Sustainable harvesting and cultivation protocols of threatened medicinal and aromatic plants of the Western Himalaya

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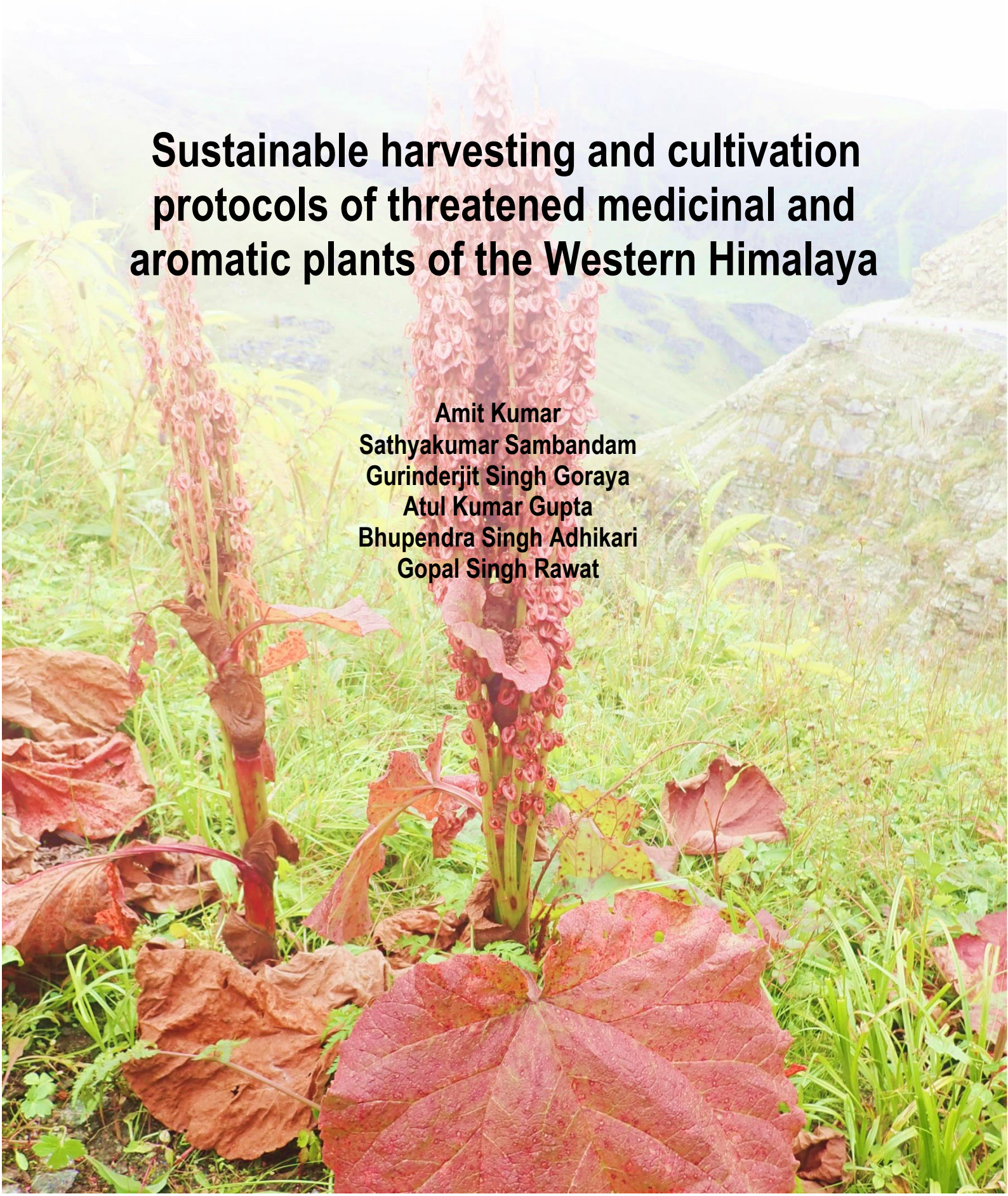

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Front cover
Above: *Fritillaria cirrhosa, Sinopodophyllum hexandrum, Picrorhiza kurroa, Aconitum heterophylloides and Aconitum heterophyllum*
Below: *Fritillaria cirrhosa, Picrorhiza kurroa, Sinopodophyllum hexandrum*, *Aconitum heterophyllum and Bunium persicum*

Back cover
Seichu Tuan Nala Wildlife Sanctuary, Chamba

This publication has been developed by the Wildlife Institute of India, Dehradun under the assignment *'Assessment of medicinal and aromatic plant species on their collection, usage, demand, markets, price trends and life cycle in Lahaul and Pangi landscape, Himachal Pradesh'* under the GEF-GoI-UNDP SECURE Himalaya Project.

Key words
Aromatic plants, Drug, Herbal trade, Threatened medicinal plants, Western Himalaya

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- Authors

Background and rationale

Nested in the Western Himalaya, the state of Himachal Pradesh [30° to 33°N and 75° to 79° E] is known for its rich biological diversity. It covers an area of 55,673 km^2 with >3,300 distinct plants species (Rana and Rawat, 2017). Based on extensive floristic studies, a number of workers have documented plant species richness of Himachal Pradesh. For example, in an extensive floristic inventorization, Chowdhery and Wadhwa (1984) published 'Flora of Himachal Pradesh' in three volumes with a comprehensive list of 3200 species of flowering plants. Aswal and Mehrotra (1994) published a comprehensive account of the flowering plants (985 species under 353 genera) of Lahaul and Spiti, representing semi-arid and cold desert areas of the state. Singh and Rawat (1999) documented 832 species of vascular plants belonging to 427 genera under 128 families from the Great Himalayan National Park. Sekar and Srivastava (2009) enlisted 513 species of vascular plants in Pin valley. Chawla et al. (2012) reported 911 species of vascular plants belonging to 881 species of angiosperms and gymnosperms distributed among 102 families and 433 genera and 30 species of pteridophytes from Kinnaur.

According to Rawat (2007), the alpine areas of Lahaul and Spiti are one of the major hot spots of wild medicinal and aromatic plant species (MAPs) in the Western Himalaya. Unfortunately, the remote valleys such as Lahaul, Pangi, Spiti, Kinnaur lying in the cold-arid regions of Himachal Pradesh are relatively less studied in terms of floristics and MAPs diversity (Bargali et al. 2021). Further, the information on recent levels of trade of MAPs are available only from a few localities of the Western Himalaya (Rawat 2007). Like other areas, these areas have also been facing additional stress due to over-exploitation of forest resources, including the unscientific and premature harvesting of MAPs from the wild, which functions parallel to the illegal and hidden markets thus, putting tremendous pressure on the wild resource base resulting in the dwindling populations and precarious livelihoods of local communities (Kala, 2000; Mathela et al. 2020, 2021). The rising demand of herbal products has caused excessive harvesting of many of the important MAPs from these regions, putting their wild population at the risk of extinction. Keeping aforementioned aspects in view, Kumar et al. (2021) aimed to study selected Medicinal and Aromatic Plant (MAP) species of Lahaul and Pangi landscape of Himachal Pradesh with a focus to ensure sustainable harvesting and cultivation by (i) identifying usage patterns of MAPs, and (ii) studying existing value chains. In order to address the project objectives, the study was categorized into 12 key tasks **(Table 1)**.

Table 1. Proposed key tasks of the study

Sr.no.	Key Tasks
1.	Ethno-botanical documentation of MAP species
2.	Identify and list MAPs with significant economic end usage in the landscape
3.	Select five MAPs each in two categories
4.	Assessment of distribution, abundance and conservation of the listed ten species identified as per the criteria above in the landscape
5.	Study of value chains for the ten listed species
6.	Understand the role of ten MAPs in livelihoods of respective communities and assess how businesses pertaining to these MAPs operate under the existing economic and legal framework
7.	Create one pilot project to demonstrate Access and Benefits Sharing (ABS) model in the project landscape
8.	Design sustainable harvesting and collection protocols
9.	Areas of high conservation value
10.	Cultivation tools and techniques of MAPs in respective landscape
11.	Access and Benefit Sharing (ABS)
12.	Hold consultative workshop with stakeholders

As a result, this publication on 'Sustainable harvesting and cultivation protocols of threatened medicinal and aromatic plants of the Western Himalaya' namely *Aconitum heterophyllum, Aconitum heterophylloides, Bunium persicum, Dactylorhiza hatagirea, Fritillaria cirrhosa*, *Picrorhiza kurroa*, *Polygonatum verticillatum, Rheum australe, Rheum webbianum* and *Sinopodophyllum hexandrum* with special reference to cultivation tools and techniques' is an outcome of the key tasks 8 and 10. A detailed information on the sustainable harvesting and collection framework including five core elements viz., what to collect, what stage, when, how and how much, species and location profile, habitat and distribution, morphology and phenology, population status, conservation status, potential threats, medicinal uses, market and trade, good harvesting and collection practices and last but not least cultivation and propagation methods has been discussed for the selected MAPs. The protocols have been developed by using all the important references.

Study area

The Lahaul and Pangi landscape lies between the Dhauladhar-Pir Panjal and Zanskar ranges in Himachal Pradesh in the upper catchment of Chandrabhaga (Chenab) forming a transition zone between the Greater and Trans-Himalaya. This landscape is contiguous with Doda and Zanskar region of Jammu and Kashmir in the North and spread over an area of nearly 8000 km^2. The landscape is mostly tough, mountainous, dotted with a number of remote valleys. The lowest elevational limit of Pangi is ca. 2000m at Sansari Nala and ranges over to 6,000m comprising the lofty peaks adjacent to the Zanskar range. Beautiful valleys in Pangi include Sural, Hudan, Seichu and Parmar, the way through which leads to Zanskar range. Biogeographically, Pangi landscape falls in the transition zone of the Greater Himalaya and the Trans-Himalaya. Pangi is a remote, rugged and poorly developed tribal area. One of the reasons for its remoteness is rugged topography cut into deep gorge by river Chenab that flows initially in the western and subsequently north-westerly direction. Much of the landscape lies in the rain shadow zone of Pir Panjal having scanty rainfall (<800 mm) and relatively high snowfall. Lahaul valley comprises of two major tributaries of the Chenab River viz., Chandra and Bhaga.

The region has crystalline high mountains interspersed with lush pastures that remain the favorite grounds for the nomadic Gaddi herders of lower Himachal Pradesh. While Pangi lies in the north-west of Himachal Pradesh bordering J&K, Kinnaur is in the east bordering Uttarakhand and China. Pangi is positioned approximately between 32°11'30"-33°13'06"N and 75°45'~77°03'33"E. There are 16 panchayats and 54 inhabited villages in Pangi tehsil. The area of Pangi tehsil is spread over 1601 km^2 with a population 18,868 (Census 2011). Lahaul lies between 32°61'92" N and 77°37'84" E. There are 132 villages with the population of approx. 10,199 (Census 2011). Location of the focal landscape i.e., Lahaul and Pangi in Himachal Pradesh along with forest cover and villages are shown in **Figure 1 and 2.**

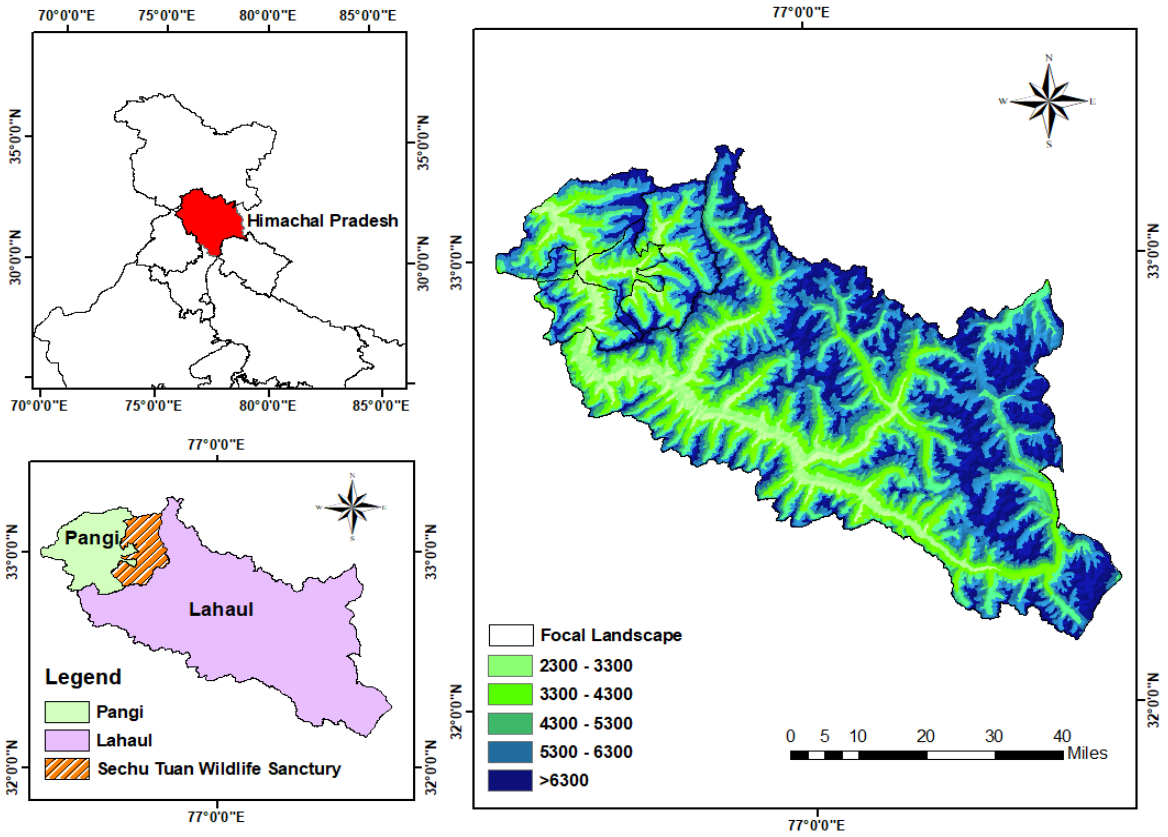


Figure 1: Map showing Lahaul and Pangi landscape in Himachal Pradesh.

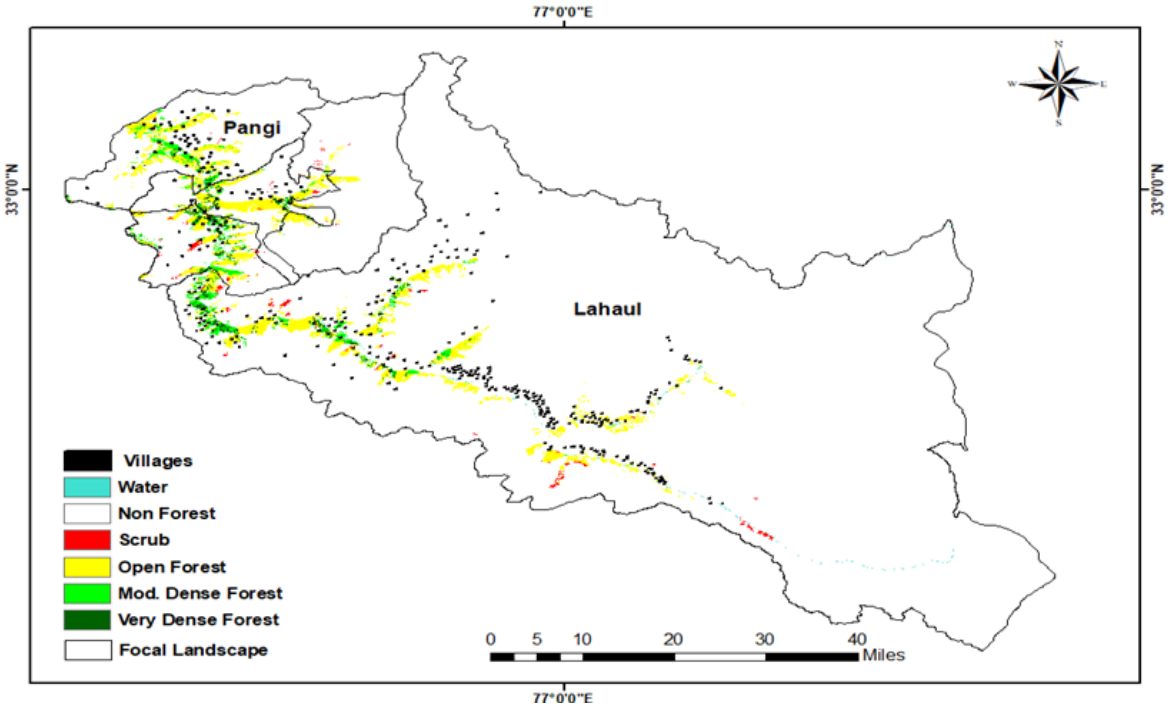
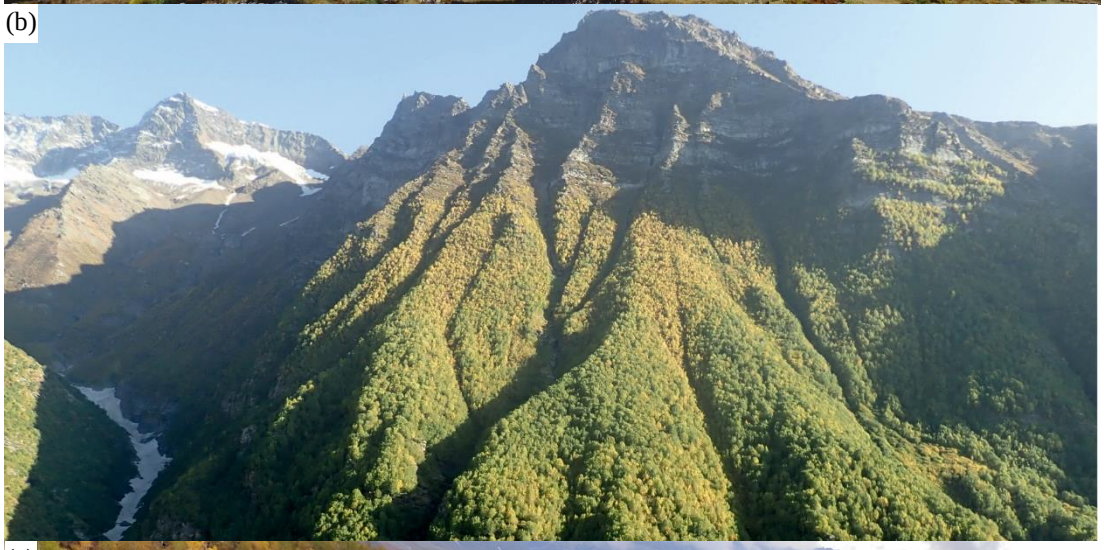


Figure 2: Map showing forest cover and villages in the focal landscape.

