Quality Standard, Good Agricultural and Collection Practices *Valeriana jatamansii* Jones

Government of Nepal
Ministry of Forests and Soil Conservation
Department of Plant Resources
Thapathali, Kathmandu Nepal

2012

Valeriana seeds

Valeriana rammet

Rhizomes of Valeriana

Plant with fibrous roots

Roots of Valeriana

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FOREWORD

Medicinal and Aromatic Plants (MAPs) are considered as a major source of household and economy of the local communities in Nepal. Great majority of species are collected from wild and very few are being cultivated. This over- increasing demand of the natural herbal products has led to over- exploitation and hazardous collection of natural resources which impacted negatively on their existence as well as on the environment and loss of consistency in batch-to-batch quality.

It was in this context, WHO has developed a series of technical guidelines for ensuring quality of herbal medicine in 2003. One of them, a good agricultural and collection practices (GACP) of medicinal plants is a guidelines formulated by WHO (2003) that provides a comprehensive framework starting from correct identification/authentication of specific protocol and package of practices for cultivation as well as pre and post-harvest handling practices for the production of medicinal and aromatic plants. The GACP is designed to ensure optimal yield of the plant for medicinal purposes in both quality and quantity without creating negative impact on sustainability as well as environment.

The valerian (Sugandhawal) is one of the important plant species that is being traded inside the country and also exported to various countries in Asia and Europe. This booklet is prepared for Valerian (Sugandhawal) as a third Nepalese country specific GACP gridlines to serve all the stakeholders involved in promoting and commercializing this species. I hope this will be useful in promoting *in-situ* conservation, cultivation and trade of this species in Nepal.

Dr. Annapurna Nand Das
Director General

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INTRODUCTION

Valeriana jatamansii (Nep. Sugandhawal, Eng. Valerian, Indian Valerian) is an indigenous medicinal herb of Nepal having multiple influences on environment, biodiversity, rural economy, health and culture. Apart from traditional use in health care and culture, valerian essential oil has been used increasingly in aroma and perfume industries in the country and abroad. Currently, a number of entrepreneurs, particularly in the Mid and Far-Western Regions of Nepal, have been processing the plant for its essential oil mainly for export to other countries where there is high value demand for it. The domestic demand is remarkable with 1200kg of dry roots and 150kg of essential oil is consumed in the Kathmandu valley alone (Tiwari *et al.* 2004). Valerian, mostly in the form of essential oil, is as well exported to different countries including India, Japan, USA and European countries.

Most of its raw materials are collected mainly from community forests. Department of Forests recorded a total of 3.71 ton of the Valerian rhizome collection from different districts of the country during the fiscal year 2010/2011 with royalty collection amounting to NRs 55650 (Source: Department of Forest, Kathmandu, Nepal). As per the Forest Regulations of 1995, the government has imposed a royalty of NRs. 15/kg on its rhizomes that have been collected.

Due to its increasing commercial demand and price in international markets, over-harvesting, pre-mature harvesting and irrational collection practices have been taking place in Nepal that has contributed to rapid depletion of the species from its natural habitats. In Nepal, *Valeriana jatamansii* has been categorized as a vulnerable species, based on the IUCN Threat Categories – version 3.1 (Bhattarai *et al.* 2002). Government of Nepal has prioritized this

species as one among the 12 medicinal plants prioritized for cultivation and research (GoN 2005a). However, very recently, as the result of demonstrations, training and capacity building efforts put forward by various governmental, non-governmental and international organizations involving local collectors and producers throughout the country, the scenario has improved and cultivation practices have evolved to supplement wild collections at many places. Currently, experimental cultivation practices has been started in Department of Plant Resources (DPR) managed medicinal plant research centers at Tistung, Daman, Salyan, Jumla with the aim of research, training and demonstration.

The community forest user groups and local farmers in districts like Doti, Dadeldhura, Baitadi and Darchula in Far Western Nepal have considered Valerian as one of the viable medicinal plant in terms of local livelihood enhancement. Seedling production in community-managed nurseries, cultivation and enrichment plantation in community forests and cultivation on private land has been considerably progressed. Valerian, thus produced, is being traded through community-owned and community-managed non-timber forest product-focused cooperatives, benefiting the community forest user group members and local farmers alike (*Personal communication: CFC/ICIMOD/HNCC project on Medicinal Plants in far-west Nepal*).

The quality of any raw medicinal plant and the consumer products derived from them depends on the genetic and environmental factors in addition to cultivation techniques, harvesting stages and practices, post-harvest procedures including storage and transportation, etc. Inadvertent microbial or chemical contamination during any of the production stages may lead to deterioration in the quality and

efficacy of the raw materials and the resultant consumer products. Therefore, it has been felt necessary that detail information on the species including its good agricultural and collection practices, post-harvest procedures and quality standards should be documented for wider dissemination and to facilitate all stakeholders in the identification, collection/production and subsequent management procedures.

1. Plant Identity

Scientific Name: *Valeriana jatamansii* Jones

Synonyms: *Valeriana wallichii* DC.
Valeriana spica Vahl
Valeriana villosa Wall.
Nardostachys jatamansi (Jones) DC.

