertility.
- **Transplanting and Optimum Spacing:** Small slices of tuber of 4.0 mm size with meristematic tissues are reported to develop plantlets when transplanted at 5.0 -7.0 cm depth at spacing of 15cm X 15cm.
- **Intercropping System:** Intercropping with *A. heterophyllum* Wall. ex Royle is found suitable because of similar edaphic conditions for good growth and yield. Intercropping with *Swertia chirayita* Roxb. ex Fleming is also recommended for subsidiary income from the cultivation of medicinal plants.
- **Intercultural and Maintenance Practices*:*** Frequent weeding at every seven to ten days especially during the rainy season favour optimal growth.
- **Irrigation Practices:** At the early stage, 80-90% humidity is required for plant development of rooting and leaf initiation. Irrigation at every twelve hours is needed, especially at lower altitude during this stage.
- **Crop Maturity and Harvesting:** Tubers are usually harvested after five years to fetch a good yield. Sometimes it is harvested after two or three years of the tubers are seed as food, nervine tonic and aphrodisiac.

8. *Angelica glauca* Edgew.

Climate and Soil: It requires cool and temperate climate. It can be cultivated between 2000-3000 meters amsl. It requires deep rich porous and moist soil with shady situations. For its ideal cultivation, the plenty of organic manure is required.

Agro-technique

Nursery Technique

- **Raising Propagules:** Seeds are sown immediately after harvesting during November and December inside polyhouse. Seed viability is very low and moist s e eds have a better germination potential than dry seeds. Germination takes 25-40 days.
- **Propagule Rate and Pretreatment:** Approximately 50,000 plants or 6.2 kg seeds are required for its cultivation in one hectare land area.

Planting in the Field

- **Land Preparation and Fertilizer Application:** The field should be ploughed thoroughly followed by harrowing to bring the soil to a fine tilth and free from weeds. Seedlings are transplanted 45X45 cm apart in April and May. Apical portions of roots are transplanted during the rainy season at 45 cm apart. By this method, plants can be harvested within two years.
- **Green Manuring:** Sheep and goat manure is reported to be good for its cultivation. Approximately 15-20 tonnes of manure is required for one hectare of land initially, at the time of starting cultivation in lower altitudes. Manuring is done before planting. If required, manuring should be done after the completion of the vegetative growth phase during October or in the winter after two or three years of cultivation. At higher elevations, where forest litter is available, it enhances growth as well as survival and yield.
- **Transplanting the Seedlings to Main Field and Optimum Spacing:** After four to six months growth of seedlings raised inside a greenhouse or in a small nursery, transplanting is done at the beginning of the rainy season. Raised beds are better for growth. If the site is moist or has good irrigation facilities, transplanting can be done during April and May.
- **Intercropping System:** It requires similar climatic and edaphic conditions as *Saussurea costus* so intercropping with this plant is beneficial.
- **Intercultural and Maintenance Practices:** The intercultural operation like weeding/ hoeing is carried out periodically as and when required.
- **Irrigation Practices:** Irrigation twice a week during the dry season is required.
- **Weed Control:** Weeding once a month and earthing every month during the rainy season and every two to three months during the dry season is essential.

- **Disease and Pest Control:** No disease and pests have been reported.

Harvest Management

- **Crop Maturity and Harvesting:** Under cultivation, harvesting can be done within two to three years. Roots are harvested during September and October when seeds become partially mature. Harvesting can be done after every two years, once the cultivation is well established and gives the maximum yield.
- **Post-harvest Management:** After harvesting the rhizomes, an apical portion is transplanted in a field for future crops. The remaining portion is washed with water to remove soil, and roots are cut into small pieces and put in partial shade for drying. After complete drying, roots are stored and packed in cloth bags.
- **Chemical Constituents:** Roots contain 1-1.5% volatile oil, valeric acid, angelic acid, lactones, sesquiterpenes, -cadinene, umbelliprenin, terpene alcohol and angelisine resin.
- **Yield:** At high altitudes of Garhwal Himalaya, nearly 593-600 kg/ha yield is estimated under cultivation which is greater than all medicinal plants traditionally cultivated and thus has great potential as a cash crop. For a long time, the collection of this species has been done by Bhutiyas (tribes) from nature, and they still sell it as a condiment in valley villages to earn money. Nearly 15-25% A. glauca is sold in trade of medicinal plants by local people, especially from the Niti and Mana Valleys of Uttarakhand.

Therapeutic Uses: *A. glauca* is used in dyspepsia, constipations, ulcer of palate, infantile atrophy, dysentery, menorrhagia and rinderpest. Roots/rhizomes are used as a drug for wounds and gastric pains. It has stomachic, carminative, stimulant, and sudorific properties. It is useful in anorexia, spasms, flatulent colic and bronchitis. The powdered root is administered in warm water for children's stomach ailments; it also checks vomiting. It is also used for flavouring confectionery and liquors. The leaves and stem act as a stimulant, cordial and used in stomach troubles.

9. *Viola canescens* Wall.

Climate and soil: The plant grows well in cool and moist climate but heavy and frequent rain is fatal during blooming. Sandy loam soil is best for its cultivation.

Propagation material: The plant is generally propagated through separation of the new plantlets that develop from the runners. As much as 50–60 new plantlets may be separated from one mother plant. This crop is also propagated through seeds that show about 80% germination.

Agro-technique

Nursery technique

- **Raising propagules**: The planting stock can also be easily raised through division of mother plants, which are directly planted in the field. To raise the planting stock through

seeds, they are sown in the nursery in March– April, 10–15 cm apart from line to line. About 80% seeds germinate within three weeks. Sowing of the seed directly in the field is not recommended, as the seed size is very small.

- **Propagule rate and pretreatment:** About 110 000 plantlets are required for planting in 1 hectare of land. When seeds are used as propagation material, about 1–1.5 kg seeds per hectare are required. No seed treatment is required before raising the nursery, as the seed coat is not very hard.

Planting in the field

- **Land preparation and fertilizer application:** Field should be well prepared through two to three ploughings, followed by planking to make the soil suitable for the transplanting of the plantlets. Bed should be raised or oriented in such a way that there is proper drainage and no water stagnation, especially due to heavy rains in the rainy season. Exposure to frequent and heavy rains is very damaging for the flowers. In places of water scarcity, sunken beds may be prepared to conserve moisture. Well-decomposed FYM (farmyard manure) @ 12 tonnes/hectare should be applied to the soil before transplantation of the seedlings to obtain maximum yield. The seedlings are planted at a spacing of 30 cm × 30 cm. P
- **Transplanting and optimum spacing:** The crop is grown in kharif season during May–June, with the onset of pre-monsoon rains. This is the best period for establishment of plantlets in the field. When the crop is propagated through division of the mother plants, the separated plantlets can be planted directly in the main field in May–June. About one-month-old seedlings can be transplanted in the main field, at an optimum spacing of 30 cm × 30 cm.
- **Intercropping system:** The crops can be grown in orchards where partial shade conditions prevail, provided no waterlogging takes place.
- **Interculture and maintenance practices:** Only organic manure @ 12 tonnes/hectare is recommended as a basal dose. The field should be free from weeds, especially at the initial stages of plant establishment. Field should be drained well by digging channels across the field, especially during the rainy season. Irrigation should be provided as and when required during hot weather. For promoting the growth of the plants, 50 PPM (parts per million) solution of GA3 (gibberellic acid) may be sprayed at an interval of one month from September to May**.** Manual hoeing and weeding once in a month are recommended to control the weeds.
- **Disease and pest control:** Browning and blotching of the leaves with dead areas having distinct black margins may occur during rains. These infected leaves should be collected and either burnt or buried deep in the soil to check the further spread of the disease. Pesticides or fungicides should never be used.

Harvest management

- **Crop maturity and harvesting:** Leaves can be harvested after two months of establishment of the crop and subsequent harvesting may be done at an interval of one month till December. The plant starts flowering after 9–10 months of growth during

February–March, corresponding with the increase in temperature. Fruits can be harvested in April and May. Flowers and seeds should be harvested either in February–March or April–May, depending on the climatic conditions of the area.

- **Post-harvest management**: Flowers and seeds should be air-dried in shade and packed in polythene bags. The flowers should be packed in airtight polythene bags and stored in dark place at room temperature. The seeds retain viability for long periods when stored in airtight containers.
- **Chemical constituents:** Voiline, ionone, and ionine are the main active principles of the plant. Roots, leaves, and blossoms also contain methyl-salicylate in the form of a glucoside. Leaves of Viola contain rutin content in the range 0.15%–0.45%.

10. *Valeriana jatamansi* DC

Climate and soil: The plant prefers a temperate climate. It grows well in moist loamy soils having partial shades of trees like deodar and banj oak on north-facing hillocks. It can grow over a wide range of soils, with slopes up to 20%, provided that it gets sufficient water and nitrogen nutrient. However, it thrives best in humus-rich, heavy loam soils, with adequate moisture and good drainage. To harvest roots in an easy and efficient manner, a relatively loose soil with low clay content is desirable. Water stagnation in the beds should be avoided, as the roots of the plant are sensitive to rotting.

Propagation material: *Valeriana* can be propagated through seeds or by using portions of the rootstock, preferably during rainy season. It is normally advisable to raise the crop through suckers because crop raised through seeds takes more time to mature. Seeds can be collected in April–May and sown immediately in nursery.

Agro-technique

Nursery technique

- **Raising propagules:** For raising the crop through rootsuckers, a separate mother nursery should be maintained. Fresh rooted suckers can be taken from the mother nursery and planted in the field. New suckers should be planted in the nursery in June or with the onset of monsoon. Rooted suckers taken from mother nursery are planted in the field in rows at a depth of 4–5 cm. If the crop is to be raised through seeds, then nursery is prepared separately in April–May. Seeds germinate in 15–20 days and are pricked into polybags for further growth. The seedlings are ready for planting in about three months' time.
- **Propagule rate and pretreatment**: About 2.5–3 kg seeds are required to raise planting stock for 1 hectare of land. No specific treatment of seeds is required. However, rootstock is preferred as propagules.

