

Indian valerian, a highly endangered medicinal plant in north eastern Himalayan region

Abstract

Indian valerian (*Valeriana jatamansi* Jones), newly introduced endangered medicinal plant in North Eastern Himalayan region to the hilly region of West Bengal (Kalimpong 27.06°N 88.47°E) was conserved in field gene banks in Kalimpong regional research station for its highly active medicinal properties. The plant is known to be short medicinal herb and has distinct dimorphism in the floral biology and gynodioecious character. The plants were found to have flowering period in between January to April which was otherwise found in North Western Himalayas as per reports. The plants were found to have major active phytochemicals in the roots and rhizomes responsible for preventing epilepsy, snake and scorpion bite, cholera, dementia, nerve diseases of human beings. Conservation of this plant should be carefully taken in order to avoid the genetic drift and depletion of genetic base in any ex situ conservation worldwide.

Keywords: characterization, endangered medicinal plant, selection, quantitative traits, leaf margin polymorphism, genetic drift

Volume 2 Issue 4 - 2015

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Received: May 23, 2015 | Published: July 06, 2015

Abbreviations: LBD, lewy body dementia; KUBG, kashmir university botanical garden; KVJ, kalimpong *valeriana jatamansi*; IC, indigenous collection; NBPGR, national bureau of plant genetic resources; ICAR, indian council of agricultural research; DMAPR, directorate of medicinal and aromatic plants research; KUBG, kashmir university botanical garden

Introduction

Indian valerian (*Valeriana jatamansi* Jones) is considered a highly endangered medicinal plant in Northern part of Himalayan region. It is also found in all temperate regions of the world except Australia.^{1,2} It is grown in Himachal Pradesh, Northern part of U.P., Sikkim that has been recently introduced in West Bengal Darjeeling region. It is enlisted in the endangered category by IUCN and as an endangered species in the national medicinal plant board, New Delhi. The plant had been reported to be found in fragmented populations in different places of Kashmir Himalayan hilly region like Dara, et al.³ Indiscriminate collection of rhizomes from the plants made potential threat of its existence in some previously found localities.⁴⁻⁶

Discussion

Medicinal value of the plant

The importance of conservation of Indian valerian is due to its tremendous medical potential for treating diseases in human beings. It has sesquiterpenoids, valeriananoids,⁷ forty chemical constituents,⁸ constituents of essential oils and eleven jatamanins.^{8,9} These plant components have effective medicinal properties against the diseases like leprosy,¹⁰ epilepsy and hysteria,¹¹ nerve diseases,¹² snakebite and

scorpion bite,¹³ cholera,¹⁴ anxiolytic properties¹⁵ and Lewy Body Dementia (LBD).¹⁶ Valerian, the commercially produced alkaloid is found to be present in valerian roots¹⁷ which is effectively used as sedative in Germany having the trade name 'Valmane' besides other diseases. The valepotriates of the plant has cytotoxic and anticancer activity which was clinically proved, found in the leaves and rhizomes of the plant.¹⁸ The overall medicinal properties of this endangered plant emphasized the utility of conservation in a scientific and careful manner.¹⁸

Morphology of the plant

Indian valerian is a perennial herb, that found to be dioecious, tetraploid, polygamous or sometimes polygamo-monoecious^{19,20} (Figure 1). Plant height at maturity stage has the range between 10.5cm.-22.3cm. However, in poly house condition, it shows maximum growth up to 32cm compared to field condition.

Roots: The plant has seminal root system which is initiated from rhizomes of the plants. The roots have length of 6-10cm. Major active ingredients are found in roots which have preventive medicinal uses against various diseases.¹⁷ Root stock is horizontal, aromatic and modular in shape (Figure 2).

Rhizome: The plant has rhizome from where roots are emerged and forms the underground biomass of the plant. The petioles come out from it where they form the aerial biomass of the plant. Rhizome is the most important part where major active ingredients and phytochemicals like sesquiterpenoids, valerianoids and jatamanins are found.¹⁸ Rhizome length is found between 3-5cm. and width 0.2-1.5cm (Figure 3).



Figure 1 Indian valerian plant in field gene bank of regional research station, UBKV, Kalimpong.



Figure 2 Individual plant .



Figure 3 Underground bio mass with rhizome.
Rhizomes are shown in Arrows.

Stems: The plant does not have any stem or stem like part in it, it does not have any branches also. Numbers of long petioles ranges between 7-15cm in length which come out from the rhizomes and forms the aerial biomass of the plant.

Leaves: There are long petioles (7-15cm) from where leaves are found. Radical leaves are mostly present and persistent. They are bigger in shape than cauline leaves. Cauline leaves are small and less in number. Leaves are long petiolated, cordate cum ovate shaped with pinnate venation. Leaf margin is entire (Figure 4), sometimes sinuate (Figure 5) and sometimes wavy (Figure 6). Variable leaf margins are found in different plants. Leaf apex is acute.