Family: Valerianaceae

Common name: Indian valerian, Muskroot, Valerian

Local Names/ Vernacular names:

Samayo, Sugandhwal, Kanpate, Nakkali jatamansi, Simjadi (Nep);Tagara, Balem, Bhutakesi, Nata, Tagar (Sanskrit); Na Poe (Amchi, Kham); Panve (Bhotiya); Samayo (Danuwar); Poti, Mukhkhawata, Jermasi (Gurung); Naswan, Naswa Kulcha (Newari); Nhakapai, Pangbu, Panakapo (Sherpa); Albi, Daling, Soman, Nakpo, Peheyi, Lungbae, (Tamang); Samaya (Tharu) (Shrestha, K. 1998; Rajbhandari, K.R. 2001).

2. Parts used

Root, rhizome, leaves to produce essential oil

3. Distribution

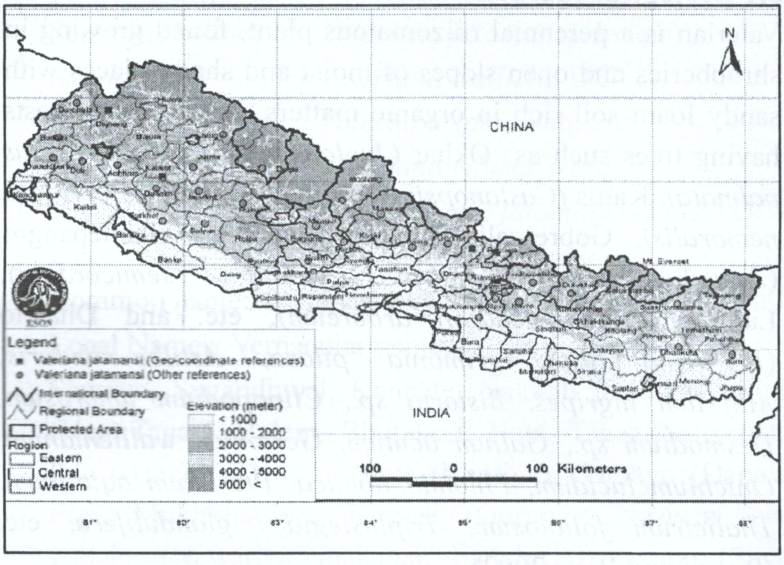
This species is distributed in the Himalaya, including Afghanistan, Northern and North-eastern India, Nepal, Bhutan, China (Tibet, Western and Central China) and Myanmar. In Nepal it is found between sub-tropical to subalpine regions from East to West along 1500-3300m altitude (Manandhar 1976, 2002; Hara and Williams 1979; Polunin and Stainton 1984, Baral and Kurmi 2006).

3.1 Ecological characteristics

Valerian is a perennial rhizomatous plant, found growing in shrubberies and open slopes of moist and shady places with sandy loam soil rich in organic matters. It grows in forests having trees such as Okhar (*Juglans regia*), Bedulo *(Ficus palmata),* Katus *(Castanopsis indica),* Dudhilo *(Ficus nemoralis)*, Gobre salla (*Pinus wallichiana*), Ghodepangro (*Aesculus indica*)Khanyu (*Ficus semicordata*), Laligurans *(Rhododendron arboreum)*, etc. and Dhatelo (*Prinsepia utilis*), *Agrimonia pilosa, Astilbe rivularis, Athyrium nigripes, Bistorta sp., Clinopodium umbrosum, Desmodium sp., Galium acutum, Geranium wallichianum, Onichium lucidum, Phlomin tibetica, Pteridium aquilinum, Thalictrum foliolosum, Triplostegia glandulifera,* etc. (Regmi and Bista 2002).

3.2 Availability in Nepal

The species has so far been reported from the mid- and high-altitude localities of 55 districts including Darchula, Baitadi, Dadeldhura, Humla, Bajhang, Doti, Bajura, Achham, Mugu, Jumla, Kalikot Dailekh, Dolpa, Jajarkot, Rukum, Surkhet, Salyan, Rolpa, Pyuthan, Manang, Mustang, Myagdi, Gulmi, Gorkha, Arghakhanchi, Lamjung, Kaski, Parbat, Gorkha, Syanja, Palpa, Tanahu, Rasuwa, Nuwakot, Dhading, Sindhupalchok, Kathmandu, Bhaktapur, Lalitpur, Makwanpur, Kavre, Dolakha, Ramechhap, Sindhuli, Solukhumbu, Okhaldhunga, Khotang, Udayapur, Bhojpur, Sankhuwasawa, Dhankuta, Terathum, Taplejung Panchthar and Ilam. (ESON 2009).