(a)

(b)



(c)

Pangi valley: (a) A spectacular view of an alpine meadow in Chasak Bhatori (Seichu valley); (b): *Betula* forest in Hudan Bhatori and (c): Majestic view of Sural valley. Amit Kumar

(a)

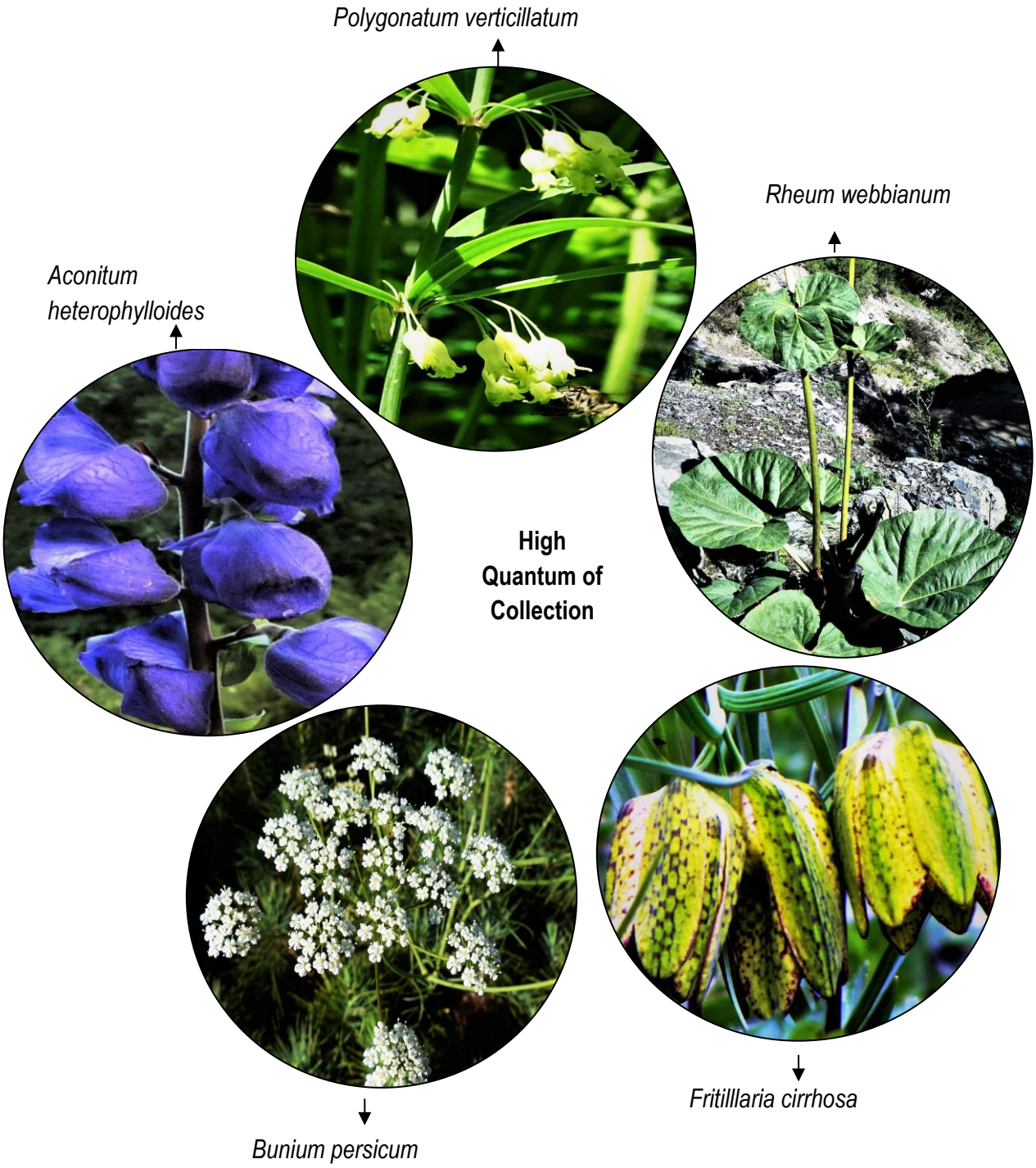
(b)

(c)

Lahaul valley: (a) Enchanted view of Chandrabhaga river; (b) Hamlet at Miyar valley; (c) An adhwari amidst coniferous forest enroute Hadsar. Amit Kumar

Selection of MAP species based on High Threat Perception.

Amit Kumar and Navendu Page

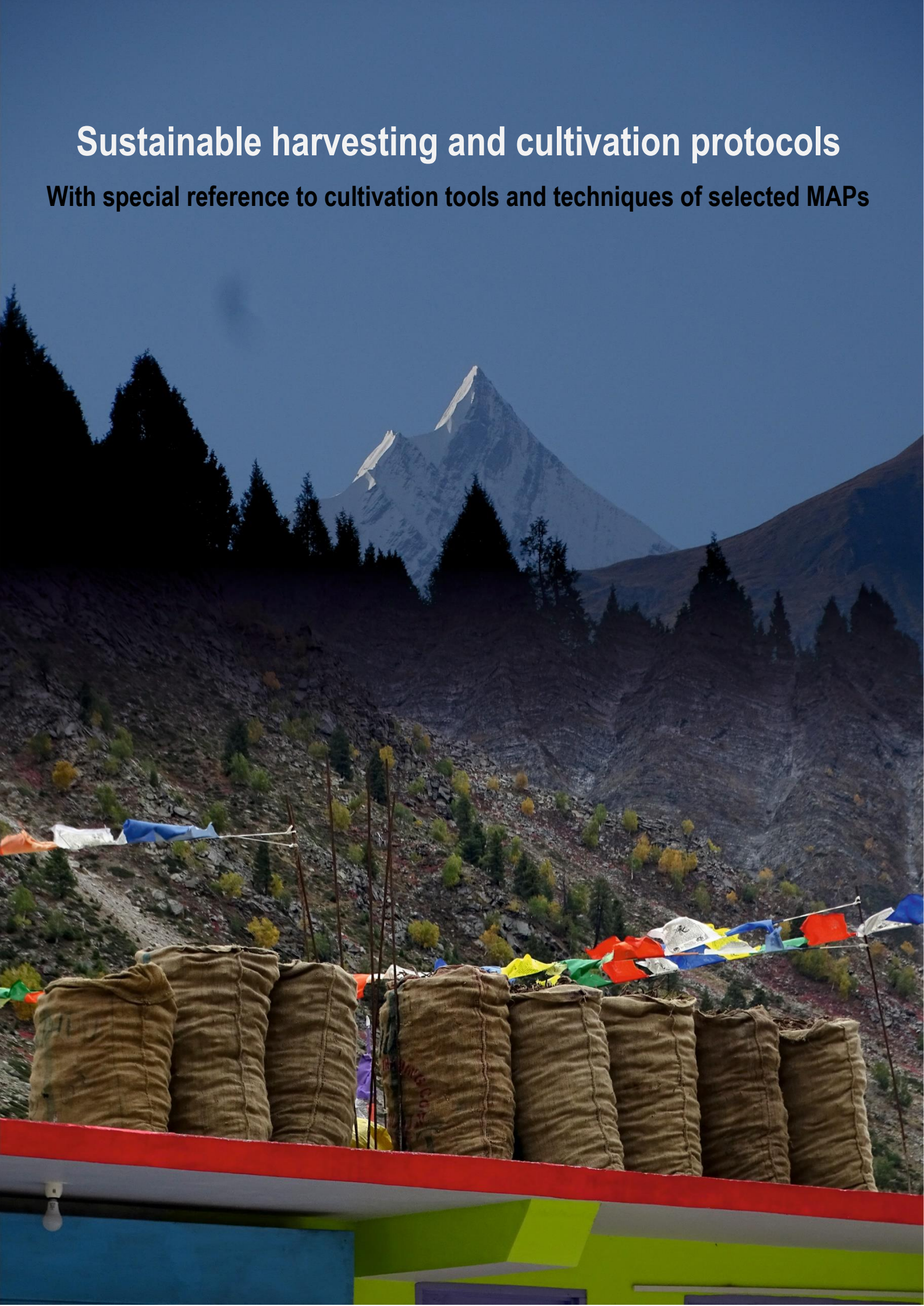


Selection of MAP species based on High Quantum of Collection (HQC).

Amit Kumar, GS Goraya and Gajendra S. Rawat

Sustainable harvesting and cultivation protocols

With special reference to cultivation tools and techniques of selected MAPs



Sustainable harvesting and cultivation protocols

Wild populations of many important medicinal plant species of the Himalayan region have drastically declined over the years due to over and unsustainable exploitation and habitat degradation. Many of these species have come under IUCN's Red List of threatened plants. Thus, there is an urgent need to initiate appropriate conservation measures to resurrect wild populations of these species towards conservation of their diverse gene pool and their continuous availability for human use. Based on secondary sources viz., offline and online, the sustainable harvesting and collection protocol for selected MAPs in the Lahaul and Pangi landscape, Himachal Pradesh have been developed **(Table 2)**. The sustainable harvesting and collection framework includes following five core elements:

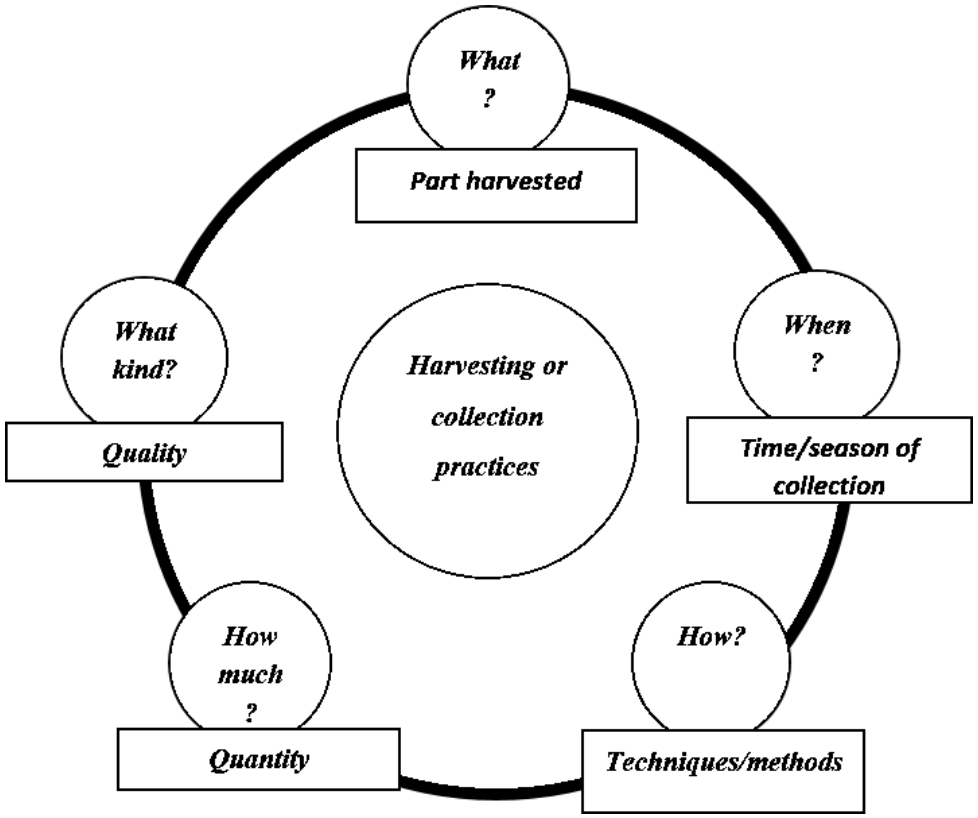
What to collect: The plant part or material to be harvested.

What stage: At the optimum stage of development with collection of mature and healthy material.

When: Harvesting season, month and the time of the day.

How: Different harvesting techniques for different parts, using the best practices by the assemblage of traditional and academic knowledge.

How much: Quantity depends upon species and population density. Sustainable harvesting practices should be species and location specific.



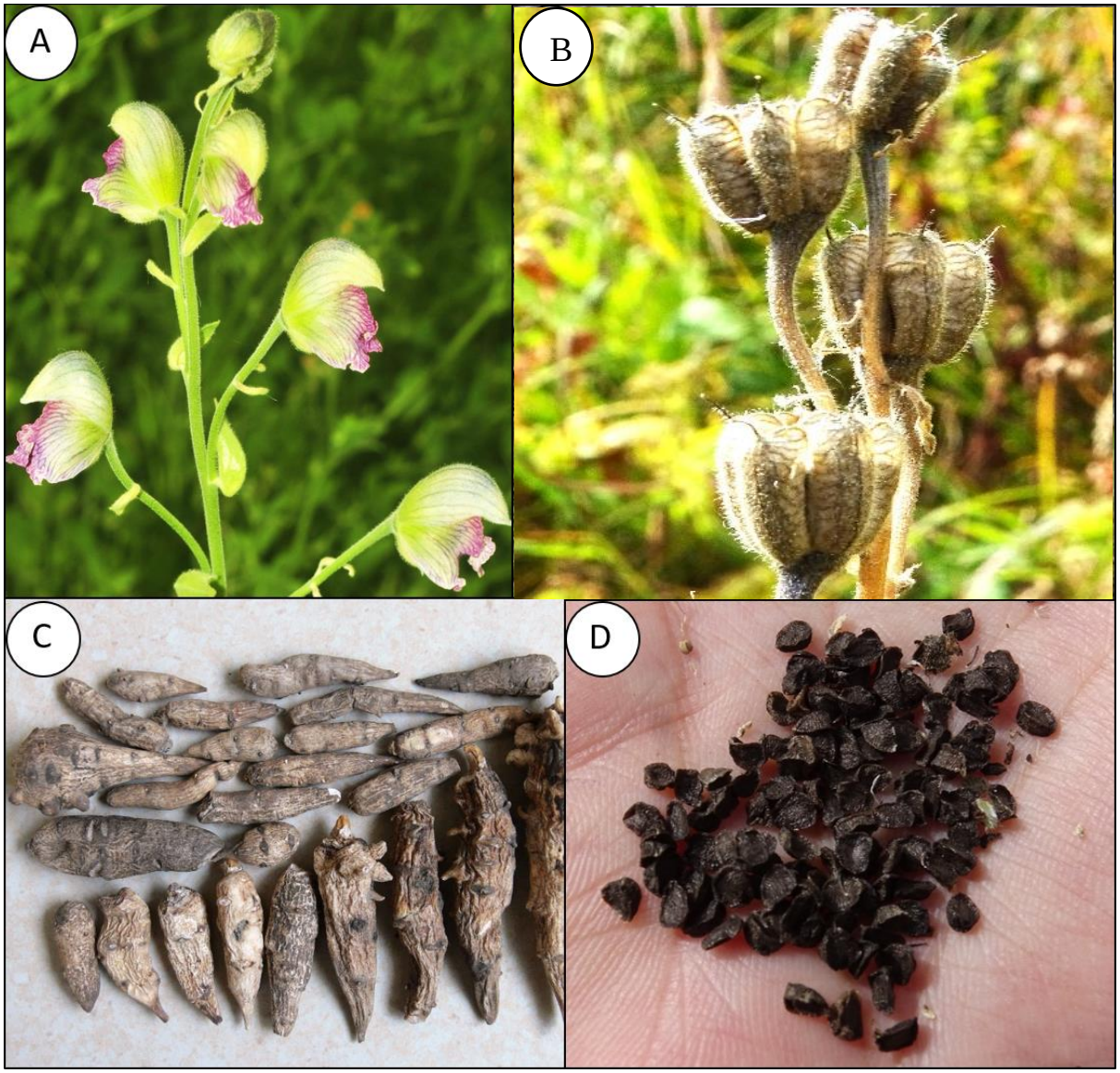
Sustainable harvesting and collection framework (adopted from Deepa et al. (2018)

Table 2: **Existing harvesting and cultivation protocols of selected MAPs in the Western Himalaya.**

Species	Reference						
	Chauhan (2001)	Samant et al. (2008)	NMPB (2008)	NMPB (2016)	Kalsang (2016)	Nautiyal and Nautiyal (2004)	Ved and Goraya (2008)
Aconitum heterophyllum	--	✓	✓	--	✓	✓	✓
Bunium persicum	✓	✓	--	--	--	✓	✓
Dactylorhiza hatagirea	--	✓	--	✓	✓	✓	✓
Fritillaria cirrhosa	--	✓	--	--	✓	✓	✓
Picrorhiza kurroa	--	✓	✓	--	✓	✓	✓
Polygonatum verticillatum	--	✓	--	--	--	--	✓
Sinopodophyllum hexandrum	✓	✓	--	✓	✓	✓	✓
Rheum spp.*	--	✓	✓	--	✓	✓	✓

*= *Rheum australe, R. webbianum* and *R. spiciforme*

Aconitum heterophyllum Wall. ex Royle



Aconitum heterophyllum; A- Flower, B- Follicle, C- Root, D- Seed 📷 A: Navendu Page; B & D: Amit Kumar; C: GS Goraya

Species and location profile

Etymology: *Aconitum heterophyllum* is a member Ranunculaceae, the buttercup family. The generic name *Aconitum* is derived from the Greek word *'akon'* means an arrow possibly pertaining to its use in poisoning the tips of arrows; and the specific name *'heterophyllum'* refers to its heteromorphic (basal and cauline leaves of different shapes) leaves.