Planting in the field

- **Land preparation and fertilizer application**: In order to have optimum root yield, pulverization of the soil is necessary. A minimum of three ploughings are recommended. If the crop is to be raised through rhizomes/ rootsuckers, first ploughing is done with soil-turning plough in June. The field should be left fallow for 15–20 days so that crop residues buried in the soil get rotten and the soil also receives appropriate sunlight. Before second ploughing, well-decomposed FYM (farmyard manure) should be spread uniformly and properly mixed in the field. Second ploughing should be done in the end of June and third ploughing should be done with first showers of monsoon. Planking and harrowing should be done after second and third ploughing to break the clods and make the soil friable with good tilth. When the crop is raised through seeds, the preparation of land should be deferred by about one month. The crop requires fertile and humus-rich soil. A dose of 35–40 tonnes/hectare of FYM, applied in split doses, is found to be the best. The first dose of about 25–30 tonnes is applied at the time of field preparation and the rest is applied in the following months of June–July when earthing-up is done. The FYM dose is kept slightly higher because no inorganic fertilizer is applied to the crop.
- **Transplanting and optimum spacing**: The rooted propagules are planted in the field in June–July, while seedlings are transplanted in August at higher elevations and in October at lower elevations. Seedlings should be transplanted when they attain a height of 8–10 cm and planted immediately after uprooting, so that they establish early and remain healthy. Planting in rows 40–50 cm apart and 20–30 cm spacing between plants in a row are recommended. Approximately, 75 000–85 000 plants are required for 1 hectare of plantation.
- **Intercropping system**: Tagar can be raised as an intercrop in the fruit orchards. Experimental trials conducted on intercropping in a peach orchard show that the crop can yield about 12–15 quintals/hectare of fresh root mass in the second year, indicating that Valerian may act as a good supplementary crop in fruit plantations.
- **Interculture and maintenance practices**: The crop requires fertile and humus-rich soil. A dose of 35–40 tonnes of FYM is found to be the best. No studies about the use of inorganic fertilizer are available. Manual weeding is recommended at an interval of 25–30 days. Once established, the plant shows good resistance against weed invasion, and because of its vigorous upright growth and dense foliage, weeds are smothered under its canopy.
- **Irrigation practices**: Irrespective of whether the crop is raised through seeds or rhizomatous suckers, fresh plantings need irrigation almost daily till they are established. Subsequently, depending upon the slope and water-holding capacity of the soil, irrigation interval may vary between one and two weeks.
- **Disease and pest control**: The crop is relatively free from pests and diseases. But occasionally, rhizome rot has been observed for which drenching with 0.2% Dithane M-45 is recommended.

Harvest management

- **Crop maturity and harvesting:** The crop may be kept in the field for one or two years. It can be harvested in the first as well as second year, but yield is much lower in the first year.

Crop attains physiological maturity in August but requires some more days for complete maturity. Digging and harvesting of roots are done in September–October.

- **Post-harvest management**: The best method of drying should prevent enzymatic breakdown of the constituents. The harvest should be dried as rapidly as possible without overheating. The maximum preservation of the valepotriates is achieved when drying is done within the range of about 35–40ºC. Dried rhizomes are best stored in gunny bags/ bamboo baskets.
- **Chemical constituents:** Roots yield 0.5%–2.12% of volatile oil. Maliol is the main marker component isolated from the essential oil.
- **Yield and cost of cultivation:** *Valeriana* can be harvested both in the first as well as second year but less yield is obtained after the first year. Therefore, it is advisable to harvest the crop in the second year. Harvesting done in the first year gives 35–40 quintals/hectare yield of fresh root mass and 8–10 quintals/hectare of marketable dry roots. The crop gives almost double yield when harvested in the second year—70–75 quintals/hectare of fresh root mass and 20–25 quintals/ hectare dry rhizomes and roots. The difference in yield is due to both size and number of the rhizomes. The rhizome represents only 25%– 30% of the weight of underground parts (root mass). The estimated input cost is about Rs 175330 per hectare.

11. *Hedychium spicatum* Ham. ex Smith

Climate and soil: Kapoor kachri is sciophytic in nature and prefers shady slopes. Waterlogging in the soil is fatal due to rotting of rhizomes. Moderate temperature and well-spread rainfall are suitable for better growth. Sub-temperate to temperate climate with annual precipitation of 1000–1500 mm, and well-drained, deep sandy loam, and humus-rich soil with good moisture retaining capacity are most suitable for its cultivation. Soil with 40%–50% of sand gives better yield.
Propagation material: Both seeds and rhizomes may be used as propagation material, but when crops are raised through seeds, rhizomes may require three to four years to mature. Propagation by rhizome is preferred due to less time involved (about two years) in crop maturity.

Agro-technique

Nursery technique

- **Raising propagules:** It is not advisable to raise the crop through seeds; rhizome pieces with apical buds are buried in 10 cm × 20 cm polybags containing soil, sand, and FYM (farmyard manure) in equal amounts and irrigated intermittently. Rhizomes may also be planted in motherbeds in the nursery and uprooted for planting in the field. Nursery is raised in April when the weather is little warmer. Propagules sprout between 25 and 30 days. Rhizomes may also be planted directly in the field.
- **Propagule rate and pretreatment**: About 25 quintals of healthy rhizomes, segregated into pieces with one bud in each and weighing about 40–50 g, are required for raising plantlets

in 1 hectare of land. Though rhizome rot is not a serious problem, high rainfall and waterlogging may cause damage to propagules. Therefore, rhizomes should be dipped in 0.01% bavistin solution for 25–30 minutes, followed by shade-drying for six to eight hours before planting.

Planting in the field

- **Land preparation and fertilizer application**: First ploughing with soil turning plough is done in the first week of March in montane ranges and in last week of March on higher hills. This makes the soil free from weeds and buries the previous crop residues. The field is left fallow for 15–20 days for solar treatment, aeration, and to facilitate decay of crop residues. With second ploughing, well-decomposed FYM at the rate of 20 tonnes per hectare should be spread well and thoroughly mixed. Planking should be done after second and third ploughing to make the soil friable and turn it into a fine tilth.
- **Transplanting and optimum spacing**: Propagules are transplanted in April in middle zones and in May in high ranges of hills. The rhizomes are planted in furrows at a depth of 10–12 cm, at an optimum spacing of 45 cm × 30 cm. At this spacing, about 64 000 propagules per hectare will be required. Saplings should be taken for transplantation when they attain a height of 12–15 cm. These saplings should immediately be planted after uprooting them from the nursery bed.
- **Intercropping system** *Hedychium* is preferred as an intercrop in fruit orchards. Experiments of intercropping in apple orchards have given better results perhaps due to the availability of congenial environment for better growth. The yield is about 60–65 quintals per hectare. In an apple orchard, only about 44 000 propagules/hectare may be required.
- **Interculture and maintenance practices**: The quantity of FYM recommended is about 30–35 tonnes/hectare. It should be applied in three split doses: the first one at the time of land preparation (20 tonnes/ hectare) and the other two doses (5–8 tonnes/hectare each) should be applied well before the onset of monsoon in the first and second year of cropping. Interculture operations mainly comprise weeding, earthing-up (hoeing), and timely watering. First hoeing is done at the time of top dressing, that is, 45–50 days after transplanting, and the second hoeing can be done just after rainy season to loosen the soil. If required, inorganic fertilizer, such as NPK (nitrogen, phosphorus, potassium), may be applied at the rate of 100:120:60 kg/hectare in three split doses. The entire amount of phosphorus and potassium along with one-third of nitrogen should be applied in furrows at the time of land preparation. The remaining nitrogen should be applied in two equal split doses: first after two months of planting and the second in the next rainy season after new sprouting.
- **Irrigation practices:** Since the crop is grown in areas with well spreadout rainfall, it requires no irrigation, except in the case of rainfall deficiency or during long spells of no rain. During winter, light irrigation at an interval of 15–20 days is sufficient. Sufficient moisture should always be available, but there should be no waterlogging.

- **Weed control:** Manual weeding is recommended for the crop. Three weedings are sufficient. First weeding is done 15–20 days after completion of sprouting. Second and third weedings are done with the first and second hoeing operations.
- **Disease and pest control:** In rhizome rot, leaves of the affected plant become pale and the affected rhizomes become soft and pulpy, and ultimately rotten. Rhizome rot can be controlled by dipping the rhizomes in 0.01% bavistin solution for 25–30 minutes followed by shade-drying before planting. In leaf spot disease, spots appear over leaf lamina; control measures involve spraying with 4:4:50 bordeaux mixture.

Harvest management

- **Crop maturity and harvesting**: The crop is biennial when planted through rhizomes, and hence, matures in second season during October–November, depending upon the elevation. Dried leaves and stalks are removed after they turn yellow, while rhizomes are left in soil for about 20–25 days for ripening before being dug out.
- **Post-harvest management** Rhizomes should be properly cleaned in water to remove soil particles. Small roots and rootlets are also removed. The produce is then dried in shade and stored in containers in dampproof stores. Healthy rhizomes should be selected before drying as future propagules and treated with 0.01% bavistin solution to prevent rotting and then buried with pits in sandy soil till next sowing period.
- **Chemical constituents:** α-pinene, β-pinene, limonene, camphor, linalyl acetate, β-terpineol, β-caryophyllene, benzyl cinnamate, benzyl acetate, γ-terpinene, β-phellandrene, methyl paracumarin acetate, cinnamic ethyl acetate, ethyl cinnamate, sesquiterpene alcohols, and hydrocarbons.
- **Yield and cost of cultivation** Second year harvesting yields about 115–120 quintals/hectare dry weight of rhizomes. However, first year harvesting can also yield 45–50 quintals/hectare dry weight. Since there is a significant increase in produce, it is recommended to harvest the crop in the second year. Estimated cost of cultivation is approximately Rs 116880/hectare for complete crop duration.

12. *Withania somnifera* (Linn.) Dunal Syn. *Physalis somnifera* Linn.

Climate and Soil: Ashwagandha is grown on sub-marginal waste lands and low fertility areas. Plant grows well in red, sandy, black and loamy soil with pH 6.5- 8.0 with good water drainage. It can be cultivated upto an altitudes of 1000 meter. Ashwagandha prefers a sub-tropical climate. The semitropical areas receiving 500-750 mm rainfall are suitable for cultivation of this crop. The crop requires dry season during the growing period. Temperature between 20° C to 35° C is most suitable for its cultivation. Late winter rains are conducive for the proper development of the plant roots.
Propagation Material: Seeds.

Agro-technique

- **Direct Sowing**: The seeds are sown directly in the main field by broadcasting. After receiving 1 or 2 showers, the field is thoroughly prepared, divided into plots of convenient sizes and the seeds are sown during the second week of July to August. A seed rate of 10-12 kg/ha is required for this method of planting. If rainfall is more, then the sowing can be done up to September.