Map 1. Distribution of *Valeriana jatamansii* Jones in Nepal (ESON 2009)

4. Uses

4.1 Pharmacological properties

Valerian has depressant action on central nervous system and is used in the treatment of hysterical fits, other nervous disorders, and flatulence (Jain 1968). The drug contains a group of iridoid or monoterpenic derivatives known as valepotriates, used as a tranquillizer and sedative in formulations similar to meprobromate (Ambasta *et al.* 1992, Tang *et al.* 2002). Root extract shows antimycobacterial property (Taylor *et al.* 1995, Mhaske *et al.* 2011) and it is chiefly used as a narcotic in insomnia (Jain 1968, Chauffard *et al.* 1981). Curcumin is a chief constituent for anti-inflammatory activity (Ammon *et al.* 1993). The alkaloids

possess antiseptic, sedative, anti-epileptic, hypotensive, cardiotonic and antidepressant properties (Leathwood and Chauffard 1982). The leaf extract was found to have analgesic effect in rats (Shrivastava and Sisodia 1970). Benzene extract produced mild hypothermia in mice. Both benzene and alcoholic extract produced antipyretic effect, corroborating its clinical efficacy as anti- pyretic (Khare 2007). The plant extracts exhibited antibiotic activity against *Micrococcus pyogenes* and *Entamoeba histolytica*, the plant inhibited growth of *Ehrlich carcinoma* (Chopra *et al.* 1956, Yamaguchi *et al.* 1964, Rastogi and Mehrotra 1991, Dash and Gupta 1994, Melhotra & Sharma 1996).

4.2 Medicinal uses

In Amchi system (Ancient Himalayan practice) of traditional medicine, rhizome is used to treat headache, eye problems, sore throat, indigestion, wounds, fever, altitude sickness, cough and cold, diarrhoea and stomachalgia (Lama *et al.* 2001). In Unani system the plant is used to treat conjunctivitis, liver and spleen disorders, as an aphrodisiac and applied on arthritis, sore throat, and as a vermicide (Bhattarai and Ghimire 2006).

In Ayurveda, the plant and rhizomes are used to treat cholera, stomachalgia, unconsciousness, gastritis, mental disorder, high blood pressure, conjunctivitis, epilepsy and headache (Ghimire *et al.* 2008). It is also used in hysteria and nervous problems (Singh *et al.* 1983). Pulverized drug is mixed with sugar and prescribed in urinary problems; decoction used as a sedative after parturition; also used as tonic, stimulant and carminative (Ambasta *et al.* 1992). Major valerian-based Ayurvedic preparations include *Chandanadi Churna*,

Dhanya-Panchaka Churna, *Mahasudarshana Churna*, *Dashamularistha*, *Sarivadyasava*, *Shringarabhraka Rasa*, etc. (SDVKVS 1999).

4.3 Ethnomedicinal uses

Crushed leaves are rubbed on the forehead to relieve severe headache (Joshi and Joshi 2001). Root paste is applied to treat headache and eye problem in Jumla district (Bhattarai 1992). Crushed rhizome is used to treat rheumatism and dislocation of joints at Chaubas and Syabru villages (Joshi and Edington 1990); crushed rhizomes mixed with water is used in child bath to get remedy from weeping sickness, the process is then followed by inhalation of rhizome fumes placing dried rhizomes on fire, this practice noticed at Makawanpur district (Bhattarai 1991). Root paste is applied to treat gout; root is used as incense in Manang district (Pohle 1990). Tamangs regard its root as insecticidal and as a remedy to relieve hysteria (Joshi and Edington 1990). Plant paste is applied on boils in Lamjung district (Manandhar 1987, 2002).

4.4 Other uses

Rootstocks contain about 0.8% essential oil, and are used in the production of cosmetics/aromatic products such as shampoo, perfume and other cosmetics (Ambasta *et al.* 1992, Watanabe *et al.* 2005). It is also used for preparation of incense (Manandhar 2002).The leaves are cooked as a vegetable (Ghimire *et al.* 2001, Kunwar 2006).

5. Morphological Characteristics of Plant

It is a perennial herb attending the height of 45-50cm with 4.5 cm long and 1-2 cm thick rhizomes with fibrous roots. Basal leaves persistent, long petioled, and deeply cordate-ovate, 2.5-8 cm, toothed or wavy margined, sometimes sinuate oppressed, pubescent above, Stem several, 15-45cm, stem leaves are few, small, entire or pinnate-lobed; opposite, upper ones usually ovate with a pair of small lobes at the base, about 3-5x 1-2 cm, acuminate, margin obscurely dentate. Flowers are often dioecious, in dense corymbose cymes, borne on erect, nearly leafless stems of about 20-30 cm, white or tinged with pink. Calyx (rolled) is nearly 0.3mm, unrolling in fruit up to 4mm with 11-13 setae. Corolla is obconical, 2.2-3.5mm, white, tinged with pink or purple, gibbous or unequal at base; lobes obtuse, 0.7-1mm. Stamens 3, stigma 2-3 lobed, ovary 3-locular, with 1-ovule. Fruit are elliptic, compressed, yellowish brown, about 2.4 x 1mm, hairy or glabrous; rootstock thick, horizontal. Fruit crowned with a persistent pappus-like calyx (Polunin & Stainton 1984).