Vernacular name: Kadwa Patis, Atees and Kour

Trade name: Atees, Atis, Ativisha and Bonga

Unani name: Atees

Folk name: Patis

Ayurvedic name: Ativisha

Sanskrit name: Amrita, Aruna, Ataicha, Atisarangi, Ativisha, Bhangura, Bhringi, Madri, Ghunavallabha, Kashmira, Mahoshadha, Mridvi, Prativisha, Pravisha, Shringi, Vira, Virupa, Visha, Vishva, Shveta and Shyamkanta

Habitat and distribution

Habitat: Atis is distributed in the sub-alpine to alpine regions of the Himalaya between 2400-4500m amsl (Ved et al. 2015). It is commonly found in grassy meadows, upper Oak or coniferous forest, *Rhododendron* forest, margins of *Quercus-Abies* forest, glacial riverine, rocky moist areas, alpine dry scrub, open grassy slopes, alpine slopes, shady moist alpine slopes and forest edges (Samant et al. 2008; Bhat et al. 2014).

Global distribution: Globally, the species is distributed in Nepal, Pakistan and India. In India, Atis is found in Himalayan states namely, Himachal Pradesh, Uttarakhand and Jammu and Kashmir (Ved et al. 2015). In Himachal Pradesh, it has been recorded in Sangla, Rohtang, Churdhar, Maral Danda, Gamgul, Saru thatch, Shagali thatch, Chansal thatch, Kangra, Mandi, Kullu, Shimla, Chamba, Lahaul and Spiti, Pangi, Dalhousie, Manali, Kinnaur, Rajgarh, Parvati valley (Samant et al. 2008). In Jammu and Kashmir, it has been reported in Saithal, Scoj and Klhoai in Anantanag, Akad Patree Nallah, Dang Tangmarg, Kandwa forest, Gulmarg, Aharbal and upper Dachigam National Park (Beigh et al. 2006). In Uttarakhand, *A. heterophyllum* has been recorded in Kharsoli, Dodital, Suki, Gangi, Gangnani, Nawali, Huri, Pilang, Sauragad, Pindarpar, Dayara, Rudranath, Kuaripass, Kyarki, Bedani, Tehri, Uttarkashi and Rudraprayag (Rawat et al. 2016).

Approximately 400 species of *Aconitum* have been reported in the world (Selvam et al. 2015). In India, 27 species of Aconites have been reported, of which 12 and 16 species are distributed in the Western Himalaya and Eastern Himalaya, respectively (Agnihotri et al. 2015). Of these, 18 species have poisonous or medicinal properties (Selvam et al. 2015). In the IHR, maximum species (13) are recorded in Sikkim followed by Jammu and Kashmir (11), Himachal Pradesh, Arunachal Pradesh and West Bengal (10 each), Uttarakhand (07), Manipur (02) and (Nagaland (01) (Agnihotri et al. 2015).

Morphology and phenology

Taxonomic description: Perennial, showy herb, erect, up to 1.2m tall. Stem long, simple or branched at the base, glabrous and puberulous above. Leaves broad, heteromorphic, basal leaves long, petioled, ovate or five-lobed and toothed, upper trifid or entire. Flowers large, 0.25cm long, helmet shaped, bright,

blue or greenish-blue with purple veins, simple or somewhat spike-like terminal racemes, rarely sub-panicled with axillary racemes, lower and upper bracts foliaceous, ovate or lanceolate, margins lobed, elliptic, entire or crenate. Follicles five, hairy.

Flowering and fruiting: August to October in the third year of growth with vibrant blue or greenish-purple flowers.

Population status

A. heterophyllum is restricted to a narrow geographical range with rigid ecological adjustments that make it difficult to invade new areas for survival and development. Besides this, the species of the north-west Himalaya has been strictly localized with thin-scattered populations to bounded ecological niches (Beigh et al. 2006). Population density of *A. heterophyllum* varies according to location and elevation for instance, the density has been reported between 1-3.7 (individuals m^{-2}) in Himachal Pradesh (Singh et al. 2008; Uniyal et al. 2006). Similarly, in Uttarakhand, the density varied from 1-6.3 (individuals m^{-2}) (Nautiyal et al. 2002; Rawat et al. 2016). Furthermore, Baig et al. (2014) reported 99-300 individuals of Atis in 4 km^2 in Jammu and Kashmir.

Conservation status

Whereas, *Aconitum heterophyllum* has been categorized as EN (Endangered) in the country following the IUCN Red List Criteria (Ved et al. 2015), it has been assessed as CR (Critically Endangered) in the regional CAMP workshops conducted during 2003 and 2010 due to drastic reduction of its wild populations in Himachal Pradesh (Ved et al. 2003; Goraya et al. 2013). Kumar et al. (2016) also report it under CR category due to excessive collection from the wild.

Potential threats

The species has been directed to numerous threats such as habitat loss, unsustainable harvesting practices, illegitimate trade, over-exploitation, overgrazing and also due to prolonged seed year and high seedling mortality (Belt et al. 2003; Beigh et al. 2006). Beside these, untrained and unskilled labourers, absence of forest staff at remote sites and specific site trampling also contribute to decline in its wild populations (Rai et al. 2000).

Medicinal uses

Tubers of this species find medicinal uses in Indian health care traditions, both the folk and the classical. The major uses are in fever, rheumatism and stomach ache, the tubers are also used in diarrhea, gastric trouble, headache, intestinal pain, hysteria, malaria, helminthiasis, hemorrhoids, cough, diabetes, dyspepsia, hemorrhage, vomiting and piles. The plant has several properties such as tonic, aphrodisiac, thermogenic, and expectorant, alexeteric, febrifuge, astringent, stomachic, digestive and anti-periodic.

Major active chemicals constituents that contribute to its healing property includes atisine, heterotisine, histisine, heterophyllisine, heterophlline, heterophllidine, atidine and hitidine, aconitic acid, tannic acid, a mixture of leic, palmitic, srearic, glycerides and vegetable mucilages are also present in addition to starch and sugar (Samant et al. 2008). It is also used in preparation of specific herbal formulations such as Balachaturbhadra churan, Ativishadi churna, Ativishadi vati, Chandraprabha vati, Khadiradi vati, Kutajghan vati and Rasnairandadi kashayam (Singh, 2017). Apart from the medicinal uses, the leaves and roots are often considered as a source of vegetable (Kunkel, 1984; Khare, 2004).

Market and trade

Tubers extracted from various *Aconitum* species in the high altitude sub-alpine and alpine meadows in the Western Himalaya are traded as raw drugs. There is a vast variation in the size and shape of Atis tubers traded in the market. Suspected adulteration of Atis with similar looking tubers of other species has been observed in the market (Goraya and Ved, 2017).

Market samples of *Aconitum heterophyllum* GS Goraya

In India, all *Aconitum* species are prohibited for export if the plants are collected from the wild. Raw drug obtained from cultivated material can however, be exported. The reported total annual consumption of raw *Aconitum heterophyllum* by domestic herbal industry and rural households was 127.65 and 25.80 MT respectively, whereas, the annual trade of raw drug was assessed to be 100-200 MT (Goraya and Ved, 2017). According to Samant et al. (2008), average market price of *Aconitum heterophyllum* varied from Rs. 2200±282.84 to Rs. 4800±282.84 (Rs/kg±SD) in major markets such as, Kullu, Solan, Dehradun, Amritsar and Delhi (**Table 3**).

Table 3: Price of *Aconitum heterophyllum* in different markets.

Sr.no.	Market/Places	Market price (Rs/kg)	Average market price (Rs/kg±SD)
1.	Kullu	2200-2400	2200 ± 283
2.	Solan	3900-4300	4100 ± 283
3.	Dehradun	3700-4400	4050 ± 495
4.	Amritsar	4600-5000	4800 ± 283
5.	Delhi	3300-4000	3850 ± 495

According to Kumar et al. (2021), the average market price of *A. heterophyllum* has been recorded between 1766.66±145 to unusually high 10,000±1154 (Rs/kg±SD) in major markets such as, Udaipur (Lahaul), Killar (Pangi), Keylong, Manali and Amritsar (**Table 4**).

Table 4: Price of *Aconitum heterophyllum* in various raw drug markets.

Sr.no.	Market	Market price (Rs/kg)	Average market price (Rs/kg±SD)
1.	Udaipur, Lahaul	2000-2500	1766.66±145
2.	Killar, Pangi	4000-6000	4166.66±601
3.	Keylong, Lahaul	3500-5000	4000±289
4.	Manali	8000-10000	9000±577
5.	Amritsar	10000-12000	10000±1155

As per HPFD (2017-2018), the estimated volume of the *Aconitum heterophyllum* tubers extracted from the Lahaul and Pangi landscape during the year 2017-18 and 2018-19 was 187 qtls. Of this volume, 104.35 qtl. of roots were collected in Pangi Forest Division, Chamba that issued 74 permits to locals/local traders for harvesting of *A. heterophyllum* in Sach, Killar and Purthi Forest Ranges (HPFD, 2018-2019). Owing to high trade *vis a vis* drastic reduction of the wild populations of *A. heterophyllum,* it has been proposed for inclusion in the Convention of International Trade in Endangered Species (CITES) appendices, but is yet to be included.

Good harvesting and collection practices

With cultivation of Atis yet to establish to commercial scale, the continuing demand of Atis by the domestic herbal industry is likely to subject wild populations to increased harvesting pressure. In Atis, tubers being the underground part need to be dug up from the soil causing adverse impact on its populations unless followed by good harvesting practices.

Good harvesting practices of Atis are aimed at getting the maximum possible yield with optimum alkaloid content on sustainable basis, and ensuring long shelf life of the produce. A look at the usual harvesting practices would reveal that in order to meet its rising market demand, Atis tubers are harvested (a) before these are fully ripe, (b) before the seeds have fully ripened and shed, (c) by deep digging of soil damaging other surrounding plants, (d) by removing the entire tubers, and (e) without giving prescribed rest to the harvested area. Some of the harvested produce gets damaged due to its poor post-harvest handling, putting greater pressure on the wild resource. It, therefore, become necessary to educate the wild gatherers about the damages done by reckless wild harvest and the advantages of the good harvesting and post-harvest handling practices.

Harvesting

In view of the sustainable harvesting framework, the following good harvesting practices are suggested for Atis

What to collect: It is the tubers that need to be harvested in case of Atis. The first and the foremost best harvesting practice are to critically identify the harvestable Atis plant before its digging up to avoid wasteful digging and damage to its young plants and other plants. The top part of the tuber has good capacity to regenerate, and as such it is desirable to chop off the top part and put it back in the dug-up hole and stump the soil around.

What stage: The plant should be harvested when the tubers are mature and seeds have ripened and are shed or ready for dispersal. It normally takes three growing seasons for the plant to reach this stage. Besides it, elevation also defines the completion of reproductive phase, for example in alpine areas, it can be achieved in the last week of October to first week of November while at lower elevation it is in the first fortnight of October. According to NMPB (2008) maximum yield per plant is obtained during the months of October-November, whereas highest active ingredient is reported during July-August. Therefore, harvesting should be done at the stage that provides optimum yield as well as alkaloid content.

When: Harvesting of Atis tubers involves digging of soil that becomes prone to erosion if it follows rainfall. The season of its harvest should, therefore, be after the rains. For Lahaul-Pangi landscape, the traditional wisdom lays down that harvesting of mature tubers from high altitude areas should be carried out after *'bees bhadon'* (after mid-September). It is to be appreciated that the tubers mature by this time, the seeds have ripened, and the rainy season gets over. This season also provides the optimum yield with optimum alkaloid content.

How: Digging should be carried out with proper tools to carry out only the bare minimum digging necessary for taking out the tuber without causing damage to the adjoining plants. It is advised to separate the top portion of the tuber at site and leave it in the dug-up portion for its regeneration.

How much: As a thumb rule, only the mature tubers having one fresh whitish daughter tuber and two darker mother tubers should be harvested and all young plants to be left unexploited. Of the mature plants one third should be kept for regeneration security. One of the management prescriptions for maintaining such harvesting discipline is to revisit the harvested blocks for next harvesting at intervals of three years.

Post-harvesting handling

Good post-harvest handling of the dug-up tubers includes a series of steps from sorting to grading before transporting to market. Sorting is the first step where the unwanted plant debris is removed. The tubers are then hand rubbed or washed and then further dried to decrease the moisture content. Drying should be at room temperature or partial shade, it is important to note that direct exposure to the sun should be avoided completely. After complete drying, tubers are graded according to the age of tubers (mother or daughter tubers) and size. The completely dried tubers can be stored in jute bags, gunny bags, woven sacks, wooden boxes and airtight polythene bags for transportation for further processing (Sharma et al. 2013).

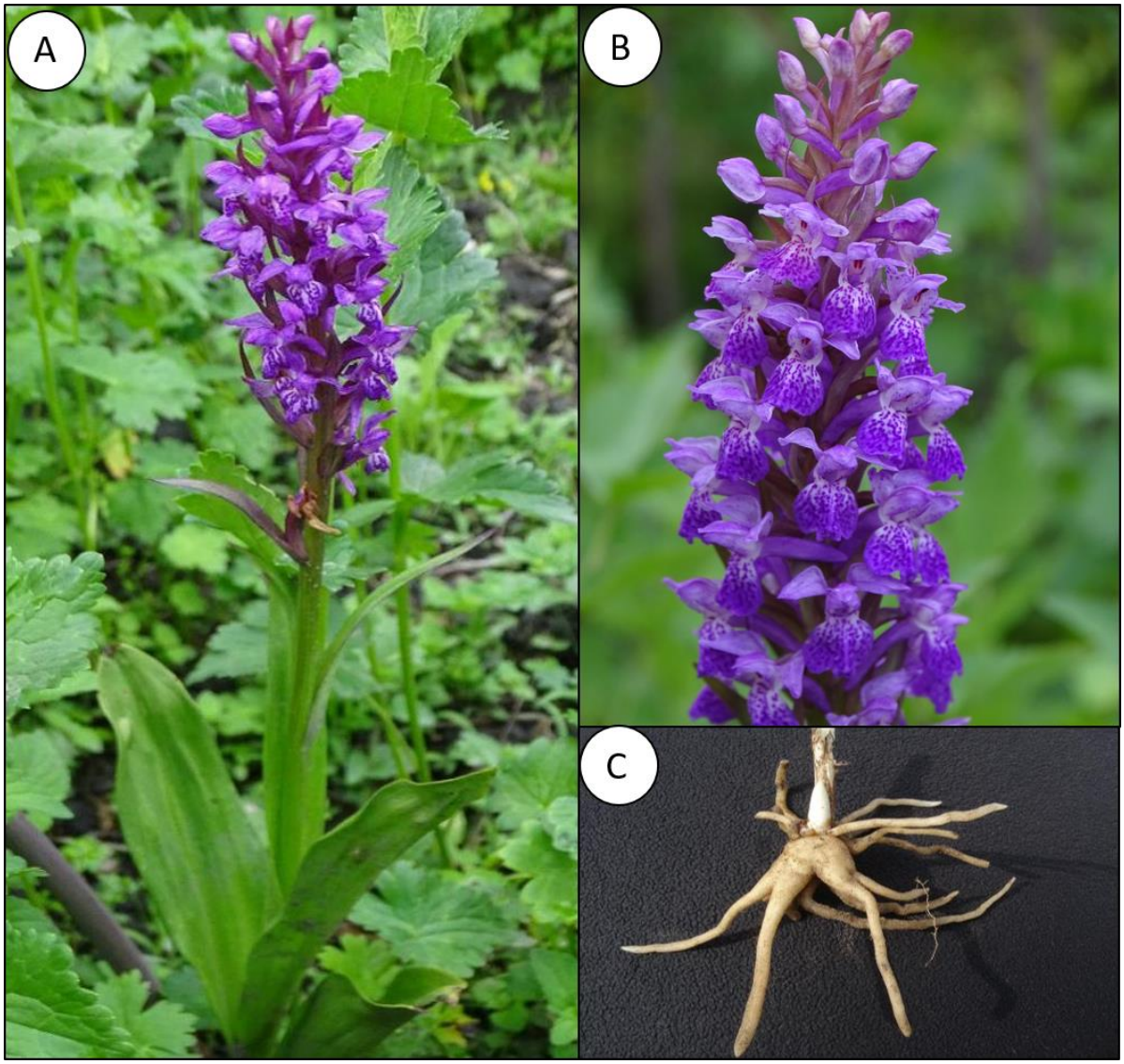
Cultivation and propagation

Resource base of Atis needs to be augmented in order to meet the growing market demand of its tubers. Whereas, efforts are afoot to build its wild populations, Atis can also be cultivated as a cash crop by propagating through seeds, tuber segments, or young leafy stems.