Nursery Technique

- **Raising Propagules:** Plant to plant and row to row distance can be adjusted according to soil fertility and variety used. The population should be dense at low fertility and more distance at higher fertility land. When the seedlings are to be raised for transplanting, they should to be sown in well-prepared, raised nursery beds. The seeds are usually sown about 1-3 cm deep in June-July in nursery. The seeds in the nursery-beds are sown in lines spaced at 5 cm and covered with light soil. The germination commences within 6-7 days of sowing and within ten days from sowing it is complete. When the seedlings are 6 weeks old and sufficiently tall, they are transplanted in 60X60 cm spaced in well prepared land in July-August.
- **Propagule Rate and Pre-treatment**: About 5 kg of seeds are required to provide enough seedlings for sowing one hectare. To avoid nursery diseases, the seeds are treated with Therum-45 at the rate of 3gm/kg of seeds before sowing. A light shower after sowing ensures good germination.

Planting in the Field

- **Land Preparation and Fertilizer Application**: Mostly organic manure should be applied. For organic cultivation no fertilizer should be applied. N 25 kg, P 25 kg and K 20 kg should be applied. All the quantity of P, K and 1/3N should be applied at the time of sowing or planting. Remaining N in the split doses. Ashwagandha is usually grown in fields, which are not well covered by the irrigation systems. The field on which food crops cannot be taken profitably for the above reason may be used for Ashwagandha cultivation. The soil of the field selected of Ashwagandha cultivation should be well pulverized by ploughing, disking or harrowing. The field may be then levelled. The crop of Ashwagandha does not require heavy doses of manure. In Madhya Pradesh, where it is grown on commercial scale, no fertilizer is applied and the crop is cultivated on only residual fertilizer. However, 200-300 kg FYM/ha may be applied. 5-6 times vermi-compost or FYM may be applied row to row. Ÿ
- **Transplanting and Optimum Spacing:** The seedlings after 25-35 days are transplanted at distance of 20-25 cm to 10-15 cm row to row and plant to plant respectively. It may be noted that since “Asgandh” is a late rainy season the time of sowing is decided by the date of arrival of monsoon in that area .30 to 60 plants/Sqm or 3 to 6 lakhs plants per hectare should be kept when ¾ rain have over in August or September sowing or transplanting should be completed.
- **Intercropping System:** *Withania* may be planted as intercrop with newly planted *Cocos nucifera* (coconut), *Mangifera indica* (mango), Tectona grandis (teak), *Simaruba officinalis* (simaruba), *Jatropha curcas* (jatropha), *Pinus* spp. (pine) and *Populus canadensis* (populus).

- **Interculture and Maintenance Practices:** The directly sown crop is thinned at 25 – 30 days to maintain a plant population of 20,000–25,000/ha. Hand-weeding at 30 days interval helps to control the weeds effectively. Total two weeding's. 2nd weeding after 2 months.
- **Irrigation Practices:** Light shower after transplantation ensures establishment of seedlings. There is no need of irrigation if rainfall is at regular intervals. Excessive rainfall/water is harmful to the crop. Lifesaving irrigation may be applied at required intervals. Under irrigated conditions, the crop can be irrigated once in 10 days.
- **Pests and Diseases:** The early stages (seedling stage) of *Withania somnifera* caused from fungus disease like damping of fungus, seedling blight, seed rotting, die-back etc. Seed should be treated with thiram or capton (2-4 gm/kg) to reduce the effect of seedling blight and leaf blight. 0.3% phytolone, diethane- 78 or D-45 is also spread on crop. Leaf curl tobacco and urtches broom disease were also recognized in *Withania*. These diseases are controlled through spraying of tetra-cyclin hydrochloride at the interval of 15-20 days. Best way to uproot and burn the infected plants. Some insect diseases were also identified on *Withania*, for controlling of insect diseases, 0.5% melathyone mixed with 0.1 – 0.3% kithane can be used as spray at 10-15 days interval.

Harvest Management

- **Crop Maturity and Harvesting:** Harvesting starts from January and continues till March. The plants start flowering and bearing fruits from December onwards. The crop is ready for harvest in January – March i.e. 150 to 180 days after sowing. The maturity of crop is judged by drying out of leaves and yellow red berries. The entire plant is uprooted for roots, which are separated from aerial parts by cutting the stem 1- 2 cm, above the crown. The roots are cut transversely into small pieces (7 to 10 cm). Occasionally, the roots are dried as a whole. The berries are plucked from the dried plants and are threshed to obtain the seeds.
- **Post-harvest Management:** The dried roots, entire or transversely cut into smaller pieces, have to be further water washed, cleaned, trimmed and graded. The roots are beaten with a club, which removes adhering soil and breaks off the thin, brittle lateral rootlets. Lateral branches, root crown and stem remain on roots are carefully trimmed with the help of knife.
- **Grading:** The entire product is then carefully sorted into four grades based on the thickness and uniformity of the pieces.

  A-Grade: Root pieces up to 7 cm in length, solid, with 1.0-1.5 cm diameter; they should be brittle and pure white on the inside.

  B-Grade: Root pieces up to 5 cm in length, solid, with a diameter of less than 1 cm, the roots should be brittle and white on the inside.

  C-Grade: Root pieces up to 3-4 cm in length, side branches solid, with a diameter of 1 cm or less.

  Lower Grade: Small root pieces, semi-solid, very thin or very thick, chopped and yellowish on the inside.

- **Chemical Constituents:** The main constituents of Ashwagandha are alkaloids and withanolides (steroidal lactones), the major groups of secondary metabolites of medicinal interest. Among the various alkaloids, withanine is the main constituent. The other alkaloids are somniferine, somnine, somniferinine, withananine, pseudowithanine, tropine, pseudo-tropine, 3-a-gloyloxytropane, choline, cuscohygrine, diisopelletierine, anaferine and anahytrine. Two acyl steryl glucoside viz. sitoindoside VII and sitoindoside VIII have been isolated from root. The leaves contain steroidal lactones, which are commonly called withanolides. The withanolides have C28 steroidal nucleus with C9 side chain, having six membered lactone rings.
- Yield and Cost of Cultivation: On an average yield from one hectare area under commercial cultivation is an approx 0.5- 0.7 tonnes of dried roots and 30- 40 kg seeds. Rs. 37670/- is the cost of cultivation for one hectare.

Therapeutic Uses: The drug is rejuvenating agent; mainly used in Ayurvedic and Unani preparations. The plant has anti-tumor, anti-inflammatory, anti-bacterial, fungicidal, anthelmintic, anti-convulsant, anti-stress, immunomodulatory and anti-pyretic properties. It is also used in insomnia, weakness, ulcers and painful swellings as aphrodisiac and in leucoderma. The paste prepared out of its leaves is used for curing inflammation of tubercular glands and that of its roots for curing skin diseases, bronchitis, ulcer and dyspepsia and eye diseases. The fruits and seeds of Ashwagandha are diuretic in nature. The leaves are reported to contain anthelmintic and febrifuge properties. An infusion of the bark is given for asthma.

13. *Bergenia ciliata* (Haw.) Sternb.

Climate and Soil: Plant grows well under humid, temperate climatic conditions, where temperature generally remains below 20ºC. Plant grows well over sandy, slightly acidic soils with high porosity and rich in organic matter or forest humus. However due to its hardy nature, this species can be grown well over medium loamy to clay soils, supplemented with manure. It tolerates light shade and grows well under open sunny conditions. But the vegetative growth has been found better in shade.

Propagation Material:

Rhizome Segment: 8-14 cm long and 23-26 gm in weight are used for direct planting; annular segments of 2 cm thickness are preferred for nursery raising. Seeds: Seed germination is low and seed viability is very poor.

Agro-technique

Nursery Technique

Raising Propagules: It takes about one month to develop a mother nursery which can supply planting material for raising cultivation.

(i) **By Rhizome Segments:** The crop can be raised by direct planting of 7.5-12.5 cm long rhizome segments (average weight: 23-26 gm) with 2-3 nodes as propagation material for quick and faster regeneration in the field in late summer or onset of monsoon. It is treated with 100 ppm IBA solution for two minutes. Raising crop through rhizome segments can reduce crop cycle by one year in comparison to propagation through seed sown. However, it requires large quantity of rhizome sections for planting. It is noted that the smaller rhizome segments of about 2 cm thickness can be planted at spacing of 10X10 cm in nursery. The rate of growth is slow and as it takes about 18 months' time for raising plants in nursery for field planting.

(ii) **By Seed Method:** The seeds are very minute in shape and exhibit poor viability and germination potential. They exhibit slightly recalcitrant nature and need to be used immediately after maturity in spring season (March-April). The seed is stratified for 15 days at 4°C to improve germination. Storing will lose viability. Seeds are sown over top surface of raised beds or poly bags over the moist layer of forest litter or farmyard manure preferably under greenhouse conditions. The seeds take 60-90 days for germination. After germination, the seedlings are picked out at two-three leaved stage and planted in fresh nursery beds atspacing of 10X10 cm and takes a season to grow large before planting in the fieldinnextsummer.

(iii) **Propagule Rate and Pretreatment:** About 88,000-90,000 plants are needed to plant one hectare land for which approxmately 18-20 quintals fresh biomass of rhizome is required. Before planting, the rhizome segments should be treated with 100 ppm IBA solution for two minutes or soaked in plain water for two hours.

Planting in the Field

- **Land Preparation and Fertilizer Application:** It is a hardy plant hence it can be planted in spring as well as summer in the hills; although the best time for planting is monsoon time (July). Land preparation is as usual for growing crops in hills. Add 35 t/ha of FYM and plough the deep in the soil. After planting, make 9-12 cm raised beds or shallow ridges for intercultural operations. For proper water retention and enhancing the porosity of soil, add sufficient quantity of locally available peatmoss or the forest litter. It enriches soil with useful microfauna and mycorrhiza, which help growth.
- **Transplanting and Optimum Spacing:** The rooted plants should be transplanted in the field in 12-15 cm raised bed at a spacing of 30X30 cm. While planting in the raised beds, keep at least 5 cm space on each side of bed along the length so that three rows of plants can be adjusted.
- **Intercropping System:** The maximum height of plants which can be achieved under optimum growing conditions may be 30 cm with heavy leaf biomass. Intercropping is possible when the two crops growing together do not compete for same nutrients. Experimental study was also conducted by planting annual crop of *Swertia angustifolia* (Chirayita) plants in a spacing of 15 cm in straight line between the gaps of two rows which showed very encouraging results and it was concluded that because these two crops have different maturity period and crop cycle, hence they can be grown together successfully.