6. Characteristics of Drug Materials

6.1 Diagnostic Features of Crude Drugs

Macroscopic

Dried pieces of rhizome are sub-cylindrical, often slightly curved, 4 to 6 cm in length and 4 to 8 mm in width; bear numerous long, wiry adventitious roots about 2 to 10 cm long and 0.5 to 2 mm wide. They exhibit numerous encircling leaf scars and circular root scars. Pieces of rhizomes are often marked by longitudinally wrinkled cylindrical stolon, with distinct nodes, internodes, 2 to 3 cm

long and 3 to 6 mm in diameter. Color is dark brown externally, pale brownish-yellow internally. It bears a strong, unpleasant camphoraceous odor and somewhat bitter taste (Gupta *et al.* 2003).

Microscopic

The rhizome is characterized by the presence of mostly thin walled rounded parenchymatous cells, with scattered vascular bundles, definite endodermis, a few layers of cork developed under epidermis, and scattered oleoresin cells with brownish contents. The cells of ground tissue are also filled with many starch grains. Epidermis is thin walled consisting of cubical cells of various dimensions. The cork cambium is developed from the subepidermal layers, and the epidermis is retained even after the development of the cork. Cork is generally composed of 4-6 layers of thin walled brick shaped parenchymatous cells. The parenchymatous cells of pith and cork contain curcumin and are filled with many starch grains. The scattered vascular bundles in the pith form discontinuous rings just under endodermis. The vessels have mainly spiral thickening and only a few have reticulate and annular structure (Figure 2).

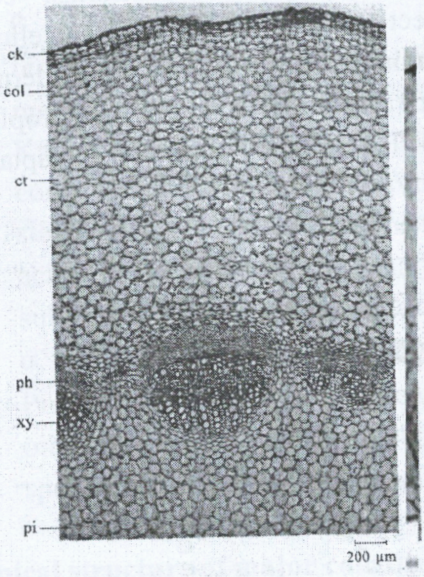


Figure 2. T.S. portion of rhizome: ck, cork; col, collenchyma; ct, cortex; ph, phloem; xy, xylum; pi, pith (Gupta *et al.* 2003)

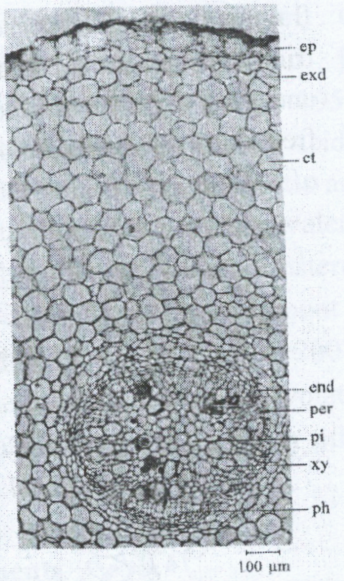


Figure 3. T.S. portion of root: ep, epiblema; exd, exodermis; ct, cortex; end, endodermis; per, pricycle; ph, phloem; xy, xylum; pi, pith (Gupta *et al.* 2003)

The transverse section of the root (Figure 3) shows a dark brown oval supersized layer of epiblema, 2 to 3 layered thick-walled parenchymatous exodermis, wide parenchymatous cortex filled with simple and compound starch grains, central narrow parenchymatous pith encircled by polyarch stele, narrow pericycle and a layer of endodermis (Rajbhandary *et al.* 1995, Gupta *et al.* 2003).

Dry root powder

Dry root powder is characterized by numerous fragments of parenchymatous cells containing numerous altered, pasty masses of spherical starch grains, 6-16 µ in diam.; with simple as well as compound central hilum, fragments of

vessels with scalariform and pitted thickenings, cork fragments of cells in sectional view; scattered unicellular trichomes; abundant starch grains; fragments of epidermal and cork cells in surface view and scattered oil droplets frequently seen (Figure 4. Rajbhandary *et al.* 1995, Gupta *et al.* 2003).

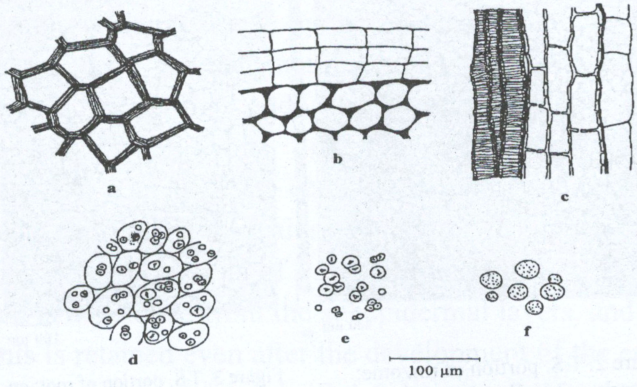


Figure 4. Powdered microscopy of rhizome and roots: a, cork cells in surface view; b, fragment of cork attached with collenchyma; c, fragment of xylum with xylum parenchyma; d, parenchymatous cells of cortex containing starch grains; e, starch grains; f, oil droplets (Gupta *et al.* 2003)

Essential oil

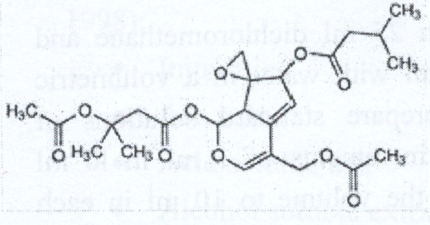
The essential oil is a viscous liquid, olive green to brown in color with balsam-root and musk like odor (Gurung 2009). A fresh-green color with slightly camphoraceous odor is the characteristic of good quality essential oil (CSIR 1976).