For getting seeds, the Atis capsules (fruits) should be collected when it starts turning light brown and are ready for seed dispersal. For better germination of seeds, it should be collected from late October to mid-November during morning hours (NMPB, 2008). Pre-treatment of seeds with hot water at 45-50°C for 90 seconds enhances the germination process (Pandey et al. 2005). For future use, the seeds could also be cryopreserved at 4°C temperature and 5% moisture level (Kushwaha, 2010).

The species generally prefer sandy, loam, porous and acidic soils whereas; climate should be cool and temperate for proper growth and development of the plant. It can be cultivated at the elevation between 2200-4200m amsl. During pre-land preparation, 75-80 qtl. manure ha-1 is required and the land needs to be ploughed or dug twice and left for 15-20 days. One-kilogram seed ha-1 is required for sowing. Sowing should be done during October-November at a distance of 30cm x 30cm. If cultivated at lower elevation, irrigation must be done every 24 hours for six months. During winters, irrigation is required once in 15-20 days. Frequent weeding is to done during the summers and rainy season (Samant et al. 2008). At the end of the third growing season, 1-2 daughter tubers are produced and collected during the autumn season (after the senescence of aerial shoots) and can be replanted during spring season. Generally, new plants produce leafy shoots during the first year of the growth while the cultivated plants produce flowers during the second year of growth (Paramanick et al. 2017). For vegetative propagation, top segment is preferred over middle and basal segments (NMPB, 2008).

Dactylorhiza hatagirea (D.Don) Soó



Dactylorhiza hatagirea; A-Whole plant, B- Flower, C- Root Amit Kumar

Species and location profile

Etymology: *Dactylorhiza hatagirea* is a member of the family Orchidaceae. The generic name of *Dactylorhiza* is derived from the Greek word *'daktylos'* means finger and *'rhiza'* means root, referring to the palmately 2-5 lobed tubers.

Vernacular name: Hathjadi, Hatpanja

Trade name: Salampanja

Unani name: Buzidan, Salab misri

Folk name: Salampanja, Hatthajari, Panja, Hathpanja, Salep

Ayurvedic name: Salampanja

English name: Himalayan marsh orchid, Spotted orchids

Habitat and distribution

Habitat:

The light demanding species *Dactylorhiza hatagirea* is widely and narrowly distributed at an elevational range between 2500-5000m amsl. The species prefers to grow in open grassy slopes, alpine meadows and moist temperate places (Bhatt et al. 2005). The main associate species include *Rhododendron anthopogon*, *Nardostachys jatamansi* and *Aconitum* spp. (Prasad, 2016).

Global distribution:

The plant is native and near endemic to the IHR, its distribution extends to Pakistan, China, Afghanistan, Nepal, Tibet and Bhutan. In India, *D. hatagirea* is reported from Jammu and Kashmir, Sikkim, Arunachal Pradesh, Uttarakhand and Himachal Pradesh (Pant and Rinchen, 2012). In, Uttarakhand, it has been recorded in Kumaon and Uttarkashi. In Himachal Pradesh, Hathjadi is found in Kullu (Seraj, Chandrakhni, Parvati valley, Kanawar, Manali and Kais WLS, Lag valley, GHNP, Jagatsukh and Hamta catchment, Chhakinal), Mandi (Shikari Devi, Nargu WLS, Kamarunag), Shimla (Hattu, Chpal, Roharu, Kotgarh), Chamba (Bhamour, Dalhousi, Pangi, Satrundi), Kinnaur (Sangla and other high-altitude areas), Kangra (Chopta, Bada Bhangal), Sirmour and Lahaul and Spiti (Sisso, Koksar, Shego, Mudh, Mane, Rangrik and Spiti valley) (Kalsang, 2016).

Morphology and phenology

Taxonomic description:

Terrestrial, erect herb up to 60cm high, with palmately divided tuberoids. Leaves are broadly lanceolate or oblong-lingulate or elliptic. Flowers purplish-lilac, rose or rarely white, in many-flowered densely cylindric inflorescence (Baral and Kurmi, 2006). The special character of this plant is that, it remains erect in excessive snowfall. Inflorescence is raceme, 5.0-15.0cm long, crowded with many flowers. Flowers are purple and the bracts green, narrowly lance shaped, lower bract longer than the flowers, upper slightly shorter. Flowers are about 1.8cm long, including the curved spur. Sepals and petals are nearly equal, three of them form a hood and the two sides spread outwards. The lip is rounded and shallowly 3-lobed, spotted dark purple. Spur straight, cylindrical, nearly as long as the ovary; column very short; anther adnate to its face, cells diverging; pollinia 2, caudicles attached to 2 small globose, viscid glands enclosed in a minute pouch overhanging the broad, 2-lobed stigma.

Flowering and fruiting: June-July and August-September, respectively

Parts used: Roots and tubers

Population status

D. hatagirea is an important ornamental and medicinal plant, reduced rapidly because of low germination rate, habitat fragmentation and human over-exploitation. Lacking endosperm, the seeds of *D. hatagirea* can germinate only with symbiotic fungi in natural conditions (Aggarwal and Zettler, 2010). The bulk demand of *D. hatagirea* for its medicinal value cause the over-exploitation of wild resources. Acording to Warghat et al. (2012), habitat fragmentation and population deterioration will increase mating opportunities between closely related individuals and finally result in loss of genetic diversity. As per Singh et al. (2019), population density of *D. hatagirea* varies from 0.03-3.58 individuals m^{-2} in GHNP.

Conservation status

D. hatagirea has been categorized as rare (Samant et al. 2001), Critically Endangered (Kala, 2000; Goraya et al. 2013; Goraya and Ved, 2017), Endangered (Chauhan et al. 2014) and listed under appendix II of CITES (Uniyal et al. 2002).

Potential threats

D. hatagirea can be considered inherently slow growing and poorly regenerating species, because of pollinator specificity and requirement for mycorrhizal association (Bhatt et al. 2005). Due to its high medicinal and edible value, the species has great demand in national and international markets. Anthropogenic disturbances such as, grazing pressure, low rate of propagation, poor seed germination, habitat destruction, over-exploitation and unavailability of proper procedure of collection and propagation are the major factors for declining this species from its natural habitats (Pant and Rinchen, 2012).

Medicinal uses

Tubers have properties such as cooling, emollient, astringent, aphrodisiac, demulcent, rejuvenating and nervine tonic. It is useful in diabetes, hemiplegia, dysentery, phthisis, chronic diarrhea, seminal weakness, neurasthenia, cerebropathy, emaciation and general debility. A decoction of tuber is given in colic pain. Powder is used to relieve fever; it is sprinkled over wounds to check bleeding. Root is also used in urinary troubles, also used as farinaceous food (Baral and Kurmi, 2006). The major active chemical constituents that contribute to its healing property includes glucoside, a bitter substance, starch, mucilage, albumen, a trace of volatile oil and ash. The major active constituents include dactylorhins A-E, dactyloses A and B and lipids are the major constituents.

Market and trade

The annual demand of Hathjadi is approximately 5000 tons due to presence of high value secondary metabolites such as dactylorhin and dactyloses which are responsible for its pharmacological activity.

Unfortunately, it has led to over-exploitation of the species from wild habitats. Local inhabitants use this high value medicinal plant for illegal trading. The local inhabitants gather dried roots of *D. hatagirea* at the cost of Rs. 100-200 kg^{-1}(Goraya and Ved, 2017). As per rough estimates, 90 to 100 mature plants are exploited for 1 kg of dried roots. As a result, the population is declining very fast, this indicates that if the careless factors continue to function, this species might become extinct within a few years. In India, *Dactylorhiza* species are prohibited for export if the plants are collected from the wild. Raw drug obtained from cultivated material can however, be exported. The reported total annual consumption of raw *Dactylorhiza hatagirea* by domestic herbal industry and rural households was 9.03 MT respectively, with its annual trade being about 10 MT (Goraya and Ved, 2017).

Good harvesting and collection practices

D. hatagirea is a high value medicinal plant which has been used since ages for human consumption due to its exclusive effects on human body such as sexual stimulant and aphrodisiac. These unique properties of plants are due to presence of unique secondary metabolites present in them. Collection of rhizomes should be done only after flowering of plants, for sustainable harvesting. Collection of mother plant takes place by leaving one immature tubers by filling with layer of soil with the help of sharp kuto (a small spade like hand tool). September to November is the harvesting period after seed ripening and fall. Proper care of the surrounding vegetation should be taken while rooting out the tubers of the *D. hatagirea*. Collection of plant should be done by applying rotating system. For harvesting, the rotation of the plant is 4-5 years. Sustainable harvestable amount is 80%. For the protection of rare and endangered orchid species, both *ex-situ* and *in-situ* approaches are important.

Harvesting

In view of the sustainable harvesting and collection framework, the following good harvesting practices are suggested:

What to collect: It is the tubers that need to be harvested in case of Hathjari. The first and foremost best harvesting practice is to critically identify the Hathjari plant before it's digging up to avoid wasteful digging and damage to other plants.

What stage: Tubers are harvested after five years for high yields though they can be harvested after 2-3 years also. The tubers should be collected after seed maturity in late September.

When: Harvesting of Hathjari tubers involves digging of soil that becomes prone to erosion if it follows rainfall. The season of its harvest should, therefore, be after the rains. It is to be appreciated that the tubers mature by this time, the seeds have ripened, and the rainy season gets over. This season also provides the optimum yield.

How: Digging should be carried out with proper tools to carry out only the bare minimum digging necessary for taking out the tuber without causing damage to the adjoining plants. It is advised to separate the top portion of the tuber at site and leave it in the dug-up portion for its regeneration

How much: Only the mature tubers should be harvested and all young plants to be left unexploited. Of the mature plants one third should be kept for regeneration security. One of the management prescriptions for maintaining such harvesting discipline is to revisit the harvested blocks for next harvesting at intervals of 2-3 years.

Post harvesting

The collected tubers/rhizomes undergo various processes to get the best out of them. Sorting and grading are done for removing and separating unwanted and damaged or immature material. The cleaning of crop is done before drying and again before packaging to ensure that the tubers is of the best quality. This is followed by drying of the tubers in the sun or in shade as required, which prevents deterioration of the product and allows storage in a stable condition. After properly drying old tubers are separated from young tubers and steeped in hot water for 1 hour. The outer membranes of the tubers are removed through this process and the tubers turn light yellow in color. These are then sun dried and can be preserved for a long time. After completion of all the process the processed materials should be protected from contamination and decomposition, the dried tubers stored in airtight bags for further transporting to the market (Nautiyal and Nautiyal, 2004).

Techniques of cultivation and propagation

Dactylorhiza favors acidic and sandy loamy soil with rich organic manure and sufficient moisture. The healthy plant development and rooting requires 80-90% humidity. The flowering season starts in early June and spreads up to July end. Subsequently the ruiting season starts in August-September. It is generally propagated vegetatively using rhizomes, which is collected after flowering while it may also be propagated through seeds. During pre-land preparation, 5ton manure is required for one hectare of land. Manure requirement increases at lower altitudes andat 1800-2000 m approximately 10.0 - 15.0 t/ha manure is required. Sowing should be done during August-September at a distance of 15cm x15cm. The mature fruits are collected in September and air dried for 2-3 weeks to extract the seeds and stored at low temperature until used (Warghat 2015). Being very minute in size, seeds are mixed with sand before sowing. Seeds require symbiosis with mycorrhiza for germination and only 0.2% germination is observed under natural habitat. Tubers may be harvested after seed maturation during mid-September to October end. The plants that are developed from the tubers become ready for harvesting in two years. About 3.5 – 4 qt/ ha dry tubers could be harvested from the well-maintained field. However, being recognized as a critically endangered plant species it is recommended that only 80% tubers should be harvested as measure of *in situ* conservation (Chaurasia et al. 2007).

Bunium persicum (Boiss.) B.Fedtsch.

Bunium persicum: Flower and Seed GS Goraya and Sipu Kumar

Species and Location Profile

Etymology: *Bunium persicum* (Boiss.) B. Fedtsch species belongs to the family Apiaceae. The commonly used Hindi term shahi zeera may be a distortion of syahi (black in Persian) zeera. However, in the Hindustani language, the term syahi also means "inky black".

Vernacular name: Jeera (Lahaul & Spiti), Singu (Miyad), Kala Zira (Kinnaur), Black cumin, Kalajira, Umbu, Siahzira

Trade name: Kala zeera

Unani name: Kala zeera

Folk name: Kala zeera

Ayurvedic name: Kala zeera

Sanskrit name: Krishna jiira

Habitat and Distribution

Habitat:

Bunium is a perennial aromatic plant with small white or pink flowers and small brown beans growing wild in areas of Alpine dry slopes especially in Lahul & Pangi. It is Native of limited zones of the West Asia (Singh et al. 2009; Behtoie et al. 2012). The plant is likely to prefer a well-drained light to medium soil in sun or light shade. In Himachal Pradesh it is found in Lahual & Spiti, Chamba and Kinnaur, Pangi, Miyar Valley, Pattan valley, Gahar valley, Spiti and Shong at the elevation range of 2500- 4000 masl (Ravikumar et al. 2018; Gupta et al. 2012; Chauhan, 1999).

Global distribution:

A native of the temperate to subtropical zones, the plant can be grown as an annual in more tropical areas. The global distribution is mainly confined to Northern Asia, North Africa, South Europe, Southeastern Europe, Siberia and western Asia. It is found in the high-altitude regions of Iran and some parts of Afghanistan, Pakistan and Tajikistan in addition to India (Panwar, 2000; Hanelt et al. 2001). In India, it is distributed in Kashmir such as Paddar valley (Gupta etal. 2 013) and Gurej valley (Goraya et al. 2013) and the high-altitude regions of Himachal Pradesh, including the Chamba, Kinnaur, Lahaul and Spiti at an elevation ranging from 1500-3500 masl (Ravikumar et at. 2018; Gupta et al. 2012; Chauhan, 1999) and, some ranges of Uttarakhand Himalaya (Chahota et al. 2017).

The genus *Bunium* contains about 166 species, including *B. persicum, B. carum, B. bulbocastenum, B. copticum, B. flexuosum, B. elegans, B. cylendricum* and *B. chaerophyllocides* that are prevalent in Central Asia, Caucasus, Crimea, and Europe (Vasilava et al. 1985).

Morphology and Phenology

Taxonomic description:

B. persicum has small (30 cm) to tall (80 cm) varieties which squeezed or expanded with large or small branches (Mandegari et al. 2012; Sofi et al. 2009). The plant is an erect, herbaceous perennial plant growing from underground tubers; it produces one or more stems that branch from the middle, growing from 40 - 60cm tall.

Flowering and Fruiting: It matures in the months of late July to August.

Conservation Status

The species is restricted to a narrow geographical range with rigid ecological adjustments that makes the species difficult to invade new areas for survival and development. *Bunium persicum* is endangered in the Himalayan region (Chauhan et al. 2020). It is also enlisted as Vulnerable (Goraya et al. 2013).

Potential Threats

The species is facing enormous threats not only due to the illegal trade and unscientific harvesting/exploitation it is subjected to, but also because of loss of its habitats, featuring unique topography and climatic conditions, due to development and degradation resulting in drastic decline in the wild populations of Kala zeera (Kala, 2000; Goraya and Ved, 2017). The fact that high demand and unorganized and destructive harvesting poses a major threat to the species and is a factor for the decline of its wild populations was also observed and found out as an outcome of the recent surveys in the Lahaul and Pangi landscape of Himachal Pradesh as part of this current study. The higher Himalayas are rich in the native and endemic biodiversity. The major threat to this habitat includes its unique topography, physical features and harsh climatic conditions which have resulted into drastic decline of various taxa represented in the ecosystem (Kala, 2000; Srivastava, 2010).

Medicinal Uses

This plant and its derivatives are valuable compounds that have antimicrobial, free radicals scavenging, anti-parasitic, antioxidant, anti-inflammatory, anticonvulsant, antidiabetic, antiasthma, antispasmodic, antiepileptic, antiobstruction, diuretic and analgesic properties which indicate its high potential for use in the medicine and food industry (Hassanzad et al. 2018; Miraj and Kiani, 2016; Agah et al. 2013; Mandegary et al. 2012). Several therapeutic effects are explained for this plant in traditional and modern medicine. B. persicum is used for treating gastrointestinal and urinary disorders such as stomatitis stimulant, flatulent indigestion, dyspeptic headache, relieve of heartburn, colic, diarrhea, dyspepsia, hysteria, improving liver function and (Sofi et al. 2009). B. persicum is used for culinary intentions as a spice and flavoring agent in foods and beverages such as bread cooking, rice, yoghurt, cheese and in confectionery products. It has a strong earthy aroma is sharpened by frying and cooking it (Aminzare et al. 2017; Sharififar et al. 2010; Sofi et al. 2009). This plant is also used in the perfume and cosmetics (Salehi et al. 2008).

Market and Trade

The price along the trade chain was studied from the production level in landscape villages, small aggregation markets in towns and large mandis in cities. The current study result illustrated an increase in the price of MAPs when it moves from village to city. Based on field surveys, individual interviews, group discussions, visits to villages (29) and local markets. It generally collected in the month of late July-August. The high demand and monetary returns of dried seed ranged between 2500-7000 INR kg^{-1} in 2019 and the annual estimated trade is < 10 MT (Goraya and Ved, 2017). *B. persicum* is also often adulterated with *Cuminum cyminum,* due to poor morphological identification between the two (Bansal et

al. 2018). This has created ambiguity in terms of the ultimate market and real use of kala jeera in the region.