Figure 4 Plants with entire leaf margin.



Figure 5 Plants with sinuate leaf margin.



Figure 6 Plants with wavy leaf margin.

Inflorescence and flower: Gynoecium is observed in this plant. So both hermaphrodite and female plant are observed in Indian valerian. It has terminal corymb inflorescence in both hermaphrodite and female type of plant.

Female plant: In female plant, androecium is absent in the flower. Flower is pistillate, its colour is white (large) or tinged with pink (small), and number of petals is four. Number of corolla in pistillate flower is four also in general in its habitats found in Northern Himalayan region and North Sikkim. Female flower is smaller than hermaphrodite flower. Petals actinomorphic, epipetalous pistil and four in numbers (Table 1). However flowers having both four and five number of petals in the same inflorescence were also found due to breakdown of floral homeostasis in this new region. Trifid stigma is seen having three prongs extended from the upper portion of the style without any presence of stamens with anther sacs.²¹ Other reports say that three prongs are found in the middle portion of the style in North Western Himalayan region.^{22,23}

Anthesis was found 6-8 A.M in Kalimpong (1210m asl) at regional research station, Uttar Banga Krishi Viswavidyalaya.²¹ Anthesis of female flowers was found to be earlier than hermaphrodite flowers in some elevations and same was reported in some elevations.²² According to Rather et al.,²² anthesis was found 8-10 days earlier than hermaphrodite flowers in Kashmir University Botanical garden (KUBG), in Ferozpur, 4-5 days earlier than hermaphrodite flowers. The flowers were 3-4 mm in length. The female plant was found to have trifid stigma which was found to be much longer in size than the length of the petal. Length of the style is 7-8 mm (Table 1).

Seeds: The seeds are found in each inflorescence and the seeds have fluffs by which it spreads outside by air. 1000 seed wt is 1 gm. This is found in both hermaphrodite and female plants.

Hermaphrodite plant: In hermaphrodite flower, androecium is present, in gynaecium stamens are three in number, epipetalous, opposite to corolla lobes. They are bisexual white, long prominently larger than pistillate flower.²⁴ Larger than female flower, petals actinomorphic, epipetalous stamen is found. Unifid stigma is present; stamens are three in number observed in between the gaps of petals inside the flower, not exactly opposite to the petals.²¹ Other reports say that stamens are found exactly opposite to the petals of the flower.^{22,23} Hymenopteran insects like rock bees, bumble bees were found to be visitors of this plant²¹ (Table 1). Other reports say that dipteran and hemiptera species are found to be visitors²² here. Anthesis was found in 6-8 A.M, other reports of anthesis are found to be different whereas in the Gulmarg, female and hermaphrodite flowers anthesis in the same time.^{22,23}

In hermaphrodite plants seeds are the same like seeds of female plants having fluffs by which it can fly far off places for successful next generation.

Reproductive phenological plasticity

Adaptation of Indian valerian in the local climate was found to have major impact in flower initiation from vegetative primordia to reproductive primordia and ultimately phenological timing flower. In case of reproductive phenology, the first flowering was observed in the first week of January and ended in the month of April in Kalimpong (Figure 7). It was reported differently in other region of India like March-June in Himachal Pradesh,²⁵ 15th March-15th June in Kashmir

University Botanical Garden (1490m asl), 15th April -10th August in Ferozpur (2150m asl) and 3rd May-15th September in Gulmarg (2500m asl) Kashmir, in North Western Himalayan region.^{22,23}



Figure 7 Full blooming sage of Indian valerian plant.

Change in reproductive phenology may be due to relationship among timing of flowering, seed dispersal and time of germination.²⁶ It is found to be correlated in such a way that the reason for change of this plant's reproductive phenology is found to have a better seed dispersal time and consequently better germination time in the month of July as suggested by Primack²⁶ in his investigation with other plants.

It was earlier reported that temperature in the months just before flowering correlates with flowering time. Nearly 60% of the plant species which are observed to be flowered in between January to April are affected two months prior to flowering.²⁷ Phenotypic plasticity of plant is the ability to change its morphotype according to its different environmental conditions and it is not heritable in nature. It might be the cause of plastic character of the reproductive phenology of plant.