7. Major Chemical Constituents

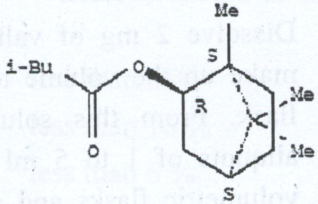
Rhizome and root contain valepotriates, valtrate, didrovaltrate, linarin isovalerinate cyclopentapyrans, Acacetin-7-0-rutinosides and iridoid ester glycosides-valerosidatum, Essential oil contain mainly ar-curcumene, α,

β, γ-patchoulene, calarene, β-bergamotene, maliol, α-fenchene, β-sitosterol, valeranone, iso-valeric acid, β-methylvaleric acid (Nadkarni 1954, Chopra *et al.* 1958, Kapoor 1990, Handa *et al.* 1998, Gurung 2009). Other acidic constituents are formic acid, propionic, butyric, palmitic and stearic acids and isovaleryl ester of D(-)-α-hydroxyvaleric acid. Essential oil from root and rootlets contain β-sitosterol, substantial amount of patchouli alcohol and small amount of α, β, γ-patchoulene and maliol in traces (GON 2007). Presence of β and γ-patchoulene is characteristics of volatile oil of *Valeriana jatamansii* that differentiates it from other species of *Valeriana (*Bos *et al.* 1997*)*

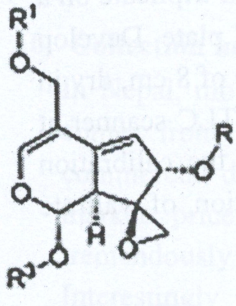
Chemical structure of major constituents



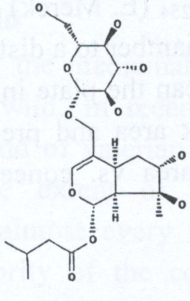
Acevaltrate



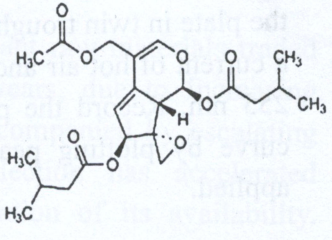
Isovalerate



Valepotriate



Valerosidatum



Valtrate

8. Assay/Analytical Methods

High performance thin layer chromatography (HPTLC) analysis of valtrate (Gupta *et al.* 2003):

Solvent system

Petroleum ether: Ethyl methyl ketone (8 : 2).

TLC plates

Pre-coated silica gel 60 F_{254} plate (E. Merck) of uniform thickness of 0.2 mm.

Test solution

Weigh about 1 g of powdered drug and extract with 25 ml Dichloromethane for 10 min by shaking at room temperature. Filter and wash the marc with additional 10 ml Dichloromethane and adjust the total volume of filtrate to 50 ml.

Standard solution

Dissolve 2 mg of valtrate in 25 ml dichloromethane and make up the volume to 50 ml with water in a volumetric flask. From this solution prepare standard solutions of aliquots of 1 to 5 ml with increments of 1 ml in 10 ml volumetric flasks and adjust the volume to 10 ml in each flask with dichloromethane.

Calibration curve F

Apply 10 µl of each of the standard solution in triplicate on a pre-coated silica gel 60 F_{254} (E. Merck) TLC plate. Develop the plate in twin trough chamber to a distance of 8 cm, dry in a current of hot air and scan the plate in the TLC scanner at 255 nm. Record the peak area and prepare the calibration curve by plotting peak area vs. concentration of valtrate applied.

Estimation of valtrate in the drug

Apply 2 µl of the test solution in triplicate on a pre-coated silica gel 60 F_{254} (E. Merck) TLC plate of uniform thickness (0.2mm). Develop the plate in the solvent system to a distance of 8 cm and record the peak area for valtrate as described above for calibration curve. Calculate the amount of valtrate in the sample from the calibration curve (Gupta *et al.* 2003).

The percentage of valtrate ranges from 0.03 to 0.30 in the standard samples.