According to Kumar et al. (2021), the average market price of *B. persicum* has been recorded between 2800±100 to 3100±208.17 Rs/kg in major markets viz., Udaipur (Lahaul), Killar (Pangi), Keylong, Manali and Amritsar (**Table 5**).

Market sample of *Bunium persicum* 📷 Himanshu Bargali

Table 5: Price of *Bunium persicum* in various raw drug markets.

Sr.no.	Market/Place	Average market price (Rs. /Kg) ± SD
1.	Udaipur (Lahaul)	2800±100
2.	Killar (Pangi)	2333.33±88.19
3.	Keylong (Lahaul)	2833.33±202.7 6
4.	Manali	2500-3000
5.	Amritsar	3100±208.17

Good Harvesting and Collection Practices

Good harvesting practices are aimed at getting the maximum possible yield with optimum alkaloid content on sustainable basis, and ensuring long shelf life of the produce. The seeds sown during October-November germinate after the melting of snow in March-April. Chilling pre-treatment for 4-5 long months enhances the germination rate and is necessary for good germination. Seeds are small and therefore mixed with sand and then sown at 3-4 cm deep in soil in line.

Harvesting: In view of the sustainable harvesting framework, the following good harvesting practices are suggested.

What to collect: The seeds are collected when the oldest fruits turn brown. Care is taken to avoid loss of seeds by shattering of the umbel. The crops raised through seeds take about 3 years time to bear fruits with viable seeds while the plants maintained through bulbs take less period for fruiting.

What stage: Normally the crop matures in late July or August depending on the climate and altitudes. Flowers bloom from mid-July to mid August and ripen in August. Browning of seeds indicates maturation. That means the total harvesting period lasts for 10-15 days.

When: Mature plants are harvested daily in the morning. The seeds are collected when the oldest fruits turn brown. Care is taken to avoid loss of seeds by shattering of the umbel.

Weed and pest control: Fields must remain weed free. Normally, 3 - 4 weeding operations are carried out at an interval of 20 - 25 days. In the first-year hand weeding is preferred to offer better protection to the juvenile plants. In the second year as the plants attain good height and therefore thorough weeding. White grubs and upper ground foliage attack the tubers by hairy caterpillars, armyworms and semi-loopers. Mixture of BHC / HCH or Aldrin 5% dust at the rate of 25 kg/ha is enough to control the white grub. Methyl parathon spray once in fortnight has been found effective for the diseases like semi - loopers, armyworms and caterpillars. It is suggested not to use any sort of inorganic pesticides. Spraying of biopesticides *Beauveria bassiana*, a fungus, at the rate of 5 ml per litre is very effective if the plants are well grown. In juvenile plants less concentration may be applied.

Post harvest handling: For better maturity and storage the fruit bearing harvested stalks are sun dried for 3 - 4 to 7 days depending upon the volume of the harvest and number of sunny days. The plants are spread out in loose bundles for drying. The seeds from the dried plants are separated with the help of beating sticks. The dried fruits are then threshed by hand or by threshing machines and are cleared by winnowing. The seeds are then stored in a paper bag or closed container and kept in a dark cool place. The dried seeds should be stored in airtight container. Further processing is done via steam distillation immediately after crushing. Distillation takes about 6-8 hours. The seed yield is on an average 0.5 ton/ha.

Cultivation and Propagation

Bunium requires well-drained acidic soil for optimum growth. Sandy loam soil that is rich in well-decomposed organic matter is preferred for cultivation. It can grow under semi-shade on gentle grassy slopes. Forest soil of low alpine pastureland is ideal for its growth. The species grows in the forests, grassy slopes and to some extent in the alpine pastures. High hill regions experiencing 1-5 m snow fall in winters and very low rains in summer are considered most congenial for germination, growth and development. Low rainfall during summer at flowering and seed setting stages contributes towards high yield, better flavour and quality of seeds. Kalajira is propagated mainly through seeds, but its subsequent

growth and production is maintained by tubers/bulbs, which are formed 10-15 cm deep in the soil by the germinating seedlings. It requires three-four years to produce viable seeds. From the same new seed crops are raised through seed. Plants raised through 7-8 years old tuber produced more branches, an average height of 50-60 cm with 40-50 cm spread.

Land preparation and soil work: The land attains a fine tilth after 2-3 rounds of deep ploughing after which, well rotten farmyard manure is mixed with the soil at the rate of 3500 kg/ha or an equivalent of 280-300 kg/bigha. A sufficient gradient is provided to the land by ploughing and levelling of the soil for facilitating drainage.

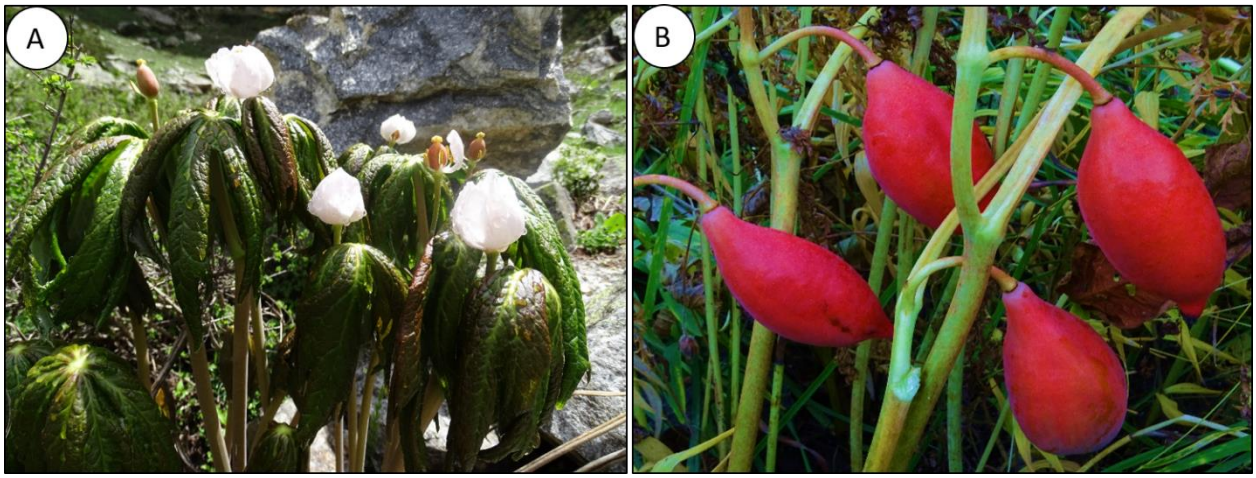
Nursery preparation: If sown in November the germination occurs in April. Maximum 200 g seeds may also be required for gap filling in the subsequent year. The maintenance of 2 lakhs plants per ha is ideal. As the seeds are very small in size, they are mixed with sand properly. Lines of furrows are prepared around 40-50 cm apart. The seeds mixed with soil should be properly placed within the furrows at around 1.5-2 inches deep. The seeds should be immediately covered with a thin layer of soil.

Transplantation: *Bunium persicum* should be grown in full sun. Even in the partial shed its growth is hampered although it may adopt the later but yield becomes less. When large enough to handle, the seedlings are pricked out into individual pots and grown them in the greenhouse for at least their first winter. It is advisable to transplant them out into field only in late spring or early summer when there is no expectation of frosts. The plants grow about 20 -30 cm in the first year and 60-80 cm in the second year. Distance between the plants should be maintained 8-10 inches. Theoretically 10-15 cm between the rows and 15 cm between the plants are an optimum option. But distance between the individuals as well as between the rows should be 45-50 cm to achieve the maximum production.

Vegetative propagation: The species can also be propagated through bulbs. A bulb of the age of one or two years produces maximum one or two plants while from a third-year bulb 4-5 buds may be developed. Tubers also require long chilling period for better sprouting and initiation of floral primordial. 1-1.5 kg of seeds is required at first sowing and re-seeding in subsequent years requires 200 g/ha to maintain optimum plant population

Water management: The first irrigation in the form of sprinkling is given just after seed sowing. The water requirement of *Bunium persicum* is not very high. About 2-5 irrigations are sufficient for reaping a good harvest. The irrigation should preferably be given before weeding to moisten the soil and weeding becomes easier. Other optimal times for irrigation are at peak time of flowering and formation of fruits.

Sinopodophyllum hexandrum Royle



Sinopodophyllum hexandrum Royle A. Plant in flowering, B. Fruit Amit Kumar

Species and Location Profile

Vernacular name: Bankakri

Trade name: Bankakri

Folk name: Bana-kakari (Punjab), Venivel (Gujarat), Patvel (Maharashtra), Paapraa, Paapri.

Ayurvedic name: Vanyakarkati, Giriparpata

Sanskrit name: Vana vrintaka

English Name: Indian Podophyllum

Habitat and Distribution

Habitat:

Sinopodophyllum hexandrum is distributed in the sub-alpine to alpine regions of the Himalaya from 2400-4200 m above mean sea level (Rajesh et al. 2014). The species thrives best as undergrowth as well as in forests in well drained humus rich, glacial riverine, rocky moist areas, alpine dry scrub, open grassy slopes, alpine slopes, shady moist alpine slopes and forest edges (Sharma and Sharma, 2018; Pandey et al. 2007).

Global Distribution:

Globally it is distributed in the Eastern North America and in bolt continental and insular East Asia. It is mainly found in different areas of China, Yunnan, Himalaya, USA, Bhutan, Indo- China, India. Four in India, *Sinopodophyllum hexandrum* has been reported to be distributed in all the Himalayan states like Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Sikkim. In Jammu & Kashmir it is reported to

occur at, Daitwas forest, Gilgit Gulmarg, Jagran river bank between Kundi & Shikar, Kishenganga valley, Kanasar, Jhelum basin, Khelanmarg, Lidwas; Muzafarabad range forest, Sind Valley, Tanmarg forest, Zaskar, Mechigaon, Zozila pass, Trumba, Dagoum, Chandanwadi, Seshnag, Kargil, Pissughile, Pahalgam, Tanmarga. In Uttarakand, it is reported from, Deoban, Kanjatra, Konain, Rudgaria Gar, Bhillangana, Panwali, Jamnotri, Jamunachatti, Barkot, DoditaI, Gaumukh, KedarKanta, Dasoli, Mundali, Bhyander, Hemkund, Madhya Maheshwar, Tunganath, Pindari glacier, Kuti, Yankti river valley, Bogudiar, (Pithoragarh). In Sikkim it is reported to occur at Chamnaga, Thangu, Tsomgo, Chanaga, Thangu (Shah, 2006). In Himachal Pradesh it is reported from, Chamba, Chulkot forest, Pangi, Killar, Sach Pass, Pulga, Haranghati pass, Pandrabis, Kala Tope forest, Keylong, Kullu, Lahaul, Pulga, Kangra, Matian, Shali hills, Narkunda, Dencho, Sissoo, Koksar, Dalhousie and Shimla (Sharma and Sharma, 2018).

The genus comprises of about 22 species, where 4 species (*S. hexandrum, P. versipelli, P. aurantiocaule* and *P. sikkimensis*) are reported from the Indian Himalaya (Airi et al. 1997).

Morphology and Phenology

Taxonomic Description:

S. hexandrum is erect herb, glabrous, up to 30 cm tall with creeping long knotty rhizomes. Stem one or two, simple, leafy without top. Leaves alternate, palmate, up to 25 cm in diameter, deeply divided in 3-5 lobes, toothed, purple spotted. Flowers are white to pinkish in colour, 4 cm across, appear in the fork of the stem. Sepals are 3 in number and petaloid. Stamens are usually 6. Fruits are ovoid, pulpy 5 cm long and scarlet when ripe.

Flowering & Fruiting: May-June and July-August.

Population Status

S. hexandrum prefers a moist peaty soil and filtered light or shade and grow in moist open woodland (Philips and Foy, 1990; Knight, 1980). Due to continuous exploitation and habitat destruction, certain species are becoming rare. It is hardy plants which can thrive up to about -20 Celsius; it takes some years to become established but is very long lived in suitable habitat (Facciola, 1990). Young leaves may be damaged by late frost but otherwise the plants are quite hardy. Young plants produce only one leaf each year; older plants have 2-3 leaves each year (Kaul, 1997). Export of Podophyllum from the wild is prohibited for the export from India under CITES. Material from only cultivated plants is allowed for export under cover of CITES export permit and legal procurement certificate (LPC) or certifies of cultivation from the designated authorities. Of the about 113 taxa, identified as threatened in Indian Himalaya, only a few species, for example, *Sinopodophyllum hexandrum* have been studied for in Western Himalaya (Chaurasia et al. 2012). Population density of *S. hexandrum* varies according to location and elevation such as the density has been reported 0.98 ± 0.24 in valley of Flowers National Park, 0.72 ± 0.30 Kedarnath Wildlife Sanctury, 2.0 ± 1.0 Pin Valley National Park (Kala, 2005).

Conservation Status

It has been categorized as Endangered (Chaurasia et al. 2012; Goraya et al. 2013; Kala, 2000). Critically endangered (Goraya and Ved, 2017).

Potential Threats

The massive extraction of its rootstock over the last several decades leading to destructive harvesting, habitat degradation. The species, which grow very slowly, are becoming increasingly scarce due to intensive collection, lack of cultivation and to their own biological characteristic (Guerram et al. (2012), this has led to severe reduction in its population density and the species is now listed in endangered plant species category. A species without enough genetic diversity is thought to be unable to cope with changing environments or evolving competitors and parasites. Considering the importance, threat perception and need for sustainable supply of its rootstock, there is need of not only multiplying its stock (by organized cultivation) but also assessing the relative active content concentration in its population in different agro climatic region and also in different morphotypes (Sharma and Sharma, 2018; Chaurasia et al. 2012).

Medicinal Uses

Fruits, as such or in concentrated form are the best to use in medicine. Rhizomes are used for typhoid fever, jaundice, dysentery, chronic hepatitis, scofula, rheumatism, skin diseases, tumerous growth, kidney, bladder problems, gonorrhoea, and syphilis. The *Sinopodophyllum* is used for treatment of vaginal warts. Two derivatives of podophyllotoxin, called eloposide and teniposide are employed for treatment of cancers. Root paste is applied on ulcers, cuts and wounds (Sharma and Sharma, 2018; Chaurasia et al. 2012).

Market & Trade

In India, *Sinopodophyllum* species are prohibited for export if the plants are collected from the wild. Raw drug obtained from cultivated material can however, be exported. The reported total annual trade of raw *Sinopodophyllum hexandrum* by domestic herbal industry and rural households was 0.10 MT respectively, whereas, the annual trade of raw drug was 10-50 MT (Goraya and Ved, 2017).

Good Harvesting & collection practices

S. hexandrum is collected in large number from wild by the local community due to which the reduction in the population will be seen as compared to other plant parts so for the (a) collection of rhizomes the whole plant was ploughed, (b) lack of awareness indiscriminate cutting of grasses and bushes were done by local community. This has resulted in the reduction in the population of these plants. Another reason is the change in environmental conditions which is going on constantly. Further, some plant has habitat

specificity, some have narrow range of distribution, land-use disturbances by human beings, introduction of non- native's plant species or invasive species, change of habitat, climatic changes, heavy grazing pressure, explosion of human population, fragmentation and degradation of the plant density, population restriction and genetic drift are the potential causes of destruction of medicinal plant species.

Harvesting

In view of the sustainable harvesting framework, the following good harvesting practices are suggested:

What to Collect: The tubes, fruit and the whole plant of bankakri is harvested. To avoid wasteful digging and damage to other plants, proper identification of vankakri is importance.

What Stage: The roots and rhizomes are harvested from mid-September when the tuber is fully mature or the aerial parts begin to wither and dry.

When: The collection of *S. hexandrum* is from July to September. The plant should be collected after full maturity. The best harvesting time is when the aerial parts dry properly and tuber gets fully mature to get optimum yield.

How: Digging should be carried out with proper tools to carry out only the bare minimum digging necessary for taking out the tuber without causing damage to the adjoining plants. It is advised to separate the top portion of the tuber at site and leave it in the dug-up portion for its regeneration.

How much: The youngest top portion of the rhizome cuttings of 1.0-2.5 cm in length, bearing leaf primordium led to better sprouting in *Sinopodophyllum hexandrum* when planted in June-July in well prepared soil at a spacing of 30-30 cm (Nautiyal and Nautiyal, 2004).