- **Interculture and Maintenance Practices:** The leaves of plants are prone to decay during rainy season. Such leaves must be removed immediately from the plants to avoid any fungal infection. The slope of water drainage can be put toward inner side of field to protect the fertile soil from washing away.
- **Weed Control:** Broad leaved weeds and some perennial grasses are common during rainy season which should be uprooted immediately. Six weeding operation are needed per year.
- **Disease and Pest Control:** Leaf hopper and snails generally attack the foliar part of crop. No bacterial and fungal diseases were reported. To check the disease, the extra foliar growth should be removed. Sometimes extreme frost conditions are observed in high hills which lead to leaf and flower decay.

Harvest Management

- **Crop Maturity and Harvesting:** The crops mature in autumn from the second year and onwards. However, it is recommended to harvest roots during third year.
- **Post-harvest Management:** The underground rhizomes are taken out and after removing the leaf and soil debris, they are washed thoroughly under running water and cut it into small pieces of 5 cm long and allowed to dry in partial shade for 8-10 days or till complete drying (4-6% moisture stage). The dry rhizomes are packed in gunny bags and stored in cool and dry conditions.
- **Chemical Constituents:** The rhizome of Bergenia ciliata contains bergenin (0.6%), gallic acid and tannic acid (14.2%), glucose (5.6%, mucilage and wax).
- **Yield and Cost of Cultivation:** The plant yields 7.0-7.2 tonnes rhizomes per hectare (dry biomass) after second year when the crop is raised through rhizome cuttings. The cost of cultivation for one hectare may come to Rs.112,940/-.

Therapeutic Uses: The drug is used as litholytic agent for urinary calculi. It is widely used in the treatment of dysuria, cystisis, crystalluria and renal failure, vertigo and headache. The rhizomes and roots of the plant act as astringent, tonic and have anti-inflammatory effect and are applied as poultice for stiff joints, boils, abscesses and skin infections. The root powder is considered to be a mild diuretic, but in higher doses, it exhibited anti-diuretic action. Various Ayurvedic classical drugs such as Pashanabhedadi kwath, Pashanabhedadi ghrit, Pashanabhedadi Churan etc. are prepared from Pashanbhed rhizome.

14. *Nardostachys grandiflora* DC Syn. *Nardostachys jatamansi* DC

Climate and soil: The plant generally grows in steep hills with 40°–70° inclined slopes and is more frequent on open, stony, and grassy slopes. It is more abundant in the western cooler slopes. Usually, it occurs on primary litter and soil deposits as pioneer species. For the cultivation of *Nardostachys jatamansi*, loamy porous soil rich in organic matter like

humus is considered the best. Thick humus layer promotes rapid growth and profuse branching.

Propagation material: Seeds are the best propagation material, although vegetative propagation may be undertaken to get a crop within two to three years, if sufficient mother plants are available. However, initially the planting stock has to be raised through seeds only. Seeds have 80% germination rate when sown in a mixture of soil, sand, and FYM (farmyard manure)/compost in equal quantities in styrofoam trays.

Agro-technique

Nursery technique

Raising propagules: The crop can be grown by raising a nursery in May, from seeds or vegetative rhizomes separated from the mother plants. Seeds may be sown manually in small plots of 1 m × 1 m size or in styrofoam trays in the polyhouse. Seed germination varies between 74% and 80%, and occurs within 12–30 days when planted at a depth of 0.5 cm in sandy soil inside the polyhouse.

Propagule rate and pretreatment: Approximately 600 g of seeds are required for raising seedlings for transplanting in 1 hectare of land. Both seeds and rhizomes are treated with GA3 (gibberellic acid; 100 PPM [parts per million]) and 200 PPM) for 48 hours for rapid germination/sprouting.

Planting in the field

Land preparation and fertilizer application: For cultivation, land is prepared by digging or ploughing well, prior to summer season. Soil is tilled thoroughly and beds are left open for a week for solarization. After the land preparation, forest leaf litter/compost/FYM is added to the beds before seedlings or vegetative rhizomes are transplanted. Raised beds are found suitable for good biomass production at high altitudes. A minimum of about 40 quintals FYM/forest leaf litter as basal dose is required for the better growth of plants and good biomass production. Only well-decomposed FYM may be used if sufficient forest leaf litter is not available.

Transplanting and optimum spacing: The seedlings may be transplanted to the main field about 50–60 days after germination at a spacing of 20 cm × 20 cm or 20 cm × 30 cm. Manuring should be done about 15 days before the commencement of transplantation work. After manuring, hoeing and earthing-up may be carried out. In all, 0.2–0.25 million saplings are needed per hectare. There is considerable mortality during plantation and early growth (20%–30%). So additional nursery plants may be kept ready for filling gaps in the second year.

Intercropping system: The plant is grown as a mono crop, and intercropping practices have not been found suitable due to harvesting of roots and rhizomes; hence, intercropping is not recommended.

Interculture operations and maintenance practices: Manure or forest litter (60–80 quintals) is recommended for 1 hectare of land. Fifty per cent manure is used during the first year and rest is applied in two divided doses during the second and third years.

Irrigation practices: Initially, watering should be done on alternate days at lower altitudes (2000 m) till proper rooting is developed. Later, watering is done at weekly intervals during dry season. Constant humidity should be maintained in the soil avoiding waterlogging.

Weed control: Manual weeding is carried out (fortnightly) during early growth season, and later at monthly intervals or as and when required to keep the crop weed-free.

Disease and pest control: No diseases, insects, nematodes or physiological disorders have been observed in this crop. Harvest management

Crop maturity and harvesting: Maturity period of the plant depends on the propagules used. Plants raised through seeds may take three to four years to mature, while the plants raised through splitting of rhizomes mature in two to three years and are ready for harvesting earlier. To obtain good active chemical ingredients, plants must be collected after senescence in October.

Post-harvest management: After harvesting in October, the roots should be washed and well dried in shade to reduce their moisture content to 8%–10%. Dried material should be filled in jute bags or wooden boxes, which can be stored in dry godowns. During storage, hairs on root separate due to rubbing, and are often used as dhoop.

Chemical constituents: The dried rhizomes are steam-distilled to yield 1.5%–1.9% of a pale-yellow essential oil, commercially known as spikenard oil, emitting a pleasant odour.

Yield and cost of cultivation: At the experimental site at an elevation of 3600 m, the recorded yield was 835 kg/hectare dry roots; plantation was raised through seedlings. At lower altitudes (2200 m), the recorded yield was 670 kg/hectare dry weight after third year of cultivation; plantation was raised through seedlings. The yield may increase in subsequent years if the plant is not harvested for one more year. Input cost is estimated to be Rs 500000 hectare for three years at lower altitudes.

15. *Jurinea macrocephala* DC. (Dhooplakkar, Jari-dhoop, Guggal Dhoop)

Morphological description: this species is less perennial herb, with woody rootstocks. Leaves are oblong, lanceolate, spreading, all radical, deeply pinnatifid, white lanate above, densely white tomentose beneath. Heads are 4.0cm across, numerous, rosulate, short-peduncled, peduncles stout, tomentose, often cottony at the base. Outer involucral bracts lanceolate or ovate- lanceolate; inner oblong lanceolate.

Floral Characteristics: Inflorescence head or capitulum. The heads range from 5-25. The plant with twenty flowering heads is considered best for dhoop.

Flowering: July-August; **Fruiting:** August-September

Distributed: It is distributed in Pakistan, Nepal, China and India. In Himachal Pradesh, it is reported fron Chamba (Pangi, Bharmour, Mani Mahesh), Kangra (Dainasar, Thamsar), Kullu (Rorag thach, Manali, Kais, Kanawar, Sainj and Tirthan Wildlife Sanctuaries, Chandrakhani, Lag valley, Parvati valley, Hirb-Shojha catchments, Great Himalayan National Park,), Mandi (Nargu Wildlife Sanctuary), Kinnaur (Chitkul, Sangla valley, Manjiban Kandas Sirmour (Churdhar) and Shimla (Chandranaha1 Chansal, Gorju, Kalgapattan, Muraldanda) districts. It grows in glacial moraines and alpine grassy slope, between 3500-4500m.

Climate and soil: This species prefers sub-alpine and alpine climates and can be cultivated between 2500- S000m in sandy and porous soils.

Chemical ingredients: Roots yield a caoutchouc-like material.

Therapeutic Uses: Roots are considered to be a stimulant and given in fever after childbirth. Decoction of the root is given for colic pain and bruised roots are applied to eruptions. The aromatic roots form the chief ingredient of Dhoop/Havan Samigri and are used as incense in homes and religious ceremonies.

Market value: 90-150 **Rs/kg; dry, (average price)**

Agrotechnology and Post Harvest Processes

Seed collection, drying and storage: Seeds of this species collected during October. After drying in shade for two weeks, seeds are filled in airtight containers and stored in cool condition.

Field preparation and manuring: The land is dug or ploughed twice or thrice to make the soil porous. Approximately 60-S0qt manure is required for one acre land. Raised beds are preferred to prevent water- logging.

Propagation and cultivation: It is propagated through seeds and roots. Seeds are sown at a distance of 30 cm during May and June. The aerial parts dry up during winter. This cycle is repeated for 4-5 growing seasons after which flowering and fruiting takes place. At lower altitudes, seeds are sown during October and November inside greenhouse and by the end of March, seedlings are well developed and ready to transplant. In one acre land nearly 33,000 plants are required.

Irrigation and weeding: The crop is irrigated in every two days interval particularly during March, April and May. Weeding is required frequently during the early stages of plants and at the seedling stage. After the second year of growth, monthly weeding is sufficient.

Harvesting: The species requires at least two years for maturation. However, harvesting after 3 or 4 years is suggested for better yield and quality. Harvesting is done after maturation in late September or October. The reproductive phase commences earlier at lower altitudes.

Yield, post-harvesting techniques and income generation: Estimated yield per acre is approximately 5-6qt after three to four years of growth. After harvesting, roots are cut into slices and dried in shade and packed in cotton bags for trade.

16. *Polygonatum verticillatum* (Linn.) All. (Salam-misri, Meda, Mahameda)

Morphological description: *Polygonatum. verticillatum* is an erect,

robust and perennial herb with many whorls of narrow lanceolate leaves. Stem angled and grooved. Rootstock is thick, creeping. Fruit a berry is distinguished by its large alternately arranged elliptic leaves.