9. Quality Standards

Quality standards of Valerian developed, based on WHO-Quality control method for medicinal plant materials are as follows (Anonymous 2002, GOI 1989, 1996, Handa *et al.* 1998):

- Impurities — less than 2%
- Ash value — less than 16 %
- Acid soluble ash — less than 6 %
- Alcohol soluble extracts — more than 5%
- Water soluble extracts — more than 7%
- Loss on drying — 10.96 %

10. Collection in Wild

In Nepal, most of the medicinal plant raw materials traded comes from the wild. In recent years, due to increasing commercial demand of valerian accompanied by escalating market price, the extent of collection has accelerated tremendously in almost every location of its availability. Interestingly majority of the collectors are untrained and

belong to the poor rural communities, for whom the crop has remained one of the major sources of their livelihoods. As a result, mostly, the collection processes are irrational, focused on collecting more, and the process disregards sustainability of the resource base. As such it is necessary that the collection of this species from the wild should be properly managed in order to maintain the steady flow of raw materials and for long-term sustainability of the resource base.

Valerian gets matured enough to provide quality rhizomes after two or more years of plantation. The harvesting should be done at least in every alternate year from the collection site. For this purpose, the collection locality should be separated into two distinct harvesting blocks, and crops need to harvest from each block in alternate years on rotational mode. This bi-yearly cycle allows the crop to adequately mature and produce superior rhizomes, both quantitatively and qualitatively (Source: Field experience in Salyan, Jumla).

During harvesting activity, some easy-to-do procedures must be strictly followed to address conservation of resource and its sustainability. The regeneration of plants through seeds in nature should be ensured while the collection of this species takes place in the forest. The harvesting of rhizome should be initiated only after the fruits are matured enough to produce viable seeds. During harvesting, the seeds should be collected and uniformly spread in the collection sites for regeneration (Source: common field practices in Nepal).
During collection, at least 5% of the mature plants, which are randomly selected in the harvesting sites, should be kept

untouched to promote natural regeneration from seeds and rammets. During harvesting, after the plants are uprooted, the mature rhizomes should be collected while the immature ones along with roots and some rammets should be planted back in the same place covering it with enough soil. These are the instances of sustainable collection and management practices adequate to assure sustainability of the resource base at the collection sites.

11. Preferred Growing Conditions

Soil/Climate Conditions

The species generally prefers sandy loam, moderately moist soil rich in organic matter with pH 4-6.4 for ideal growth (Regmi and Bista 2002). Moist surface, shady or open north facing slopes in 1500-3300m altitudes with sub-tropical to sub-alpine climatic conditions is considered ideal for its cultivation. However, cultivation at 2000- 2500m altitude has shown better results in western Region of Nepal.

12. Methods of Cultivation

12.1 Selection of Plant

Rootstock containing more than 0.8 % essential oil is considered a good strain. Healthy plants containing this much oil content is selected as a mother plant for the collection of quality seeds and planting materials. The District Plant Resources Office, Jumla has recorded 0.8% essential oil content in raw materials collected from Bumramandichaur of the same district.

12.2 Methods of propagation

Natural regeneration of Valerian takes place from seeds as well as rhizomes or rammet proliferations. The plant can be propagated from seeds, rhizome cuttings and leaves with petiole. Rhizome cuttings and division of rammets are easier methods for propagation that give nearly 100% survivals of plantlets.

Propagation by seeds

The seeds have a very short period of viability, hence fresh or recently harvested seeds should be used for propagation. Seeds can be collected during May-June when the fruits mature. Collected seeds should be well-dried and stored in a clean environment to maintain optimum viability.

The seeds are very small and light. Average seed yield per plant recorded in Jumla district, is 0.20gm which has about 250 seeds. On average 200gm of seeds are required to produce plantlets to cover a hectare of land.

Before sowing, seeds should be pretreated with cold water for 12-18 hours. They are mixed with about 10 times more sand by volume for uniform distribution and sown in moderately shaded nursery beds during March-April. Nursery beds should have soil, sand and compost in a ratio of 2:1:1. Seeds germinate 10-12 days after sowing. Eighty to 90% germination has been recorded in 17-23°C soil temperature and 26-33°C room temperature in Jumla District (Bhattarai and Ghimire 2006, Joshi 2011). Three month old seedlings are appropriate for transplantation.

Vegetative propagation

The plant can be propagated from rhizome cuttings or dividing the rammets. For this rhizomes should be fully matured, obtained from 2 or more years old plants. About 3-4 cm long rhizome cuttings with some rootlets will be taken and planted in nursery beds in autumn or spring with 5-8cm spacing. Plantlets proliferate after 3-4 months and are suitable for plantation in the field in June-July. The divided rootstocks can be directly planted in the field with spacing of 25-30cm in a row, which should be 40-50cm apart. Rootstocks planted in early autumn fetch a good harvest after two years as they are well established to withstand frost (Joshi, 2011).

Propagation from the leaves with petioles could also be done. Mature leaves with petiole need to be planted in the loose well-irrigated and shaded nursery beds during March-April. The petioles bear roots in about two weeks and are ready for plantation in the following monsoon season during June-July.

12.3 Land preparation

Valerian is widely found in slightly acidic soil, generally under pine forest. Moist and well drained sandy loam soil with rich humus and pH ranging between 4.0 and 6.0 is considered most suitable. removing gravels and weeds, land should be ploughed 2-3 times and enriched with well rotted compost at the rate of 10-15 ton /hectare. Soil could be treated with organic pesticides like Magic, Jiwatu, Delfin, etc. Beds of convenient size are prepared by having a tilt of about 10-20^{0} with uniform levelling. It can also be cultivated in wasteland and community forests with moist and shady

habitat. Generally north facing slopes with 10-25% shade is considered appropriate for its cultivation.