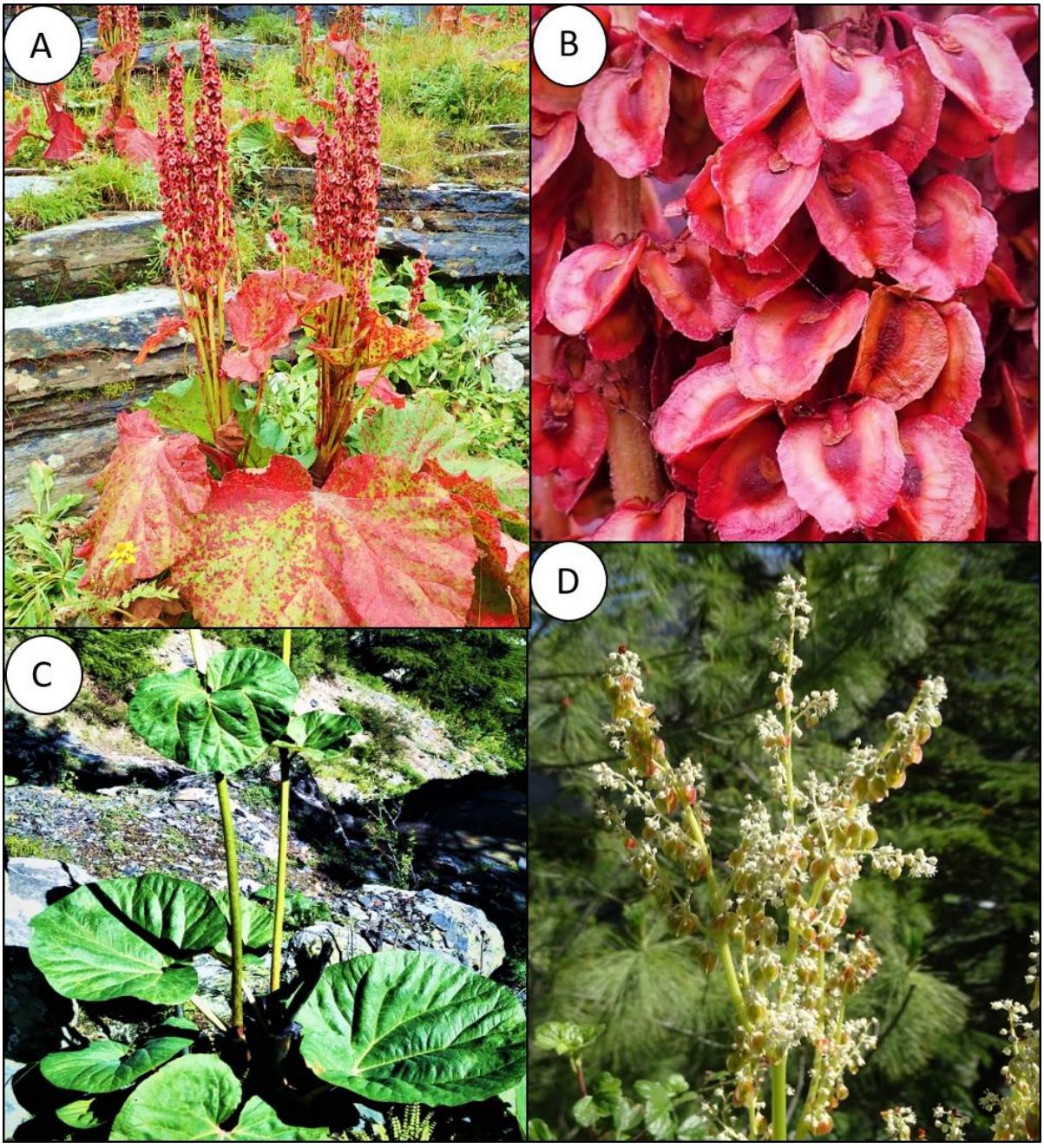
Post Harvesting Handling

Roots and rhizomes are harvested after drying of above ground parts; rhizome dug out and washes with the water. Roots and rhizomes are then cut into pieces of 15 to 20 cm long, and dried under sun. The dried material should be stored in clean containers or gunny bags in a cool and dry place.

Techniques of cultivation and prapogation

S. hexandrum grows well in organic rich black soils withsufficient moisture. Partially shaded places favor survival and growth of the plants at lower altitudes. It can be propagated by seedsas well as from sections of rhizomes (Nautiyal and Nautiyal, 2004; Qazi et al. 2011; Sreenivasulu et al. 2009). Under natural conditions, seeds show erratic and poor germination. The seeds germinate after remaining dormant for one or two years. The main reason for poor seed germination seems to be postharvest care of seeds (Nautiyal et al. 1987). Seeds washed with water showed better germination than unwashed seeds (Bhadula et al. 1996). During pre- land preparation, 10 t/ha manure is required and the land needs to be ploughed or dug after 4-week interval.7-8 kg seed is required for showing. Showing should be done during March-May (Sharma and Sharma, 2018; Chaurasia et al. 2012).

Rhubharb *(Rheum* spp.*)*



Rheum species (A-B) *Rheum australe* whole plant and Seed; (C-D) *Rheum webbianum* whole plant and flower. Amit Kumar

Species and Location Profile

Etymology: *Rheum* is a member of family Polygonaceae (buckwheat family). '*Rheum*; is a Greek name for roots and rhizomes that was imported from Iran. Rhubarb comes from Greek word '*rha*' (river) and Latin word '*barb*' (barbarian land). In ancient times, rhubarb roots were imported by Romans from barbarian lands which were beyond the Volga or Rha River. Imported from barbarians across the Rha,

the plant became Rhabarbarum. According to Lindley's Treasury of Botany, some authorities derive the name from the Greek rheo ('to flow'), in allusion to the purgative properties of the root.

Vernacular name: Himalayan rhubarb, Dolu, Revandchini, Archa, Archu, Lachhu

Trade name: Raval chini, Revan chini, Revanchini, Revanchi, Revand chini

Unani name: Revand chini

Ayurvedic name: Amlaparni, Peetmoola

Sanskrit name: Revandachini, Revatchini, Amlaparni, Amlavetasa, Gandhini, Pita, Pitamula, Pitimulika, Revatika and Soma.

Habitat and Distribution

Habitat: Revandchini plant is restricted to the temperate, sub-alpine, and alpine zones of the Himalayas from Kashmir to Sikkim, between an elevation of 3000 and 5500 masl (Tabin, 2016). It is mainly found in alpine zone on rocky soil, moraines, and crevices, between boulders, near streams in specific pockets, open slopes, rocks and shrubberies (Sankara et al. 2020). The species is hermaphrodite (has both male and female organs) and is wind pollinated species. It prefers moist and well-drained soil with medium (clay) and heavy (loam) texture with semi to no shade at all (Pandith et al. 2018).

Global distribution:

Globally the species is distributed Bhutan, China, India, Myanmar, Nepal and Pakistan. It is mainly endemic to the Himalayan region and the Indian distribution ranges from Kashmir to Sikkim. In India, it is found in Himalayan states viz., Himachal Pradesh, Uttarakhand and Jammu and Kashmir (Tabin, 2016). In Himachal it has been recorded in Rohtang pass, Rahallafall, Lahaul valley, Sangla valley, Ropa valley, Kinnaur and Pangi (Rana et al. 2014; Verma and Tewari, 2016, Pandith et al. 2018; Singh et al. 2009; Verma and Kapoor, 2010). In Sikkim the species has been recorded in Khangchendzonga Biosphere Reserve whereas, in Uttarakhand, it has been reported in Garhwal region, Valley of Flowers, Kedarnath, kyarkoti, Chamoli district and so on and in Jammu and Kashmir, Rhubarb has been reported in Saithal Kashmir, Leh and Zanaskar valley (Singh and Sundriyal, 2005; Tayade et al. 2012 and Rawat et al. 2016). More than 60 species of the genus Rheum have been reported in the world (Ghorbani and Hosseini, 2019) whereas, in the Indian subcontinent 07 species have been reported (Ganie et al. 2014).

Morphology and Phenology

Taxonomic description:

Rheum is a perennial herb, 1.5-3.0 m tall. Roots are very stout and thick. Leaves are radical, orbicular, or broadly ovate, very large, and 30–45 cm in diameter with long petioles. Floral characteristics: Flowers are small, dark purple or pale red in axillary panicles. The plant has three to five years of juvenile phase, followed by reproductive phase.

Flowering and Fruiting: Flowers from June-August and fruits from July-September.

Population Status

Population density of *Rheum australe* varies according to habitats, such as the density has been reported between 0.5-5.3 (individuals m^{-2}) in Himachal Pradesh (Uniyal et al. 2005; Singh et al. 2005). Similarly, in Uttarakhand, the density varied from 1.93-4.24 (individuals m^{-2}) (Rawat et al. 2016).

Conservation Status

Rheum australe falls under 'Vulnerable' category (Goraya et al. 2013) however, as per Previous Status (Ved et al. 2003) it falls under 'Endangered' category. *Rheum webbianum* have been assessed as Vulnerable (Goraya et al. 2013).

Potential Threats

The species mainly has been directed to numerous threats such as overexploitation for local use, overgrazing, habitat degradation rapid urbanization, selective illegal extraction and uncontrolled deforestation (Pandith et al. 2018). Beside these, construction of roads, excessive tourist flow which is usually higher than the carrying capacity of the particular health resort, industrialization, landslides (Rashid et al. 2014; Baig et al. 2014).

Medicinal Uses

The species carries many properties such as antidote, stomachic, astringent, laxative, febrifuge antitoxin, antiseptic antihelminthic, laxative, diuretic, purgative, anticholesterolaemic, antitumour and tonic with uses against diseases Asthma, Back pain, Bile disorder/Bile, Fever, Bloated stomach, Body cramp, Boils, Bronchitis, Burns, Cold, Diarrhoea, Frost bite, hematochezia, Ulcer, Cancer and so on (Rokaya et al. 2012; Zargar et al. 2011; Rawat et al. 2016). *R. webbianum* root can also be used as a dyeing substance which gives yellow color and used to dye wool and silk fibers (Tayade et al. 2012). Powdered roots are sprinkled over ulcer for healing and also used for cleaning teeth. Leaves and flowers are also edible (Nautiyal et al. 2003).

Market and Trade

The reported estimated annual trade of *Rheum webbianum* was less than 10 MT and the total annual consumption of raw *Rheum australe* by domestic herbal industry and rural households was 158.27 and 33.39 MT respectively, whereas, the annual trade of raw drug was assessed to be 100-200 MT (Goraya and Ved, 2017).

Good Harvesting and Collection Practices

Harvesting:

In view of the sustainable harvesting framework, the following good harvesting practices are suggested:

What to collect: It is the roots and rhizomes that need to be harvested in case of *Rheum.*

What stage: In lower altitudes plant mature in the fourth year if cultivated through seeds whereas it takes more time in higher ranges.

When: Harvesting should be done in September from lower ranges and in October from Alpine areas. If the requirement is large quantity of bioactive chemical compound, then it should be harvested before senescence and to achieve the maximum amount of bioactive ingredients plant should be harvested in July-August at lower ranges and October in higher ranges.

How: Digging should be carried out with proper tools to carry out only the bare minimum digging necessary for taking out the tuber without causing damage to the adjoining plants.

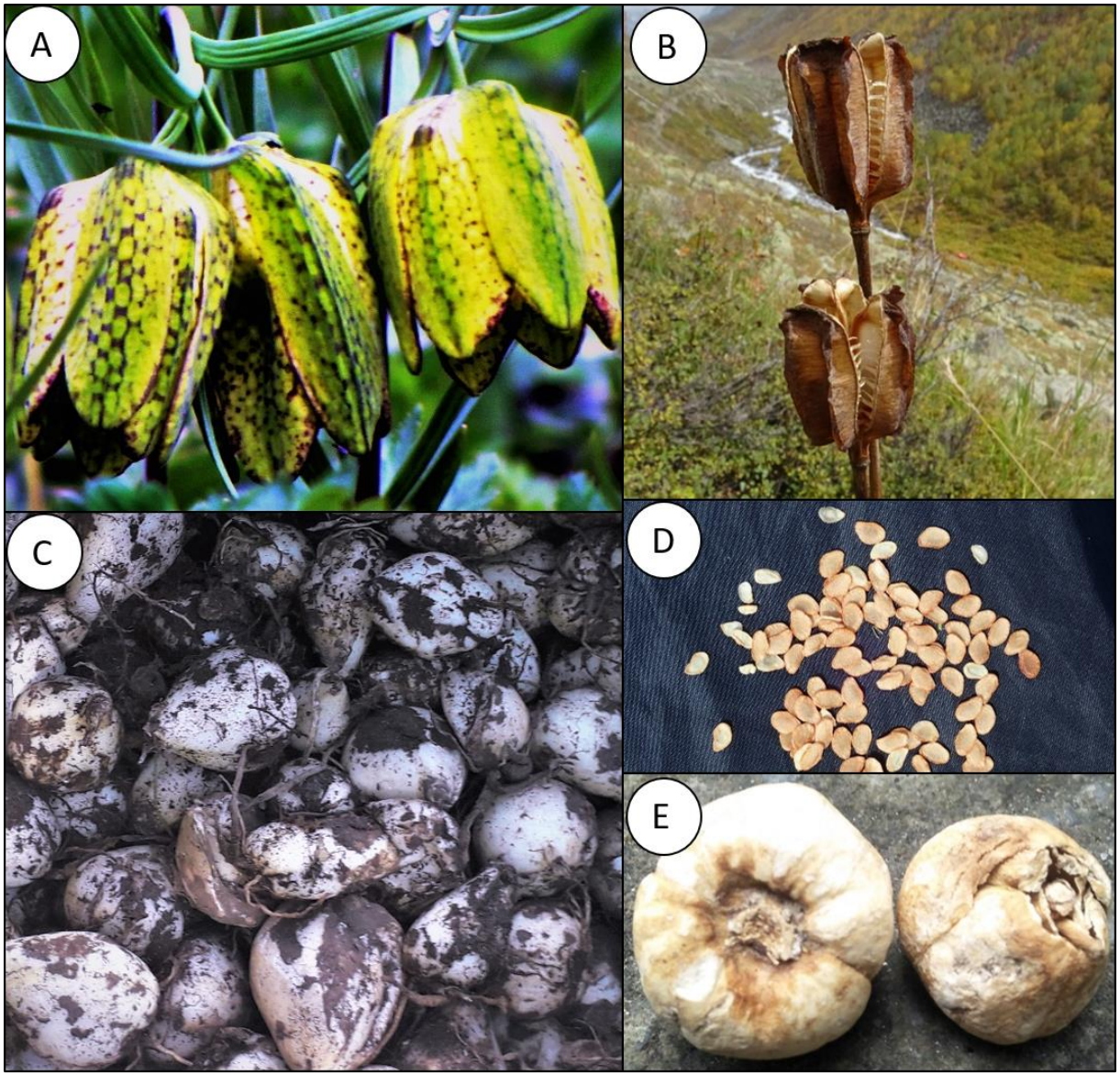
Post-Harvesting Handling:

The root and rhizome are cleaned, thoroughly washed to remove soil particles. Further cut into 3-4 cm long pieces and dried in partial shade or in warm air. The dried drug material is packed in gunny bags for marketing or may be stored in cold chambers (Nautiyal ans Nautiyal, 2004).

Cultivation and Propagation

Seeds and rhizomes both can be used as means of propagation. Sandy and porous soil with fully decomposed farmyard manure; whereas sunny sites with high moisture favours the growth and yield of plant. First the land may be ploughed and prepared to fine tilth and made aerable followed by farmyard manure (100 quintals/hectare) as a basal dose for soil containing 1%–1.5% of organic carbon at 2200 m. At lower altitudes (1800 m), higher dose of manure (about 150–200 quintals/hectare) is desirable for maximizing the yield. The seed production ranges from 250-300 seeds per plant. About 600 g of seeds are required to raise a nursery for planting at a spacing of 50 cm × 50 cm in 1 hectare of land with 60-70% seedling survival. In temperate conditions, seeds are sown in the spring season (March–early April) with 15 cm apart where the germination of the seeds is completed within one month of sowing. No specific pretreatment is required for the seeds. Transplanting is done in the month of May when the plants are almost three months old with optimum spacing for the crop is 50 cm × 50 cm. Before transplanting half dose of nitrogen and full dose of phosphorus and potash are also applied as a basal dose. Rest of nitrogen is applied as top dressing six to eight weeks after transplantation. Irrigation is done immediately after transplantation, followed by light irrigation at four-week intervals. Light sprinkler irrigation during the summer season has proved to be useful for the growth of the crop. However, excessive watering may cause decay of underground rhizome, especially in winter months. Regular weeding/hoeing should be done at an interval of 15–30 days, during the establishment phase, initial growth phase and monsoons. Soil drenching with Carbendazim 50 at a rate of 2 g/litre of water is proven beneficial against Fusarium sp. infection (Anonymous 2020; Kalsang, 2016; Nautiyal and Nautiyal, 2004).

Fritillaria cirrhosa D.Don



Fritillaria cirrhosa; A- Flower, B-Follicle, C- Immature bulb, D- Seed, E- Mature bulb. A-Gajendra Rawat; B, D, E-Amit Kumar; C-Himanshu Bargali

Species and Location Profile

Etymology: Also known as Kakoli, the species is an important component of a polyherbal formulation of eight herbs (asthavarga). *Fritillaria cirrhosa*, common name yellow Himalayan fritillary is an Asian species of herbaceous plant in the lily family also known as yellow Himalayan fritillary. The name *Fritillaria* comes from the Latin '*fritillus'* meaning dice-box, possibly referring to the checkered pattern on the flowers.

Vernacular name: Hindi: Kakoli, Tamil: Kakoli, Malayalam: Kakoli, Telugu: Kakoli, Kannada: Kakoli, Sanskrit: Kakoli, Ksirakakoli, Ksirasukla, Payasya, Bhutia: Chichaor, Nepal: Kakolee.

Trade name: Jangli lehsun

Vernacular name: Jangli lehsun, Ban lehsun

Ayurvedic name: Kakoli

Habitat and Distribution

Habitat:

Fritillaria cirrhosa D.Don (Liliaceae), commonly inhabiting the alpine slopes and shrubberies of the Himalaya in northwest India (Prakash and Nirmala, 2013; Khan et al. 2005), prefers to grow in open sunny meadows with moderate slope, rich in humus (Chauhan et al. 2011a), at an elevational range of 2700–4000 masl (Prakasha and Nirmala, 2013). *Fritillaria cirrhosa* generally grows in open sunny slopes of temperate to alpine or sub-alpine meadows of the Himalaya at altitudes ranging from 3200–4600 masl (Chen and Mordak, 2000). This herbaceous plant grows in rocky and grassy slopes of alpine and sub-alpine regions amidst shrubberies such as *Lonicera* spp., *Rosa* spp. and *Salix* spp. Populations of *F. cirrhosa* are scattered in isolated patches throughout its distribution range.