Flowering and Fruiting: June-September (*P. verticillatum)*

Distribution: This species grow from temperate to alpine regions between 1500-3700m. *P. verticillaltum* has wide range of distribution from Himachal Pradesh to S.W. China. It is distributed in Tibet to Europe. In Himachal Pradesh this species are reported from Shimla, Sirmour, Kullu Mandi, Kangra, Kinnaur and Chamba districts from 2000-3800m.

Chemical ingredients: Meda and Mahameda are among the eight constituents of *Ashtha Verga* in Ayurveda. Rhizomes contain saponins, flavonoids and vitamin, starch, protein, pectin and aspagin and digitalis glucoside, saponosides A, B, C and D, lysine, serine, aspartic acid and threonine.

Climate and soil: This species can be cultivated in partially shaded moist places rich enough with humus. It requires porous soil holding sufficient moisture.

Therapeutic Uses: This species used as tonic. It promotes body heat, dries up serious fluids, carminative and antitussive. Also used against loss of vigour, pain in the kidney and hips, swelling and fullness in the abdominal region, accumulation of fluids in bone joints, skin eruptions and cough. The rhizome accelerates healing, recommended for tuberculosis and as a remedy for menstrual problems. A paste of seeds and leaves is applied to itching and chapped skin. The rhizomes are eaten raw or cooked, the powder is given for gastric complaints and the paste applied to wounds.

Market value: 100 Rs/kg; dry (average price)

Agrotechnology and Post Harvest Processes

Seed collection, drying and storage: The period of fruit ripening varies among the species. Ripend fruits are collected and seeds are segregated from the pulp. After one month of drying at room temperature, seeds are packed in airtight containers and stored at low temperature.

Field preparation and manuring: The field is ploughed 2-3 times and stones, weeds, etc. are removed from the soil. About 1St/ha of forest humus or FYM is mixed thoroughly during the winter months.

Propagation and cultivation: This species propagates through seeds or tubers. Seeds of this species show dormancy and require chilling for germination. Germination in *P. verticillatum* is good. Seeds can be sown during October in beds or March-April in polybag containing mixture of sandy loam and forest humus (1:1). The polybags are placed in shade. Vegetative propagation is very encouraging for early growth and higher yield as well. During March, rhizomes **are** divided into slices (2-3cm) and planted in polybag or nursery beds at a distance of 30x30cm. Total 1,10,000 seedlings or cuttings are required for hectare land.

Irrigation and weeding: Regular irrigation is required in the initial stage. After complete germination, the beds are irrigated within 5 days gap. During rainy season irrigation is rarely required. Weeding is done weekly during summer and winter season and twice in a month during remaining months.

Harvesting: The tubers are harvested after seed setting during late September or October.

Yield, post-harvesting techniques and income generation: The estimated production of this species is 9-10qt/ha after three years of cultivation. After harvesting, rhizomes are washed and dried in the sun or in warm air, and divided into small slices. After drying, these are packed into gunny bags for trade.

17. *Trillium govanianum* Wall. ex D.Don (Naagchatri)

Morphological description: *Trillium govanianum* is a perennial herb found growing in patches in forests under shade in humus-rich soils. Rootstocks are thick, creeping, stem erect and unbranched. Leaves are broadly ovate, acute, leaf- stalk 0.5-1.5 cm long; arranged in a whorl at the summit of stem with a solitary stalked flower in the centre. Flower brown- purple. Fruit are globular, red berry around 2 cm in diameter, seed ovoid, numerous, having a pulpy lateral appendage.

Flowering and Fruiting: May-June-September (*Trillium govanianum)*

Distribution: Himalayan Trillium is scattered localities in the Himalayas, Bhutan, Nepal and China, at altitudes of 2700-4000 m. It is so distinct that it prompted a few to think of it as a separate genus Trillidium. The plant has some similarity to Himalayan Paris.

Chemical ingredients and Uses: *Trillium govanianum* roots contain Trillarin, which on hydrolysis yields 2.5% diosgenin—a cortico-steroid hormone. The cortico-steroid hormone isolated from the plant is used in various preparations like sex hormones, cortisone, and allied preparations used to treat rheumatism, regulation of menstrual flow, and the like. It is also used to address stomach- related problems. Because of its effective medicinal properties, demand forthis drug is high in international markets. Photograph 16 shows different parts of *Trillium govanianum*.

Agrotechnology and Post Harvest Processes

Propagation

Trillium govanianum propagation proceeds mainly by division and planting of rhizomes with growing bud. Multiplication by seed is reported in many research publications, but details regarding seed collection, dormancy, and viability are not described. Propagation occurs only through planting of rhizomes with growing tip.

Soil requirements

This grows well in soils with pH range of 5.6-7.5—slightly acidic to neutral soils. The plant prefers sandy and loamy soils. The plant requires moist, humus-rich soil and thus regular watering is essential to maintain soil moisture. Polyhouse and nursery-raised beds are prepared with a mixture of forest soil, sand, and vermicompost (1:1:1). Bulbs are fleshy and thick, and require rich nutrient soil for development and growth of the plant.

Rhizome planting

Trillium govanianum is propagated by planting rhizomes with growing apical bud; growing from seed has not yet been practiced. Rhizomes of this species are smaller and planted in nursery polybags or directly in the field (prepared prior to planting) in rows. Smaller sizes of plants and rhizomes allow greater density of planting and placed 10 cm apart and 15-20 cm row to row.

Planting of rhizomes occurs during dormant period in winter months November-December, and sprouting begins in February-March.

Nutrient requirement

Trillium govanianum is a tuberous crop, requiring high soil nutrients and organic matter, achieved by addition of 4000-5000 kg vermin-compost/ha. Importantly, these are preliminary specifications for this species, resulting from initial studies and subject to change per future investigations/experiences.

Irrigation and weed control

Trillium govanianum also requires a high soil moisture (60-70%) level for desired growth. Water two to three times during summer months to help ensure survival of the plants in nursery and vigorous growth.

Maturity and best harvesting

Trillium govanianum flowers during May-June, and seeds mature in early September. Best period for harvesting of rhizomes is during mid September. Rhizomes are harvested by digging the rhizome and cutting the apical portion with bud of the rhizomes for planting in nursery polybags or in bed for growing fresh plants for future production.

Post-harvest management

Trillium govanianum rhizome is washed and dried after collection from forests to remove soil and adhering debris. Washed rhizomes are spread on tarpaulin for drying in shade for 4-5 days. Dried material is packed in gunny bags or cotton bags for sale.

18. *Aloe barbadensis miller* (Ghrit Kumari)

Morphological description:

It is a succulent plant, an evergreen perennial herb. Stem less or short stemmed, grows upto 60-100 cm of height. Its leaves are thick and fleshy. They may be green to grey- green in color. Margin of leaves are serrated and it has small white teeth. The shape of leaves is rosette shape. Large amount of pulp is present in the parenchyma of leaves. The width of base is 10 cm. The size of flowers are 90 cm. Flowers have a yellow tubular corolla which is upto 2-3 cm. The color of flower is ranging from white to yellow to orange to near-red. Seeds are held in dry capsules. It has no calyx. Roots grow wide and not too deep in soil. Roots are forms arbuscular mycorrhiza.

Distribution:

Chemical composition: Aloe vera contains 75 potentially active constituents: vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids and amino acids.

Climate Required for Aloe Vera: Basically, Aloe Vera is a warm tropical crop. Aloe Vera can grow in various climatic conditions. This can be successfully grown in low rainfall regions and dry areas with warm humid conditions. This plant is very sensitive to extreme cold conditions. This

plant thrives best on dry sandy soils in the regions where lower rainfall is expected. This plant cannot tolerate frost and cool climatic conditions.

Soil Requirement for Aloe Vera:- Aloe Vera can be cultivated on a wide variety of soils from sandy soils to loamy soils. However, it thrives best in light soils. As this plant is sensitive to water stagnation, make sure to select the well-drained soils for its cultivation. This plant can tolerate soils with a high pH range up to 8.5. Aloe Vera growth would be faster in black cotton soils with good drainage. This plant also thrives best with higher foliage. This plant also tolerates soils with salty in nature.

Propagation and Planting Method of Aloe Vera:

In Aloe Vera farming, propagation is done through root suckers/rhizome cuttings. In Aloe Vera farming, propagation is done through root suckers/rhizome cuttings. In case of root sucker propagation, select medium size root suckers and should carefully dig without damaging mother plant at the base. This can be directly planted in the main land. In case of rhizome cutting propagation, after harvesting the crop, dig out the underground rhizome and make about 6 cm length cuttings with two to three nodes on them. Place these on prepared sand beds. Once sprouts are popping up, transplant these into the main field. Usually, about 15000 suckers are required for 1 acre of the nursery.

Land Preparation, Planting Density and Spacing: Land should be plowed and cross plowed thoroughly to bring the soil to the fine tilth stage. To increase the soil fertility, add about 15 to 20 tonnes of well-rotted farmyard manure during the last plow. Form ridges and furrows @ 40 cm apart. The suckers should be planted @ 40 cm distance.To accommodate about 50,000 to 55000 plants per hectare, the spacing between plants should be 40 x 45 cm (or) 60 x 30 cm maintained.

Irrigation: Aloe Vera crop can be grown both under rainfed and irrigated conditions. Irrigation should be carried out immediately after planting the suckers. A couple of irrigations in hot summer weather will result in good yield. In the rainy season, avoid water logging in the field as this crop is sensitive to water stagnation.

Weed Control/Intercultural Operations: As part of intercultural operations in Aloe Vera farming, earthing up should be carried. Weeding should be done @ regular intervals.

Manures and Fertilizers: As part of the land preparation, apply 15 to 20 tonnes/ha of well-rotted farmyard manure (FYM). Thereafter the same dose of farmyard manure should be applied every year. As a basal dose, fertilizers like NPK in the ratio of 50:50:50 kg per hectare should be applied.

Pests and Diseases : Aloe rust, basal stem rot and bacterial soft rot are the common pests and diseases found in Aloe Vera farming. For control measures, contact your nearest agriculture department.

Harvesting: Aloe Vera crop will become ready for harvesting from the second year after planting. Fresh leaves of 3 or 4 can be picked. Picking up leaves should be done during morning or evening times. Three harvests can be carried in one year time. This crop is a labor intensive crop. After harvesting leaves, again they re-generate up to 5 years after planting. Not only leaves, but side suckers can also be harvested for use in planting material.