12.4 Plantation

Three months after seed sowing, the seedlings attain about 15 cm or 2-leaved stage and are ready to transfer in the field. They are transplanted with a spacing of 25-30cm from plant to plant and 40-50cm from a row to another row. The crop can also be raised along with other tree and shrubs like Apple, Lauh salla etc. as an intercrop such as fruit trees, timber trees etc.

13. Management

13.1 Irrigation

Frequent irrigation is needed during initial months of plantation. Afterwards, irrigation is needed twice a month in summer and dry season during first year and once a month in the second year or as per the site specific requirements. In other periods bimonthly irrigation is adequate. However, water logging should be avoided for the better growth of rhizome and roots. Water used for irrigation should be free of contaminants from domestic animals, human wastes and chemicals (Joshi 2011).

13.2 Thinning and weeding

Thinning and weeding is needed in rainy season. In summer, the crop requires regular weeding to achieve better yield, and cutting-off of old floral stalk is needed to avoid exhaustion and promote the formation of larger rootstock. Interspaces are harrowed to loosen the soil. A low ridge of soil is usually raised along the crop to promote the formation of larger rootstocks (Source: Field experience in Salyan District).

3.3 Manuring

In addition to 10-15 ton compost incorporated in field per hectare before plantation during land preparation, about 150 kg of nitrogen and 50kg each of potash and phosphates are also recommended for better growth of plant. But incorporating organic manure including bone meal and plant-based ash are suggested to use instead of inorganic chemicals. Increasing the organic matter content in the soil also helps improve the soil texture. Side dressing with compost or nitrogen in the second year gives extra nutrition to the crop and facilitates root growth. The crop can also be intercropped with legumes and other nitrogen fixing plants for adequate nitrogen supply in the soil (Joshi 2011).

13.4 Disease and Pest Control

Valerian is found to be relatively free from pests and diseases. White/black grubs were observed in cultivated fields in Jumla. In some cases Rhizoctonia root rot has been observed in plants propagated from root cuttings. Organic pesticides like Jiwatu or preventive spray of Neem (*Azadirachta indica*) or Mugwort (Titepati, *Artemisia* spp.) based preparation can also be used to control certain diseases and pests.

14. Cultivation/Collection Calendar

Flowering Time:	April-June
Fruiting Time:	May-June
Harvesting Time:	September-November
Seed Sowing:	March- April
Rhizome cutting:	December-January
Plantation Time:	June- July

15. Harvesting and post harvest procedures

Crop usually matures after second year of plantation and will be ready for harvest. In most community managed forests it is harvested 3 years after plantation. Although the plants could be harvested annually, in order to have higher yield of underground parts and essential oil content, it is recommended to harvest them after two or more years, (Regmi and Bista 2002). October-December is the best period for harvesting when the basal leaves start to wither and seeds are mature. Roots and rhizomes collected during November are yellowish and found to have higher oil content. The above -ground parts of plants can be cut 15-20 days before harvesting to facilitate growth of roots and rhizomes. Harvesting should be done on dry period of the day. On average, 1500-2000 kg/ha of dry root could be harvested from the second year crop.

16. Economics of Cultivation

The economics of Valerian cultivation has been worked out on the basis of field-research and trial (Table 1). The cost of production per hectare is NRs. 172,000 while the raw material harvested in every alternate year is worth NRs. 270,000. This indicates a net profit of NRs. 98000 per year per hectare. However, this is only a general scenario, there are number of issues that may influence productivity and net income. For example, the labor cost assigned for site clearance and land preparation is applicable mostly for the first year if the proposed cultivation site is virgin. One can also reduce the cost involved in composting, plantation, weeding, harvesting and post-harvest procedures.

Table 1. Economics of valerian cultivation per hectare

S. No	Description	Unit	Quantity		Rate NRs	Budget in NRs.	
			1st year	2nd year		1st year	2nd year
1	Seedlings	No	66000	8000	0.5	33,000	4000
2	Compost	ton	10	5	1000	10000	5000
3	Laborer						
	Site clearing	MD	30		300	9000	
	Land preparation	MD	60		300	18000	
	Composting	MD	30	10	300	9000	3000
	Plantation	MD	60	10	300	18000	3000
	Irrigation Weeding	Lump sum MD	30	30	300	6,000 9000	6000 9000
	Harvesting /Post harvesting	MD		40	300		12000
	Storage	MD		10	300		3000
4	Agricultural materials	Lump sum				15000	
	Total					127000	45000
	Grand Total						172000
5	Production	KG		1500	180		270,000
	Profit						98,000
	Contingency				5%		4900
	Net Profit						93100

Source: Information generated in DPR's Medicinal Plant Research Stations in Jumla, Salyan, Makawanpur and Ilam districts, and other sources.