Global distribution:

F. cirrhosa is an endangered perennial herb, distributed mainly in China, India, Nepal, Myanmar, Qinghai, Pakistan, India, Bhutan and Myanmar. It shows distribution in the Indian states of Uttarakhand, Himachal Pradesh and Jammu & Kashmir. The species is endemic to the high Himalayan ecosystems (Chauhan et al. 2011a). It occurs in western temperate Himalaya from Kashmir to Kumaon (Khare, 2007) and from Pakistan to Uttarakhand (Prakash and Nirmalaa, 2013).

Morphology and Phenology

Taxonomic distribution:

It is an erect bulbous perennial herb, attaining 18–76 cm height. Bulbs are globose, white and non-tunicate, 1.3–1.4 cm across. Flower solitary, terminal, nodding, usually creamish-green in colour. Fruit a six-rigid capsule, containing large number of flat triangular seeds arranged in six rows, seeds golden brown in colour. Has yellowish green to brownish purple bell-shaped solitary flowers, leaves are linear, lanceolate and long pointed.

Flowering and Fruiting: Flowering period last May-July, flowers generally have yellow petals with purple spots and developed nectarines. The capsules mature in September or October, and contain 80–200 seeds per capsule with 1000-grain weight for 1.96 g (Mathew, 1996).

Population Status

Fritillaria cirrhosa faces threat due to heavy harvesting pressure, anthropogenic activities, competition with other associated species and low seedling establishment. Nearly 58–77% population reduction was recorded during the last 20–30 years (Chauhan et al. 2011a). It is under pressure due to over exploitation for commercial purposes (Kala, 2000). The market demand of this species is increasing while the supply is gradually decreasing (Ved and Goraya, 2008). Over exploitation for medicinal use has decreased its availability in natural habitats and brought this species in endangered state, making conservation and cultivation studies necessary (Chauhan, 2011).

Conservation Status

Fritillaria cirrhosa D.Don belonging is a perennial and Critically Endangered (CR) medicinal herb (Shafi et al. 2018). It is among the 36 species of globally significant medicinal plants of Western Himalaya (Bisht et al. 2016).

Owing to the declining population of *F. cirrhosa,* the species has been assessed using IUCN red list categories and criteria and has been listed as Critically Endangered in Uttarakhand and Endangered in Himachal Pradesh and Jammu and Kashmir (Ved et al. 2003; Singh et al. 2020). Extensive regional assessments of MAPs in Himachal Pradesh (Ved et al. 2003, 1998; Bisht et al. 2016; Goraya et al. 2013) have also categorized this species into Endangered category hence, restoring wild populations is very crucial. Thus, this valuable species is under multiple threat factors being a medicinally important plant, this species should be given priority for conservation through both *in-situ* and *ex-situ* methods (Chauhan et al. 2011a).

Potential Threats

Due to its strict habitat requirements, domestication and cultivation are extremely difficult. Therefore, majority of *F. cirrhosa* is still gathered from the wild. Due to over-harvesting, habitat fragmentation and over-grazing in the last decades, the wild populations and sizes of *F. cirrhosa* are rapidly decreasing and it is facing extinction (Zang et al. 2010). The species also faces threat from unorganized, premature and destructive harvesting coupled with the illegal markets functioning parallel (Mathela et al. 2020).

Medicinal Uses

It is mainly used as antitussive, expectorant and antihypertensive drugs. Its bulb is an important constituent of many medicines and health tonics (Chauhan et al. 2011b). It is a bitter tonic and gastric stimulant, cures fevers and urinary tract infections and is reported to be a remedy for 80 diseases (Sultal et al. 2013). It is used as a refrigerant, diuretic, galactagogue, expectorant and aphrodisiac. The

subterranean bulb has properties such as febrifuge, galactagogue, haemostatic, expectorant, aphrodosiac, anti-rheumatic, spermatogenic and tonic whereas, the rhizome is useful in excessive thirst, rheumatic pain and heamatemesis (Dhyani et al. 2010; Bisht et al. 2016). The bulbs of the herb are important constituents of Chyavanprash, Mahatraiphala Ghritham, Jeevanthyadi Ghrutham and Danwantharam. Also known as Kakoli, the species is an important component of a polyherbal formulation of eight herbs (asthavarga), however, no such medicinal uses were reported from the local communities of Himachal Pradesh. The bulbs of *F. cirrhosa* (Chuanbeimu) have been used as traditional Chinese medicine (TCM) for a long time in China. It treats haematemesis, tuberculosis and rheumatism. It also reduces pain in pregnant woman, promotes flesh and alleviates various pains (Dhyani et al. 2010). The alkaloids from the bulbs of Fritillaria cirrhosa exhibit remarkable biological activity, showing hypotensive, anti-inflamatory, antitumour, antitussive, expectorant, antiasthmatic properties (Wang et al. 2014).

Market and Trade

It is one of the 18 species that are actively traded throughout the world and constitutes large scale industry; worth 400 million US dollar per annum demand in China (Luo et al. 2018). In India, market value of dry bulbs is approximately 10,000–15,000 kg^{-1} INR in local markets (Kumar et al. 2021). In India, *Frtillaria cirrhosa* is prohibited for export if the plants are collected from the wild. Raw drug obtained from cultivated material can however, be exported. According to (Goraya and Ved, 2017) trade per annum and price of *F. cirrhosa* was found to be <10 MT with price ranging from 1200-6000 kg^{-1} respectively. As per HPFD, the total estimated volume of the *F. cirrhosa* extracted from the Lahaul and Pangi landscape was 108.41 qtls in the year 2017-18.

Fritillaria cirrhosa bulbs collected by local collector 📷 Himanshu Bargali

Enthusiastic collection of premature bulbs during July (instead of September-October on bulbs maturity) has resulted in the absence of perennating buds for the next growing season. For instance, premature bulbs collected by a local was more than 5kg costing INR 60,000. According to Kumar et al. (2021), the average market price of *F. cirrhosa* has been recorded between 9666.66±881.92 to 17666.66±1452.97 (Rs/kg±SD) in major markets viz., Udaipur (Lahaul), Killar (Pangi), Keylong, Manali and Amritsar (**Table 6**).

Table 6: Price of *Fritillaria cirrhosa* in various raw drug markets.

Sr.no.	Market/Places	Market price (Rs/kg)	Average market price (Rs. /Kg) ± SD
1.	Udaipur (Lahaul)	10000	9666.66±881.92
2.	Killar (Pangi)	15000	7666.66±881.92
3.	Keylong (Lahaul)	15000-20000	16000±2000
4.	Manali	12000-25000	16333.33±3382
5.	Amritsar	20000	17666.66±1452.97

Acoording to (Goraya and Ved, 2017), 'BanLahsun' (*Fritillariacirrhosa*)witnessed a sudden spurt between 2009-10 and 2014-15 in Himachal Pradesh, Jammu & Kashmir and Uttarakhand foritsbulbs. The wild populations of *Fritillaria cirrhosa* have succumbed to this high annual harvesting pressure pushing these species towards possible extinction.

Good Harvesting and Collection Practices

Due to its strict habitat requirements, domestication and cultivation are extremely difficult. Therefore, majority of *F. cirrhosa* is still gathered from the wild. Due to over-harvesting, habitat fragmentation and over-grazing in the last decades, the wild populations and sizes of *F. cirrhosa* are rapidly decreasing and it is facing extinction (Zang et al. 2010). To date, cultivation has been unable to meet the entire market demand for *F. cirrhosa* bulbs, although other Fritillaria species are successfully cultivated on a larger scale (Cunningham et al. 2018).

Harvesting:

In view of the sustainable harvesting framework, the following good harvesting practices are suggested: Good harvesting practices are aimed at getting the maximum possible yield with optimum alkaloid content on sustainable basis, and ensuring long shelf life of the produce. In *F. cirrhosa*, tubers form the officinal part and need to be dug up from the soil, thus, the procedure leads to destructive harvesting. However, if the sustainable harvesting framework is followed, the jangli lehsun plants can be harvested on sustainable basis. A look at the usual harvesting practices would reveal that in order to meet its rising

market demand, *Fritillaria* tubers are harvested (a) before these are fully ripe, (b) before the seeds have fully ripened and shed, (c) by deep digging of soil damaging other surrounding plants, (d) by removing the entire tubers, and (e) without giving prescribed rest to the harvested area. Some of the harvested produce gets damaged due to its poor post-harvest handling, putting greater pressure on the wild resource. It, therefore, become necessary to educate the wild gatherers about the good harvesting and post-harvest handling practices.

What to collect: It is the tubers/bulbs that need to be harvested in case of Jangli lehsun. The first and foremost best harvesting practice is to critically identify the plant before its digging up to avoid wasteful digging and damage to other plants, proper care has to be taken to only collect the mature bulb.

What stage: It is very crucial to avoid premature harvesting of the plant leaving no perennating structure for the next growth season. The premature bulbs are low on medicinal properties therefore; the plant should be harvested when the tubers are mature and seeds have ripened and are shed or ready for dispersal. It normally takes three growing seasons for the plant to reach this stage

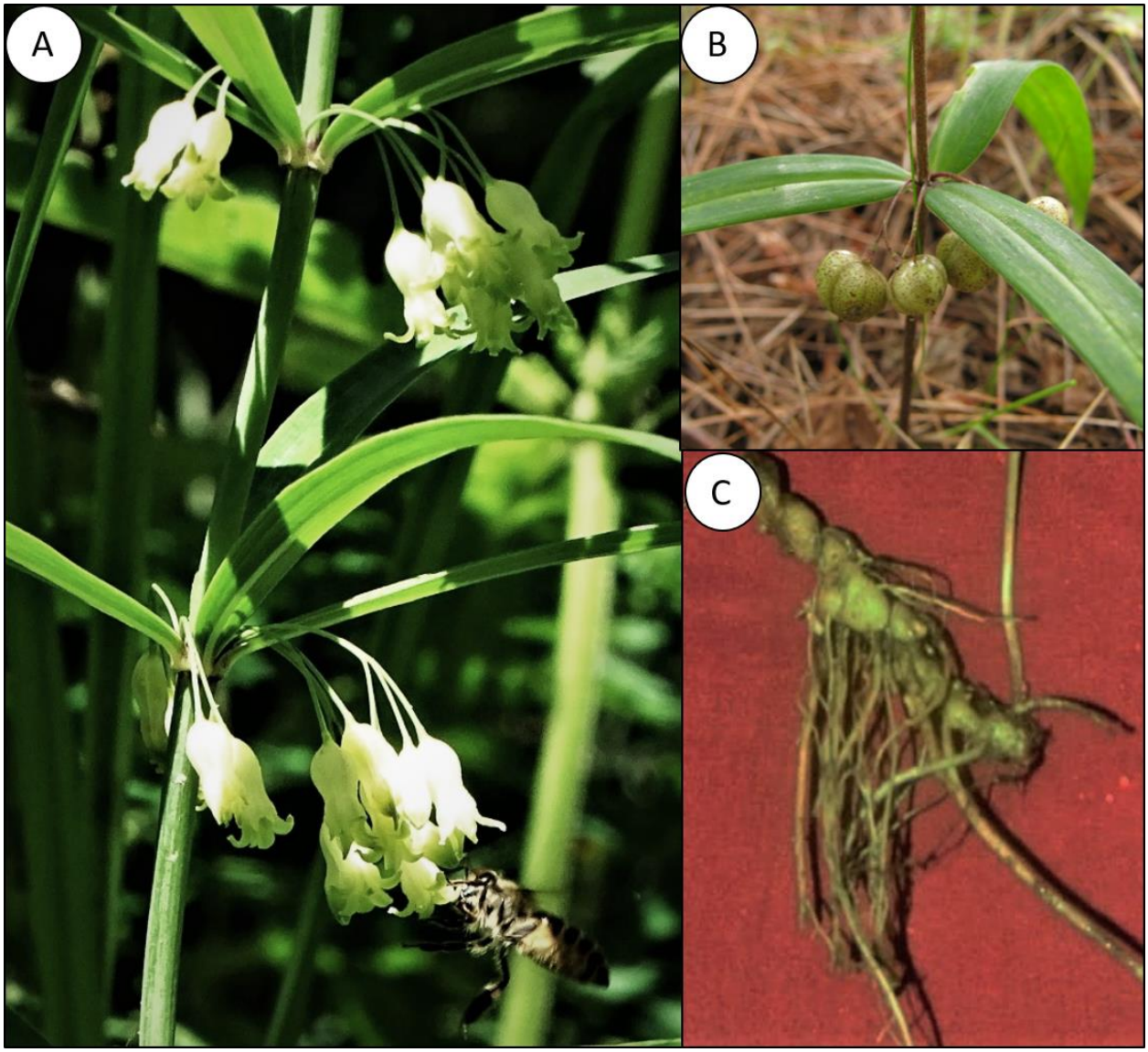
When: Harvest time- August – September. The capsules mature in September or October, and contain 80–200 seeds per capsule with 1000-grain weight for 1.96 g (Chen et al. 1993; Mathew, 1996). This species can reproduce both sexually or asexually, but the former is dominant (Mathew, 1996).

How: Digging should be carried out with proper tools to carry out only the bare minimum digging necessary for taking out the tuber without causing damage to the adjoining plants. It is advised to separate the top portion of the tuber at site and leave it in the dug-up portion for its regeneration.

Cultivation and Propagation

As such there is no available cultivation and harvesting protocols for *Fritillaria cirrhosa* on a large-scale basis however, few locals have been successful in cultivating the plant on a very small scale on their landholding in the Lahaul landscape. Mr. Tok Chand from Lahaul demonstrated his method of cultivation of this species. He added that the species must be grown in sandy and loamy, moist soils that is slightly alkaline. Seeds are used for the cultivation that must be sown when ripe. The seeds start germinating in spring and, can take a year or more to germinate. Flowers are produced from three to five years from these seeds. Once they die down at the end of their growing season, divide up the small bulbs and plant them in permanent plots. The crops may take up to six years to fully mature further, the plants need to be protected from frost.

Polygonatum verticillatum (L.) All.



Polygonatum verticillatum; A- Flower, B- Friut, C-Rhizome 📷 Amit Kumar and Renu Suyal

Species and Location Profile

Etymology: *Polygonatum verticillatum* is synonymous with *Convallaria verticillata* belongs to the family Liliaceae.The etymological root of the binomial name *Polygonatum* is derived from the Greek '*polys*' meaning many and '*gonu*' meaning a small joint. *Verticillatum* is derived from the Latin '*verticitas'* meaning vertical direction (https://davisla.wordpress.com/). According to Miller (1754) the generic name of *Polygonatum* is derived from the character of the rhizome which resembles much as yovi, a Knee, because it has many little Knees.

Vernacular name: Salam mishri, mitha dudhia, Kantula

Trade name: Salam mishri

Urdu name: Nor-e-Alam

Unani name: Medaa

English name: Whorled Solomon's seal

Hindi name: Basuchidra, Devamani, Pandura, Shakakul, Seal, Vasuchhidra, Mahamaida

Ayurvedic name: Mahameda, Medaa

Sanskrit name: Tridanti, Devamani and Vasuchhidra

Habitat and Distribution

Habitat: A rhizomatous, perennial herb usually found on moist, nutrient-rich, usually basic soils in wooded gorges, wooded river bank, moist habitat and oak forest, margins of woods and shady rocky places (Devi et al. 2019; Suyal et al. 2020). It can grow in full shade (deep woodland) or semi-shade (light woodland).

Global distribution: *P. verticillatum* is distributed in the temperate Himalaya (West Asia and Europe) at an altitude ranging between 2400 to 2800 masl (Anonymous, 2008; Chauhan, 1999). It has a worldwide distribution in Europe, Turkey, Central and North Asia, Pakistan, Afghanistan and Tibet and has been considered as the most important medicinal herb of Himalayan region (Dhyani et al. 2010). Distributed from montane to alpine Himalaya, in Himachal Pradesh it is reported in Manali wildlife sanctuary and Kinnaur whereas, in Uttarakhand it was reported from Garhwal Himalaya, Bhuna, Dunagiri, Binsar, Tungnath, Rudranath, Valley of flowers, Dayara, Niti andNanda Devi National Park (Naithani, 1984).

Morphology and Phenology

Taxonomic description:

It is an erect rather robust plant with many whorls of narrow lanceolate leaves, bearing branched clusters of 2-3 small, pendulous, tubular and white flowers with green tips in their axils. The stem is angled and grooved, 60-120 cm long. The flowers are 8- 12 mm long, fused into a broad tube below with short triangular spreading lobes. The perianth is 6-parted and somewhat reflexed. It is found in rare, moist-shady localities of montane forests. The fruit is a berry, which at first is bright red, becoming dark purple later. The rootstock is thick and creeping.

Flowering and Fruiting:

The flowering and fruiting take place in the month of June to October (Samant et al. 2007).

Population Status

The natural habitat of *Polygonatum verticillatum* is declined in many parts of the world (a) due to over exploitation, harvest in an uncontrolled way, overgrazing and lack of awareness is the reason for the decline of this species (Bhatt et al. 2014) in some regions of the world the plant were also utilized in herbal formulations and have some market value so the local people harvest plant before maturity due to

which mature seed production become very low and large number of seeds destruction also take place (Sharma et al. 2011). Furthermore, rhizome of the plant has much medicinal value so the whole plant is uprooted from the soil which also destroys the plant. Thus, there is a need for its in-situ as well as, ex-situ conservation and propagation to conserve this important medicinal plant.