Post Harvesting Tasks:- After harvesting the fresh leaves, care should be taken for drying the leaves. Usually, harvest crop is allowed to lose the moisture in the field itself before transporting. To prevent any mold growth, leaves should be kept dry and cool. Use of concrete floor is useful in stacking or storing them.

Economic Life: – Commercial yield of Aloe Vera can be obtained from second to the fifth year. Thereafter, the field should be re-planted.

Yield :- An average yield of 40 to 45 tonnes of thick leaves can be obtained per 1-hectare land cultivation. Excellent plant for cultivation in the dry and regions with less annual rainfall and once planted, it gives the yield for 5 years. Due to its international demand, this crop can turn into gold with good crop management practices.

19. *Taxus contorta* Zucc. (Rakhal,Thuner)

Morphological description: Shrubs or trees to 20 m tall and 300 cm dbh, single or multi stemmed Branches numerous, forming a rounded or pyramidal crown. Bark thin, red-brown, exfoliating in large flakes. Twigs alternate, slender, round, finely grooved along leaf bases, green turning yellow-brown or gray. Leaves spirally inserted but arranged in a V-formation, linear, slightly twisted at the short-petiolate base, 15-40 × 1.5-2.5 mm, with revolute margins and a cuspidate apex. Midrib raised, 0.2 mm wide, continuous to apex on upper surface; flat, 0.2 mm wide, also continuous on lower surface. Leaves dark green with two pale yellow stomatal bands on lower surface; stomata randomly distributed. Pollen cones axial, solitary, in rows along both sides of cone-bearing twigs, ovoid, 6-8 mm diameter, pink when ripe, turning brown.

Floral Characteristics: Seed cones axillary, solitary, with a thin green aril that ripens to a succulent red, 9-12 × 7-9 mm. Seeds oblong, slightly flattened, 6-7 × 4-5 mm, green turning dark brown

Flowering: July-August; **Fruiting:** August-September

Distributed: It is distributed inSW Tibet (Jilong region); central and W Nepal; India: Himachal Pradesh, Jammu & Kashmir, N Pakistan; Afghanistan. In Tibet, it occurs at elevations of 2500-3400 m in pine forests or mixed conifer-hardwood forests, usually as a subcanopy tree or shrub. In Afghanistan, *T. contorta* has been recorded as a minor component of conifer forests at elevations

of 2400-2900 m in the NE Hindu Kush. In Pakistan, its distribution is also restricted to a relatively narrow altitudinal band (2000-3100 m) in the Northwest Frontier Province, the Federally Administered Tribal Area and the Pakistan territory of Kashmir, usually along streams within conifer forests at elevations of 1700-2600 m. In W and central Nepal (west of longitude 83.5° E) *T. contorta* occurs in similar situations as in India (Thomas 2011).

Climate and soil: This species prefers sub-alpine and alpine climates and can be cultivated between 2500- 3000m in sandy and porous soils.

Chemical ingredients: The bark, leaves and twigs are harvested for the commercial production of Taxol, an anti-cancer drug, and this use is the main driver behind the ongoing decline of T. contorta in India and Nepal

Therapeutic Uses: Medicinal uses include leaf extracts for cough, cold, fever, headache, and gastrointestinal problems. Bark juice or tea is also used for fever and to feel warm during winter. Leaf or bark juice are taken daily to cure cancer, and a paste made from the bark is applied to the skin to treat headache, muscle pain, joint pain and rheumatism. Of all these uses, the most prevalent are medical use for gastrointestinal complaints, timber, tools, and food

Agrotechnology and Post Harvest Processes

Cultivation For economic development and continuous availability of raw materials from Taxus, proper cultivation techniques need to be developed. Barren lands, leasehold forests, community forests and private forest can be used for cultivation of Taxus *contorta*. Propagation this species can be done through seeds and cuttings.

For propagation of Taxus *contorta* through seeds and cutting, following steps need to be considered:

Bed preparation Bed should be laid towards southern aspect with irrigation facility. Bed should not made in such a way that it can be washed away in rainy season and grazing animals cannot accessed. Bed width of 1 m but length can made with required necessity ranging from 10 to 15 m. Bed should be covered with 5 inch of sieved sand. Bed should be demarcated with stones, woods or bamboos in order to prevent sand to get washed away in rainy season. Generally, bed is made inside polyhouse.

Seed preparation In October-November month, completely ripen seeds are collected. Outer red covering of seeds are removed and seeds are washed with clean water. Then, seeds are dried in shady places. After four month, those seeds are stored in such a way that it cannot be attacked by fungi, insects and rodents.

Nursery preparation To propagate Taxus *contorta* from seeds, polyhouse is necessary. For germination of seeds, sieved fine clean sand is to be kept in bed. While preparing bed, it should be properly leveled and four sides need to be fenced by bamboos, woods, stones or bricks. In bed, about 5 inch clean watered sand need to be placed. After preparation of bed, Falgun-Chaitra is prefered for seed sowing. Seeds should be sown below 2 cm of sand keeping 15 cm between consecutive seed sowing location. Bed should be watered in morning and evening observing amount of moisture present in bed. Inside polyhouse, it is prefered to be 25 ℃

temperature. After one month of germination of seeds, it should be transferred to polybag. In polybag, ratio of soil, fertilizer and sand should be 2:1:1 respectively. After transferring seeds in polybags, it should be kept in polybag for around one year and then it is suitable to sow in field.

Seedling preparation through cutting

Cuttings can be placed in same bed in which seeds are placed. While selecting cuttings, mother tree should be matured, healthy and non-diseased. In case of selecting branches, one to two years old aged fine branches are selected. Above two years branches are not suitable for cuttings. From selected branches, around 15 cm length parts are made. Those parts made are soaked in Rootex-3 no. root inducing hormone solution. Then, those parts of branches are planted in slanted way position below 3 cm sand. January month is suitable for cutting and after six month onwards, roots can be observed. After observing roots, it is placed in polybags for one year and then plants is suitable to plant in fields. While planting 0.3 m depth below soil need to be dug and in it soil and fertillizer is placed. In private field, it can be planted keeping 3-3 m difference between consecutive plants and in forest, 5-5 m difference between consecutive plants can be made.

Summary of pack and practice of selected medicinal plants are provided in the following table:

Table 2: Agro-techniques of selected species with market trends

Species	**Spacing**	**Planting material**	**Sowing**	**Harvesting period**	**Maturation period**	**Intercropping**
Saussurea costus	30 x 30 cm	Seed	Sept-Oct	Sep-Oct	2-3 years	*Angelica glauca*
Inula racemosa	50 x 50 cm	Seed	Nov or early March	Oct-Nov	1.5 years	Monocrop
Aconitum heterophyllum	2 x 2 m	Seeds, tuber or young leafy stems	Oct-Nov, March-April	Oct-Nov	3-4 years	Monocrop
Picrorhiza kurroa	30 x 20 cm	Seedlings, rhizomes/stolons/offsets	Oct-Nov	September	3 years	*Foeniculum vulgare* (saunf), potato, and *Digitalis purpurea*
Hippophae rhamnoides	20 x 5 cm	Seeds	May	Oct-Nov	3-5 years	Normal agricultural crop
Bunium persicum		Seeds	April	Oct	Every year	Normal agricultural crops
Dactylorhiza hatagirea	15 x 15cm	Seeds			5 years	*A. heterophyllum*
Angelica glauca	45 x 45 cm	Seeds	Nov-Dec	Sept-Oct	2-3 years	*Saussurea costus*
Viola canescens	30 x 30cm	Plantlets, Seeds	March-April	April-May	Leaves-2 months Flowers-9-10 months	Can grow in orchards
Valeriana jatamansi	40 x 20 cm	Seeds	June–July	Sept-Oct	1-2 years	Fruit orchards

Hedychium spicatum	45 x 30cm	Seeds and rhizomes	April	Oct–Nov	Biennial	Fruit orchards
Pistacia integerrima	1 x1m	Seeds	June-July	July-August	9-10 years	Pure crop or with medicinal plants
Zanthoxylum armatum	50 x 50cm	Seeds	Aug-Sept	May-June	5 years	Monocrop
Withania somnifera	60 x 60 cm	Seeds	July Aug	January-March	5-6 months	*Cocos nucifera, Mangifera indica*, *Tectona grandis*, *Simaruba officinalis*, *Jatropha curcas*, *Pinus* spp. and *Populus canadensis*.
Bergenia ciliata	30 x 30 cm	Seeds and Rhizome	Rhizhomes-Aug-Sept, Seeds-March-April	Sept-Dec	2 years, Roots in 3rd year of plantation	*Swertia angustifolia* (Chirayita)
Podophyllum hexandrum	9 x 9 m	Rootstocks	March-June	March-June	5 years	

*ha-Hectare, t-tonnes, qt-quintals

Economic return to the farmers and Cost:Benefit ratio of selected medicinal plants

The economic return to the farmers through cultivation of selected medicinal plants species have been worked out from available agro-techniques, current market price of medicinal plant as per NMPB (e-chark) and other source. Most of the agro-techniques was developed by NMPB, GBPNIHE and other universities and research institutions between the year 2000 to 2014. Hence, rate of inflation has been adjusted using www.inflationtool.com/indian-rupee to get cost of medicinal plant cultivation and net return at current price leve (tabl 3).