Likewise, the cost of seedling production or purchasing them is applicable for the first year only which, in later seasons, can be substituted with the seeds and rhizome cuttings and/or rammets produced in the farm. Plants developed from rhizomes or rammets adopt more easily exhibiting better vegetative growth followed by increased rhizome production and, finally, providing better income. The production per hectare has been estimated as 1.5 ton which can be considerably enhanced as there are records of 2 tons or more production per hectare. Likewise, the selling price can be

increased with the product quality and finding a better and, of course, non-exploitative market. Last but not the least, the income can be enhanced many folds if provisions could be made to extract essential oil for marketing and selling marc, the by product, to local incense industries. Incorporation of Velarian cultivation under other tree crops could also increase the income per unit area considerably.

17. Market and Value Chain

Valerian is one of the major traded species of Nepal occupying major share in the international trade. The ever growing demand of the raw materials from national and international markets has prompted local communities to collect more and more quantities from the wild as well as encouraging them to initiate cultivation of this species in private land, community forests and other common lands.

Nepal exports about 345 tons of valerian rhizome and roots annually in its raw form (Ghimire *et al.* 2008). Average annual export of Valerian oil is about 125 ton (PSPL-DPR 2009). Major proportion of the raw material entering into trade and processing comes from wild sources, especially from the mid- and far-western Nepal. Currently market price of the rhizome ranges between NRs 130-369/kg depending on the market Centers (ANSAB 2012). The essential oil price ranges between NRs 15,000-20,000/kg (MAPIS 2012). The main market center for the valerian in Nepal is Nepalganj and the others include Birtamod, Basantapur, Hille, Dharan, Lahan, Kathmandu, Butwal, Tulsipur, Ghorai, Surkhet, Attaria and Mahendranagar.

Value chain

Value chain system is the sequence of dynamic processes from the provision of specific inputs for a particular product

to primary production, transformation, marketing and distribution, and final consumption. Understanding of the position and behaviors of stakeholders in value chain of a product is necessary to know entrepreneurship and innovation by stakeholders in the market.

The major actors in the value chain of Valerian are primary collectors and producers, village-level traders, road-head traders, whole-sellers, raw material exporters, processors, processed product exporters, domestic aroma and herbal enterprises who use processed products, retailers, consumers and input suppliers.

18. Adulterants/Substitutes:

All concerned entrepreneurs must be careful of any adulterants in the products as some bad people in the business might use substitutes or adulterants to make easy money discrediting the fair business.

Four species of *Valeriana* are found in Nepal (Hara and Williams 1979):

1. *Valeriana jatamansii* Jones: Distributed in West, Central and East Nepal along 1500-3300m altitude.
2. *Valeriana barbulata* Diels: Distributed in East Nepal along 4250m altitude.
3. *Valeriana hardwickii* Wall.: Distributed in West, Central and East Nepal along 1200-4000m altitude.
4. *Valeriana stracheyi* C.B.Clarke: Distributed in East Nepal along 2600m altitude.

Among these, *Valeriana hardwickii* is available along the range of *V. jatamansii* and hence used as substitutes. Other species are rarely used as an adulterant or substitute for *V.*

jatamansii while commercial adulteration with other species or material is generally rare.

The underground parts of *Nardostachys grandiflora* has been reported to be used as a substitute for Valerian in some cases.

19. Value Addition on raw materials

Primary processing

Primary processing includes cleaning, drying, sorting, grading and packaging the rhizomes. Well- graded and properly packed raw materials fetch higher prices, cylindrical rhizomes, 1-1.5 cm in diameter are considered best. These are cut into 3-5 cm long pieces, weighed and packed in jute or cloth bags for better storage.

Secondary processing

Essential oil extracted from the roots and mature rhizome through steam-distillation constitutes the more value-added product. The well-cleaned underground parts are distilled under low pressure and dry steam for 6-10 hours. Generally 0.8 – 2.2 percent of oil can be extracted from dry rhizomes that have a good market demand as well as attractive price (MAPIS 2012).

20. Conservation Status and Measures

Valeriana jatamansii Jones is one of the thirty prioritized NTFP species of Nepal (GON 2006). In Nepal, the species has been listed as vulnerable (Bhattarai *et al.* 2002). The government has banned its export in raw form. Only essential oil can be exported with permission from the Department of Forest (GON 2005b).

21. Government Royalty

According to the Forest Regulation 1995 Section 3, and its amendment in 2005, the government's royalty rate for the rhizome is NRs. 15/kg.

22. Authorized Institutions

The following are the organizations related to the Governmental collection permit of raw materials and collect royalty and taxes of the raw and processed products (MAPIS 2012).

SN	Prerequisite	Responsible organizations
1	Collection permit	Department of Forests/ Community Forest User Groups
2	Royalty collection	Department of Forests/ Community Forest User Groups
3	Release (transit) permit	Department of Forests
4	Local taxes	District Development Committees
5	Certificate of origin	Federation of Nepalese Chamber of Commerce and Industries
6	Product certification	Department of Plant Resources/ Department of Forests
7	Export license	Department of Industries
8	Export duty	Customs offices

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Sugandhawal cultivation
in Aghor VDC, Daman

Valeriana cultivation
in slopyland

Rhizomes of Valeriana

Plant with rhizome