Population density of *Polygonatum verticillatum* varies according to location and elevation such as the density has been reported between 1.50 (individuals m^{-2}) in Chandrabhan, Himachal Pradesh (Butola and Badola, 2008); (0.07/1.33) in Rakchham- Chitkul WLS, Kinnaur (Verma and Kapoor, 2014); 1.56 in GHNP, Kullu (NMHS Progress Report, 2018). Similarly, in Uttarakhand 4.40 plant m^{-2} (Mukteshwer and Gagar) and 2.60 plant m^{-2} (Bhaman gupha) (Lohani et al. 2013).

Conservation Status

The species has been categorized as 'Vulnerable' as per the CAMP report, Shimla (Ved et al. 2003).

Potential Threats

Overexploitation of rhizome and other parts for medicinal use and consequent degradation of natural habitat are reported to be the major threat to this species (Samant et al. 2007). Whereas *P. verticillatum* has been categorized as EN (Endangered) in the country following the IUCN Red List (Ved et al. 2015). Destructive harvesting has also brought about depletion and scarcity to this plant. The habitat loss by export of medicinal plants collected from wild sources finally lead to severe and irreplaceable loss of genetic stock of the species. Narrow range of distribution, land-use disturbances, introduction of non-natives, habitat alteration, climatic changes, heavy livestock grazing, explosion of human density, fragmentation and degradation of plant density, population bottleneck and genetic drift (Kala et al. 2006; Kala, 2007) are the potential causes of rarity in medicinal plant species.

Medicinal Uses

Polygonatum verticillatum is an important ingredient of Ashtakvarga and high value in medicinal herb is one of these Himalayan medicinal plants.Root used for urino-genital disorders, nerve tonic, general weakness, spermatorrhoea, haemorrhoid, leucorrhoea, anemia, gastric problems, wounds, rheumatism, aphrodisiac, appetiser, backache, menstrual troubles, vitaliser, rejuvenative, digestive, eaten as raw vegetable; Rhizomes Rheumatism, general body weakness, aphrodisiac, nervine tonic, kidney trouble, wounds, emollient, vitiated condition of pitta and vata, appetizer, glactagogue, anticancer, boils, eaten mixed with dairy products and as a tonic; Tuber as Seminal weakness, strangury, anorexia, fever, general debility, tonic, promote body heat, appetizer, aphrodisiac, nerve tonic, urinary problems, edible used as vegetable; Bulb in powdered form used for tuberculosis, general debility, as tonic, leucorrhoea, tonifying spleen, dampness, treat ''xiaoke'' (diabetes) and tonifying Qi; Green foliage as nutritive item utilized as

vegetable, shoots are cooked with other spring herbs; Seed as in Indigestion; Whole herb as to cure appetite, nervine tonic, kidney trouble and also restores body strength.

Good Harvesting and Collection Practices

P. verticillatum is collected in large number from wild by the local community due to which the reduction in the population will be seen another reason of the reduction of plant is the rhizome of plant which have more medicinal value as compared to other plant parts so for the (a) collection of rhizome the whole plant was digged from the soil due to which large number of plant were destroyed, (b) due to lack of awareness indiscriminate cutting of grasses and bushes were done by local community moreover the cutting of plants take place along with the underground reproductive parts of the plants and the cutting also destroyed the matured seeds. This all result in the reduction in the population of these plants. Another big reason is the change in environmental conditions which is going on constantly in the different ecosystems of the world such changes also occur in Himalayan region which is the rich source of natural vegetation and home for many native plant species due to the anthropogenic destruction of natural vegetation, environmental changes and the change in the natural habitat of the plant due to the change in the geographical and climatic conditions, decreased the overall density and availability of the plants. Bisht et al. (2012) also concluded that some plant has habitat specificity, some have narrow range of distribution, land-use disturbances by human beings, introduction of non- native's plant species or invasive species, change of habitat, climatic changes, heavy grazing pressure, explosion of human population, fragmentation and degradation of the plant density, population restriction and genetic drift are the potential causes of destruction of medicinal plant species. In some areas of the world the women carry all the activities of livestock domestication and for that they collect the food and fodder from the nearby forests and due to lack of identification they also cut the medicinal plant species along with the fodder grasses. Therefore, this is one of the reasons of threatened status of these medicinal plant species.

Harvesting:

For managed and sustainable harvesting, the following good harvesting practices are suggested:

What to collect: The roots, rhizomes, tubes, bulb, green foliage, seed whole plant of Salam mishri is harvested. To avoid wasteful digging and damage to other plants, proper identification of Salam mishri is of utmost importance.

What stage: The roots and rhizomes are manually harvested from mid September when the shoots or the aerial parts begin to wither and dry.

When: The collection period is from mid-July to September. The plant should be collected after full maturity. The best harvesting time is when the aerial parts dry properly.

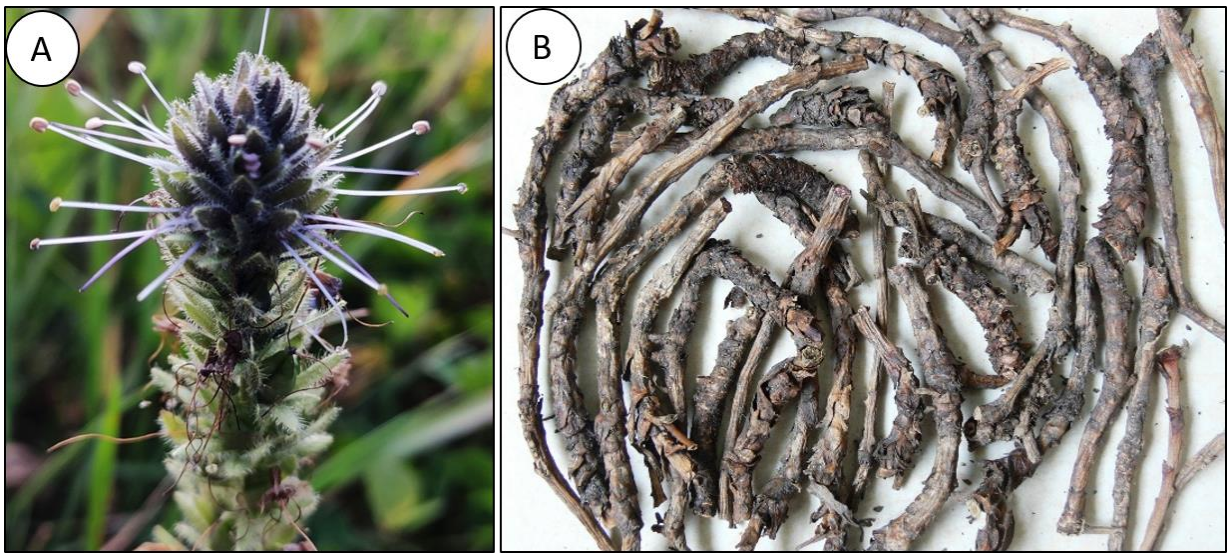
How: The entire plant is dug up and kept in gunny sacks. Salam mishri plant is dug out from soil to extract roots or rhizomes hence digging should be carried out with proper tools without causing damage to the adjoining plants.

Post-Harvesting Handling: After harvesting, these rhizomes are properly washed with running water to remove soil particles and rhizomes should be then cut into small slices and kept in the partial shade for drying.

Cultivation and Propagation

Seed - best sown as soon as it is ripe in early autumn in a shady part of a cold greenhouse. Sow stored seed as early in the year as possible. Germination can be slow; they may not come true to type and it takes a few years for them to reach a good size. When they are large enough to handle, prick the seedlings out into individual pots and grow them on in a shady position in the greenhouse for at least their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts. Division in early spring or early autumn. Larger divisions can be planted out direct into their permanent positions. We have found that it is better to pot up the smaller divisions and grow them on in light shade in a cold frame until they are well established before planting them out in late spring or early summer. Plants reproduce vegetatively, by rhizomatous spread, but fruiting is generally poor, with recruitment from seed apparently very infrequent (Singh et al. 2009).

Picrorhiza kurroa Royle ex. Benth



Picrorhiza kurroa; A- Flower, B-Root Amit Kumar and GS Goraya

Species and Location Profile

Etymology: *Picrorhiza kurroa* commonly known as Kutki, belongs to family Scrophulariaceae. The genus *Picrorhiza* belongs to the Greek word where 'picros' means bitter, while 'rhiza' means root and species name is taken from the Punjabi dialect 'karu' means bitter.

Vernacular name: Kali Kutki, Tikta, Katui and Katuka.

Trade name: Kutki.

Unani name: Kutki.

Ayurvedic name: Katuka.

Sanskrit name: Anjani, Aristha.

Habitat and Distribution

Habitat:

Kutki is a perennial creeping herb present in wild form in the north-western Himalayan region from Kashmir to Sikkim. Naturally Kutki grows at an elevation of 3000-5000 masl (Samant et al. 2007). It prefers moist, relatively less exposed, north-west facing slopes and, found near springs on moist rocks from timberline to alpines. Kutki grows in wild form near springs on moist rocks from timberline to alpines, cliffs, and the turf of glacial flats and in organic soils (Masood et al. 2015).

Global distribution:

Kutki is widely distributed in the Himalaya of Pakistan, India, Nepal, Bhutan and Southern China. In India, *Picrorhiza* is predominantly present in the north-western Himalayan regions. Kutki is found in Chota Bhagal, Himanchal Pradesh (Uniyal et al. 2006); Miar valley, Harsar, Kadu Nala and Kurched (Kumar et al. 2021), Chauras valley in Uttarakhand (Joshi et al. 2010), Zumu in Sikkim (Bhattacharjee et al. 2013) and in Jammu Kashmir (Dawa et al. 2018). In Himachal Pradesh, it is mainly found in the higher reaches of Chamba, Kangra, Mandi, Shimla, Kinnaur and Lahaul and Spiti districts (Kumar et al. 2012).

Morphology and Phenology

Taxonomic description:

Kutki is a perennial rhizomatous herb. The leaves are flat, basal, alternate, sharply serrated, 5–10 cm long. Terminal Spikes are present, 5 lobed, 4–5 mm long, actinomorphic. Rhizome 2.5–12.0 cm long and 0.3–1.0 cm thick, sub-cylindrical, straight or curved. Root is elongated, tubular, 5–10 cm in length and 0.5–1.0 mm in diameter, straight or marginally curved mostly associated with rhizomes. Flowers are small, pale or purplish blue, borne in cylindrical spikes with long stamen. Fruits are 1.3 cm long. The fruit type is usually a 2 chambered capsule. The flowers are born in racemes, light blue or purple blue in dense terminal racemes (Kansang, 2016), fruits are ovoid capsules and contain numerous seeds.

Flowering and Fruiting: The flowering period of Kutki is from June-August with numerous small, purple flowers of 1 cm length.

Population Status

Picrorhiza kurroa comprises of restricted distribution in the alpine and sub-alpine regions where its occurrence is limited to specific habitats and for the commercial purpose it is largely being exploited from the wild (Arya et al. 2013). The regeneration status of the high conservation priority Medicinal and Aromatic Plants is low. Likewise, the density per m² of *P. kurroa* was 0.38 and the seedling per m² was 0.13 and sapling per m² was 0.07, respectively (Uniyal et al. 2011). In Uttarakhand, particularly in the Kumaun region poor relative density of the species was recorded 0.03 per m² (Arya et al. 2013).

Conservation Status

Due to unorganized cultivation and indiscriminate collection from the wild, Kutki is listed as EN 'Endangered' (Rawat et al. 2013). According to (Arya et al. 2013), the taxon is considered rare and threatened in the Himalayan region, due to the destruction of its natural habitats and overexploitation.

Potential Threats

Picrorhiza kurroa has been affected from various threats like over exploitation for commercial use, degradation of natural habitat, unsustainable harvesting practices, illegal trading and unorganized cultivation (Rawat et al. 2013). The extraction of Kutki is unselective and unmanaged, which ultimately pose a threat for its survival and regeneration capacity (Uniyal et al. 2011).

Medicinal Uses

Kutki is widely used in traditional medicine systems in India with the rhizomes valued for their effectiveness as anantibiotic, hepatoprotective, anticholestatic, antioxidant and immunomodulatory properties (Kant et al. 2013). Local people use it to cure cough, cold, stomache, fever, malnutrition, jaundice, diarrhea, dysentery and for veterinary purposes. The rhizome is used to treat skin disease, liver disease, indigestion problems and metabolic disorders. The plant extract also contains some important chemical constituents like carbohydrate, aromatic acids, vanillic acid and ferulic acid (Masood et al. 2015).

Market and Trade

The Underground parts (roots and rhizomes) of Kutki extracted from high altitude sub-alpine and alpine regions in the Western Himalaya are traded as crude drug (Masood et al. 2015). The annual supply of Kutki from Nepal, India and Bhutan has been estimated to 375 MT and the consumption of Kutki in different sectors in India has been estimated to 415 MT/year. Due to high market demand of Kutki, it is extracted in larger scale. As in 1980, 1.468 MT was extracted from Himachal Pradesh and 9.06 MT was extracted from the alpine ranges of Chhota Bhangal. More than 5 MT of *P. kurroa* was extracted from 12 villages of Gori valley in 2001- 2004 and up to 6 MT is extracted annually from Sikkim. During 2007–2010, the price for Kutki at the village level varied from Rs. 220 to 340/kg. A total of 200–300 plants are harvested as shoot parts and 500–600 as root parts to make 1 kg dry weight of *Picrorhiza* (Uniyal et al. 2011).

Good Harvesting and Collection Practices

Due to increased commercial demand of Kutki, unmanaged, unorganized cultivation and harvesting practices occurs that affects the wild population of Kutki. The plant should be collected after full maturity. In Kutki, the underground part (root, rhizome) is to be collected by digging out the entire plant. Sand, dirt and foreign organic particles are removed and plant part should be dried in shady places (Arya et al. 2013). Attaining maximum possible yield on sustainable basis is the main aim of good harvesting

technique of Kutki. To meet rising market demand of Kutki, unmanaged and unsustainable harvesting methods is practiced and revealed that Kutki's roots and rhizomes are harvested (a) before crop mature, (b) before the shoots dry and wither (c) by digging of soil deeply damaging other surrounding plants, (d) without proper drying (e) without giving prescribed rest to the harvested area. Some of the harvested produce gets damaged due to its poor post-harvest handling, putting greater pressure on the wild resource. It, therefore, become necessary to educate the wild gatherers about the damages done by reckless wild harvest and the advantages of the good harvesting and post-harvest handling practices.

Harvesting:

For managed and sustainable harvesting, the following good harvesting practices are suggested:

What to collect: The roots and rhizomes of Kutki is harvested. To avoid wasteful digging and damage to other plants, proper identification of Kutki is of utmost importance.

What stage: The roots and rhizomes are manually harvested in September when the shoots or the aerial parts begin to wither and dry. Kutki has a life cycle of 3 years and needs 1 year for complete maturity of seeds. To get higher active contents, plants must be collected before flowering occurs. Time of completion of reproductive phase depends on the altitude. Generally, plants grown in alpine areas complete their reproductive phase during the months of September–October, while plants growing at lower altitudes complete their reproductive phase during the month of September.

When: The peak Kutki collection period is from mid-June to September. The plant should be collected after full maturity. The best harvesting time is when the aerial parts dry properly.

How: The entire plant is dug up and kept in gunny sacks. Kutki plant is dug out from soil to extract roots or rhizomes hence digging should be carried out with proper tools without causing damage to the adjoining plants.

Post-Harvesting Handling: After harvesting, the stolons and roots are washed to remove soil particles, mud and other unwanted materials. Stolons and roots are dried in shade to yield higher content of picrotin and picrotoxin. Proper drying is a critical process, because traders offer better prices for clean and dried material therefore Kutki is dried at room temperature (15-25°C). On completion of drying, the weight of fresh material is reduced by half. Drying in direct sunlight or in oven is avoided as this process decreases the active contents rapidly. Once the material is completely dried, it is packed in gunnysacks, airtight polythene lined jute bags to ensure protection from moisture (Chand et al. 2015).

Cultivation and Propagation

The cultivation of Kutki will certainly reduce the pressure on wild medicinal plant population, ensure regular supply of raw material to industries and uplift the economy of the local farmers. Picrorhiza kurroa was propagated through seeds and stolons in Styrofoam trays and nursery beds (Rawat et al. 2013). Germination of seeds was good when sown on the upper soil surface in Styrofoam seedling trays and covered with a thin layer of dry moss powder. This increases seed germination from 52 to 58% at lower altitudes. Seeds are sown during November- December in greenhouses, during March-April in beds at lower altitude and during May in the alpine area. Seedlings raised from seeds at lower altitudes are transported to higher altitudes during March and April and transplanted in nursery beds. Thus, the harvesting period can be reduced by at least six months, by raising seedlings at lower altitudes in winter and transplanting them at higher altitudes during the spring. Propagation through stolon cuttings proved more successful than cultivation through seeds. Vegetative propagation of stolon segments can be successfully done through hormonal treatments as well as through convenient and simple methods Top segments of stolons are found more suitable for multiplication. Kutki is also grown along with Foeniculum vulgare, Solanum tuberosum and Digitalis purpurea and proves quite successful, as these plants provide favorable microclimate for better growth, retain moisture for longer time and provide shade for the better growth of Kutki (Chand et al. 2015).

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