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Table 3: Economic return and Cost: Benefit ratio of selected medicinal plants

Medicinal plant Species	*Cost of cultivation (Rs/ha)	Estimated yield (kg/ha)	Current Market Price (Rs/kg.)	Total Returns (Rs/ha)	Net Benefit (Rs/ha)	Benefit Cost Ratio	Crop cycle duration (Years)	Source
Sassurea costus	1,80,000	4200	450	1890000	1710000	9.55:1	3	NMPB 2006, Kuniyal et al. 2019
Aconitum heterophyllum	3,04,500	500	4000	2000000	1695500	5.56:1	4	NMPB 2006*
Hippophae rhamnoides	2,00,000	3000	50	150000	130000	6.5:1	4	DIHAR
Aloe barbadensis	179000	30000	15	450000	271000	1.51:1	1	www.agrifarming.in
Angelica glauca	110000	800	500	320000	210000	1.90:1	2	Kaintura, et al 2019
Bergenia ligulata	112940	7000	100	700000	587060	5.19:1	3	NMPB 2014*
Dactylorhiza hatagirea	305800	1800	500	900000	594200	1.94:1	3- 4	Shekhar et al. 2000*
Hedychium spicatum	116880	9000	130	1170000	1053120	9:1	2	NMPB 2006*
Inula racemosa	110460	7000	290	2030000	1919540	17.37:1	2	NMPB 2006*
Nardostachys jatamansi	559150	835	1100	918500	359350	0.64:1	3	NMPB 2006*
Picrorhiza kurrooa	327280	600	1600	960000	632720	1.93:1	3	NMPB 2006*
Valeriana jatamansi	175330	2000	400	800000	624670	3.56:1	2	NMPB 2006*
Polygonatum verticillatum	180000	1000	850	850000	670000	3.72:1	2	Samant et al. 2008
Withania somnifera	37670	500	280	140000	102330	2.71:1	1	NMPB 2014*

*Cost of cultivation includessoil and land development, seeds & QPM cost, weeding and hoeing, maintenance, uprooting or harvesting, and drying and packaging approx. cost

Conservation status of prioritization of medicinal plants of Kullu and Lahaul Spiti districts

The conservation status of prioritized medicinal plants species of clusters of Kullu and Lahaul & Spiti districts have been assessed from CAMP (2003), CITIES & IUCN red list and community consultation (Table 4). Survey revealed that local people are cultivating *Saussurea costus* and *Inula racemosa* in their agricultural land for livelihood generation in Keylong cluster. Several threatened species such as *Aconitum heterophyllum, Picrorhiza kurrooa and Hippophae rhamnoides. Bunium persicum* and *Dactylorhiza hatagirea* are being collected from the wild by indigenous community for their own therapeutic uses and trade as per the ethnic customary rights. Small scale cultivation of *Picrorhiza kurrooa, Saussurea costus, Inula racemosa, Angelica glauca, Aconitum heterophyllum* are being carried out by few farmers of of the Kullu and Lahaul & Spiti districts.

Table 4: Conservation Status of Prioritized Medicinal and Aromatic Plants from Keylong, Kullu, Jari and Largi Clusters of Kullu and Lahaul Spiti districts.

Species	Conservation Status		
	CITES	IUCN	CAMP
Aconitum heterophyllum Wall. ex Royle	-	CR	CR
Aloe barbadensis Mill.	A-II	-	-
Angelica glauca Edgew.	-	EN	EN
Berberis aristata DC.	-	LC	EN
Bergenia ciliata (Haw.) Sternb.	-	LC	-
Bunium persicum (Boiss.) B.Fedtsch.	-	-	VU
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	-	LC	VU
Dactylorhiza hatagirea (D.Don) Soo	-	CR	CR
Hippophae rhamnoides L.	-	-	VU
Inula racemosa Hook.f.	-	-	-
Picrorhiza kurrooa Royle ex Benth.	A-II	EN	EN
Rheum australe D. Don	-	-	EN
Saussurea costus (Falc.) Lipsch.	A- I	CR	CR
Sinopodophyllum hexandrum (Royle) T.S.Ying	A-II	EN	EN
Taxus wallichiana Zucc.	A-II	-	EN
Trillium govanianum Wall. ex D.Don	-	EN	-
Zanthoxylum armatum DC.	-	LC	EN

Abbreviations used: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; LC= Least Concern; R= Rare; DD=Data Deficient; RDB= Red Data Book of Indian Plants; IUCN= International Union for Conservation of Nature; CAMP = Conservation Assessment and Management Prioritization, A-I = Appendix-I; A-II= Appendix-II

Sustainable Harvesting and Collection Protocols of selected Species

'Sustainability' is a principle that has been used for centuries in forestry and in the management of natural resources and has been simply described as a system that meets the needs of the present without compromising the ability of future generations to meet their own needs. This includes timing of harvesting, material to be harvested, harvesting techniques, harvesting equipment and storage. Special consideration needs to be given for sustainable harvesting of medicinal plants. The sustainable harvesting and collection protocols for medicinal plants are discussed in the following paragraphs:

When to harvest

- Determine the right time for harvesting which will vary from one species to the other. Collect at a time when the plants are in optimum condition with respect to required medical quality and efficacy.
- Determine the best time for collection, *e. g.* the season, date or time of day, rather according to the quality and quantity of the active ingredients than the total amount of material you can gather. This ensures the best possible quality of raw material and products. The concentration of biologically and medically active ingredients varies with the stage of plant growth and development. This also applies to non-targeted poisonous ingredients. Often, you will be able to rely on a broad range of indigenous knowledge on the appropriate harvesting dates and times.
- Harvest medicinal plants under the best possible climatic conditions for the specific species to avoid either desiccation or fermentation and mould growth and thus deterioration of the material.

What to harvest

- Be sure that you can identify the plants that you intend to harvest without doubt. Distinguish clearly between the medicinal plant and its closely related relatives in order to avoid unwanted mixtures.
- Choose healthy and well-developed plant material. Do not harvest plant material that is infested with fungal growth or insects. This is because by-products of these organisms will alter the ingredient profile and could even be poisonous.
- Be sure the plants you intend to harvest have not been sprayed with pesticides, herbicides, or fertilizers. Be especially aware of this around the edges of farm fields, roadsides, or near industrial activity.

How to harvest

- Gather only plants that are abundant in that area. Be conscientious about leaving a healthy population behind.
- Take special care with leaves and flowers which are much more vulnerable to deterioration than roots due to the nature of their tissue.
- Avoid any unnecessary damage to the plant i.e. exercise caution to enable the plant can re-grow
- Avoid mechanical damage to the harvested material that results in undesirable quality changes.

- Identify and discard unwanted plant materials during harvesting this is to ensure that no foreign matter, weeds, or toxic plants are mixed with the harvested medicinal plant materials.
- Put different plant material in different containers.

Equipment to use

- Make sure that all equipment used is clean and free of remnants of previously harvested plants.
- Keep all containers used during harvesting clean and free from contamination by previously harvested medicinal plants and other foreign matter.
- If plastic containers are used, pay particular attention to any possible retention of moisture that would lead to the growth of moulds.
- When containers are not in use, keep them in dry conditions and in an area that is protected from insects, birds, and other pests.
- In order to reduce the risk, observe carefully whether there are any signs of over-harvest especially, when the plants that you want to collect are in a lower quantity or in a worse condition. Other signs of over-harvesting can be:
  - The distance you have to walk to collect your desired plants increases.
  - The plants do not seem to be in a good condition and/or are infected by pests.
  - Some plants cannot be found locally anymore (Khumalo *et al*., 1998).

Table 5. Time and method of collection of different parts of Medicinal Plants

S. No.	Plant Parts	Time and method of collection
1.	Bulbs	Late autumn, long after the plant has flowered and fruited. Bulbs should be dug from considerable distance from the main plant. Collect mature big bulbs and leave small bubs for regeneration. Bulbs/roots should be collected only after the seed shedding unless otherwise specified. It facilitates regeneration of species.
2.	Bark	Autumn (after leaf fall) or spring (before development of leaves). Remove the bark in long vertical strips using a thin flexible blade/bush knife. Stem bark should not be collected again from same tree unless adequate time has been allowed for it to regenerate completely. Do not practice ring barking, which is the cut of off entire rings around the tree
3.	Root and rhizomes	From annuals shortly before flowering. From biennials during the autumn or winter following the first-year growth. From perennials during autumn or winter following the second- or third-year's growth. Dig the root at a considerable distance, at least 30 cm, from the main stem or tap root. Avoid severing of the tap root. Do not collect all roots from the plant. Collect only the lateral roots.
4.	Leaves	Collection should be made in dry weather whilst the plant is flowering. Pluck individual leaves instead of leaf striping and avoid use of sharp pruning shears for leaves. Collection in the morning is providing quality

		product in some plants (solanaceous leaves). Leaves should be harvested before or at the time of initiation of flowering unless otherwise specified.
5.	Flowers	Collection should be made in dry weather and in early hours of the day, after due has dissipated. Harvest flowers carefully without damaging plant main stem. Flowers must be harvested when they have just opened or shortly afterwards to capture its aroma. Flowers Collection should be made in dry weather and in early hours of the day, after due has dissipated. Harvest flowers carefully without damaging plant main stem. Flowers must be harvested when they have just opened or shortly afterwards to capture its aroma.
6.	Seeds and fruits	Collection should be made when fruits are fully grown and ripe or nearly ripe until otherwise it is required. To avoid seed dispersal, it is advantageous to collect slightly earlier. In forest areas, only collect fruits from some trees or shrubs and leave others completely for regeneration. Branches of the tree or shrub should not be cut for ease of collection of fruits and seeds.
7.	Annual herbs/ whole plant	Annual herbs should be harvested at the time of initiation of flowering. Whole population in a given area should never be harvested. Adequate population should be left for regeneration to facilitate future collections.

Source: WHO. 2003; Heron and Maiti, 2010

Action plan for post-harvest management

Post-harvest management is very crucial to minimize loss & in enhance the marketability of the produce through drying and storing followed by sorting, grading and packing. Due to in adequate infrastructure of drying shade, storage go down etc many medicinal products are loss after harvest.

1. Standardization of Post-harvest technologies and protocols: Medicinal plants should be harvested during an appropriate season or time period to ensure the best possible quality of source materials. It is well known that the concentration of required chemical constituents (active ingredients) is strongly influenced by its developmental stage of growth as well as the season. So, to ensure the quality, Medicinal plants should be harvested by following the sustainable harvesting practices
2. Capacity building of the farmers to ensure the proper knowledge transfer.
3. The raw material should be shade dried and stored in dry place until further process. Drying and storage are two most important step which should be done precisely to ensure quality products.
    - Drying shed: Due to lack of equipment's and sheds, this process has been left unattended and ignored. This can degrade the quality of products. A proper capacity building should be done of the farmers and the groups working with medicinal

plants. Also, some type of preliminary help should be given to the farmers in terms of subsidy of monetary to establish the drying shed.

- Storage Go-downs: Similarly, some provisions or assistance should be made to provide the storage containers, and construction of storage go-downs to the farmers.

4. Technology dissemination among the farmers and groups to ensure the sustainability of the process.
5. Regular monitoring on the process by the local research institutions.
6. Set up collection and processing unit in the area where the clusters formed.
7. Product development
8. Value addition to the products
9. Packaging and labelling of the products
10. Establish the processing linkages with the commercial enterprises.
11. Development of marketing linkages for value added products.

Assessment of existing Value Chain of medicinal plants

The value chain development is most important part of the process as it relates the role in the creation of products and value from local ethnopharmacological resources and its relevance for research on medicinal and health food plants. In a broad sense, a value chain describes the sequence of activities required to make a finished product from its initial starting material. Value chain research focuses on the nature of the relationships among the various participants involved in the chain, and on their implications for development. In practical terms, value chains are descriptions of the transactions and processing of a product until it reaches its end market. The collection and marketing of medicinal plants from the wild is an important source of livelihood for many of the local population in the Himalayas.

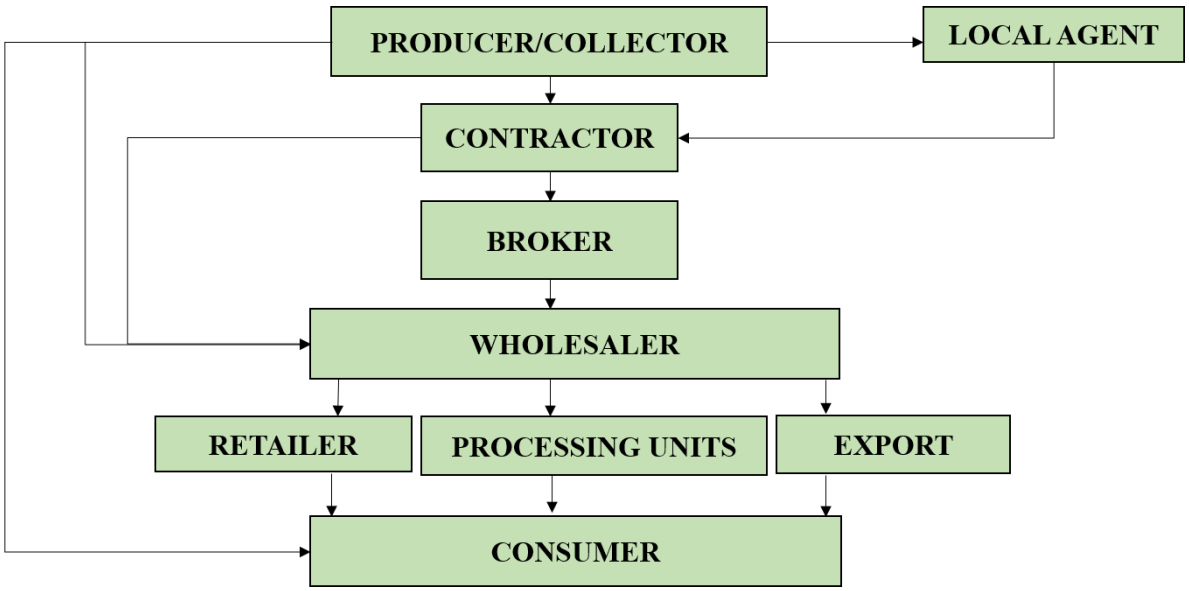

Fig. 3: Existing value chain of MAPs in Himachal Pradesh

Strategies for the value chain development in the cluster

The following value chain development strategies have been suggested for stretenthening the value chain in the selected cluster of Kullu and Lahaul & Spiti district:

1. Identification of the farmers groups and existing trade routes in the clusters
2. Identification of the local stakeholders, line departments and research institutions for the collaboration with the farmers.
3. Set up of laboratories for the continuous monitoring of the quality of raw materials and products. The findings of multiple testing of products will create scope for the Himalayan variety to be introduced in the market which is currently dominated by international brands.
4. Adoption of post harvesting technology for collection, processing and product development
5. Identification of the producers, collectors, wholesalers, retailers, promoters and consumers.
6. Introduction of the industries to the clusters to ensure farmers confidence to cultivate the medicinal plants
7. Capacity building of farmers at each stage by the local research institutions for awareness and quality assurance.
8. Involvement of some NGO's/research institute for making some self-help groups and providing some support to the producers.
9. Financial support and subsidies may also be given to the producers for promotion of the cultivation of medicinal and aromatic plants.
10. Technology standardization and dissemination among the farmers for harvesting and processing of the raw material.
11. Develop enterprise for the income generation which can be sustained after the government and institutional support.
12. Technology package for development of the cluster area and local community engagement.
13. For trade to be equitable, individuals or groups could be reasonably compensated for their contributions (labour, technical expertise, marketing skills, etc.), and level of risk taken.
14. Supply chain analysis can improve understanding of how trade networks operate, who the main actors and organizations are and what their specific activities are, the different routes for trading the MP (which exist and could potentially be developed), and the skills, capacity and experience available for successfully engaging in trade.
15. For small-scale farmers and/or collectors to move from subsistence to trade, or small informal traders to move into more regulated small-scale businesses, various barriers to entry into trade are often encountered, for example access to seedling for planting, to the resource in the wild and market information. As activities become more specialized further along the supply chain, there are greater opportunities for single traders or small groups of traders to exert their market power and establish mechanisms to prevent others entering the business. In addition, export-oriented marketing is particularly demanding, requiring detailed information about specific markets, product specifications and standards. A key challenge for people involved in Medicinal plants activities is to identify these barriers and, where possible and legal, identify ways to address them.

16. Packaging to avoid damage during transport is different from packaging to produce a final product, grade it, or improve its presentation and shelf-appearance. It increases the value of the products and attracts the consumer.

Other Recommendations/Suggestions for medicinal plants conservation and cultivation

In addition to above, several other resource development and sustainable management measures/strategies for conservation and cultivation medicinal plants in the selected cluster are summarized in the following table 6:

Table 6: Conservation, cultivation, resource development and sustainable management measures/strategies for medicinal plants in the selected cluster

S.No	Activity / Action Points	Implementing Agency	*Time Frame	Supporting agency (For fund leveraging and convergence)	Remarks
1	Systematic documentation of MAP diversity, distribution, conservation status and identification of MAP hotspot for robust MAP database development	G B Pant National Institute of Himalayan Environment (GBPNIHE), Botanical Survey of India (BSI), and other local research institutions	Short Term	State Medicinal Plants Board, National Medicinal Plant Board, State and Central government, Forest Department (FD), External funded projects	To fill gaps and updating the previous documents.
2	Prioritization of the species on the basis of local threat and global threat	GBPNIHE, local research institutions/universities	Short term	SMPB and NMPB, FD	Meeting/workshop for prioritization of the species for conservation with local experts and subject matter experts
3	Identification of Gaps for conservation of medicinal plants	GBPNIHE, FD, State Biodiversity Board	Short term	SMPB and NMPB, external funded projects	Strategies and action plan for conservation of medicinal plants and challenges in the route of action.

4	Identification of Biodiversity hotspots and Establishment of Conservation Areas like MPCDA's for *in-situ* conservation of medicinal plants	GBPNIHE, Local Research Institutions, FD and State Biodiversity Board (SBB)	Long term	NMPB and Forest Department	The areas of higher illegal collection can be prioritized for conservation and protection.
5	Knowledge sharing and awareness programmes	GBPNIHE and other local research institutions	Short term	SMPB and NMPB	Promotion of MAP cultivation to check illegal collection.
6	Continuous long term monitoring of MAP diversity & distribution	FD, Wildlife departments	Long term	Forest Department	For conservation and sustainable utilization.
7	Promotion of cultivation of higher demand medicinal plants	GBPNIHE, Agri. R&D institute and univerities, NGO's	Long term	External funding agency, SMPB, NMPB, FD	Will reduce the pressure on natural resources and helps to protect the natural habitat
8	Involvement of local people in the conservation process	Local Research Institutions and FD	Short term	External funding agency, SMPB, NMPB	More people involve in the process of conservation, more awareness will be disseminated regarding the importance of in-situ conservation
9	Implementation of ABS model in the clusters	GBPNIHE, SMPB, NMPB, FD	Long term	SMPB, NMPB	It will stop the Illegal collection and trade of medicinal plants and also conserve the traditional values related to the medicinal plants. Allows equitable sharing of benefits.

10	Documenting sacred groves and their role in conservation	SBB	Short term	MoEF &CC, SMPB, State government	Traditional methods of ex-situ conservation, rituals, beliefs, taboos, possibilities of their replication, etc.
11	Strengthening of existing herbal gardens and creation of more herbal gardens on the basis of traditional knowledge associated	SMPB, GBPNIHE	Mid term	AYUSH, NMPB, NHM, Forest Department	Will provide the fresh raw material to the traditional healers and industry
12	Strengthen and promote the existing traditional medicine practioners	AYUSH, Local institutes	Mid term	AYUSH, NMPB, SMPB	Will conserve the traditional values associated
13	Establishment of Germplasm	GBPNIHE, other local research institutions	Long term	AYUSH, NMPB, SMPB, SBB	Conservation of species and genetic material
14	Strengthening of medicinal plant mandis and creation of more mandis in the cluster areas	SMPB and State Marketing Board	Mid term	NMPB, SMPB, State marketing board	Confidence to the farmers to promote cultivation of medicinal plants
15	Provision of planting material to the farmers and local villagers	SBB, Research Organizations, pharmaceutical companies, stakeholders	Mid term	NMPB, SMPB, SBB	Promotion of Medicinal Plants cultivation
16	Dissemination of proper standardized sustainable harvesting protocols to the farmers	GBPNIHE, and other research organizations	Mid term	NMPB, SMPB, SBB	To ensure the quality harvesting and collection
17	Research Grants and	GBPNIHE, IARI, Dr.Y.S. Parmar University of	Long term	NMPB, SMPB, SBB, external	Will lead to extensive research

	projects related to medicinal plants	Horticulture and Forestry, National research institutions		funding agency, State government, Central Government	on the medicinal plants and the active ingredients.
18	Establishment of highly equipped labs for phytochemical analysis in the cluster area	Research organizations	Long term	NMPB, SMPB, SBB, external funding agency, State government, Central Government	To ensure the regular monitoring of the quality of raw materials and developed products. It will also add value to the products and certification for acceptance in national and international market
19	Training & Capacity Building Programs programs	GBPNIHE, Local Research organizations	Long term	FD, NMPB, SMPB, SBB	Help farmers and local people to adopt the knowledge
20	Preparation of training manuals, Sustainable harvesting and post-harvesting protocols manuals	GBPNIHE, Local Research organizations	Long term	FD, NMPB, SMPB, SBB	Help farmers to cultivate and harvest the medicinal plants in a proper way

*Time frame –Short term-1-3 yr, Medium term-3-5 yr & long term-more than 5 years)

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