In case of North Eastern Himalayan region, where lowest temperature in the month of October and November was found to be 14.6°C and 10.3°C and highest temperature was found 23.3°C and 20.1°C respectively, this temperature regime might affect the initiation of flowering stage as pointed out by Fitter and Fitter.²⁷ Photoperiodism was found to be an important factor for initiation of flowering in Indian valerian where day length in the month of January was observed 10.50 hrs/ day means along with adjacent factors like temperature range (7.9°C-15.6°C) which may be responsible to trigger the flowering phase in this plant.²¹ This temperature range is found to be suitable for initiation of flowering stage in other places like Himachal Pradesh²⁵ and Jammu and Kashmir.^{22,23}

The temperature and day length in February (12.6°C-20.1°C and 11.15hrs/day), March (15.1°C-29.1°C and 11.30hrs/day), April (16.2°C-29.3°C and 11.45hrs/day) were observed and found to be favorable for initiation of plant flowering stage. This range of day length is found in Himachal Pradesh in the month of March-June²⁵ and in Jammu and Kashmir between July – September which was reported to be favorable for initiation of flowering stage in this plant.^{22,23} It was also interpreted that direct effect of photoreceptors on flower initiation may be triggered by circadian clock which generally acts in different photoperiodic responses.²⁷ Temperature and day length which was different from Kalimpong to other regions of North Western Himalaya created important external factors for initiation of flowering gene in plant although detailed investigation is needed.

Breeding and propagation of the plant

The plant can be propagated by cuttings of rhizomes. Farmers

can propagate the plants by cutting and splitting the rhizomes into several plants and sow them in the month of rainy season. Generally in Kalimpong, plants are propagated through rhizome cuttings and sowing them in the well prepared field in the month of June-July.

The spacing of this plant plays significant role in growth of fresh aerial biomass during observation. Maximum biomass was found with spacing of 30x45cm at 6month, 9month old, 12month old, 15month old and 18month old stages of this plant. It was found in case of underground biomass that transplanting time and spacing was better at 9month old stage for rhizome wt per plant than other stages. Maximum underground biomass was observed in June transplanting. Planting space gave positive note with 30cmx45cm spacing and gave significant response at 9 and 12month stages of Indian valerian in this research station.²⁸

Breeding procedure and conservation

Breeding of Indian valerian should be conducted keeping the variability in the overall population. Observation of variability and thereafter screening according to morphological characters is the most important scientific observation of a breeder. Screening of morphological characters is essential for retaining the overall genetic base of the population.

As Indian valerian is a gynodioecious plant, it has intrinsic genetic character of cross pollination. Characterization, categorization and maintenance of different genotypes are very much essential steps to keep its original genetic potential as it may lose its variability due to genetic drift or genetic erosion. As it is a cross pollinated plant by nature, inbreeding depression causes genetic erosion and loss of important characters from this plant. In the open field condition, keeping the plant year after year without characterization and categorization, it will certainly face genetic erosion and will be extinct from the place in one day.

Hermaphrodite and female plants should be kept in separate polyhouses or maintained several meters isolation distances (more than 1000m) from each genotypes.²¹ In our research station, seeds of plants were collected in bulk from Sangtok village (27 °25'N and 88 °31' E of altitude 2000m above sea level) of north Sikkim area in the

state of Sikkim. Variability of Indian Valerian found from the collection was categorized it into three morphotype. They were found to have entire leaf margin, sinuate leaf margin and wavy leaf margin in the population.²¹ Separate polyhouses were built to keep the population in those polyhouses having different morphotype.

Categorization was also made according to the length of flowering time found in this elevation (1210m asl) as early, medium and late flowering lines keeping one month duration of the flowering period. Here KVJ stands for Kalimpong *Valeriana Jatamansi* as per the directives of ICAR DMAPR (www.dmapr.org.in).

In order to find the stability of characters, crossing between individual phenotypes should be conducted. In the F1 generation, the segregation pattern of the character should be very carefully observed. From here also phenotypic plasticity of the plant can be determined. Whether a character is dominant or not can be ascertained from F1 generation. The pattern of heritability can also be ascertained in the first filial generation (F1) from its parental generation (P) or second filial generation (F2). The segregation pattern can be found from how many number of plants will form the type of parental characters. According to Mendelian law of segregation, the pattern should follow 3:1 ratio or close to that ratio in F1 generation.

Different quantitative characters like plant height, number of leaves per plant, petiole length, leaf length, leaf breadth, leaf area index, number of inflorescence per plant, root length, root weight, rhizome weight, fresh weight, dry weight, seed wt per inflorescence and total seed weight per plant. These quantitative characters should be observed and selected in both hermaphrodite and female plants along with other qualitative characters.

In case of Indian valerian, crossing should be done both in hermaphrodite and female plants where hand emasculation is necessary to emasculate the hermaphrodite plants. Crossing should be done in hermaphrodite and female plants at the time of stigma receptivity. Anthesis is pre-requisite to find out whether female plants anthesis earlier than hermaphrodite plants in each morphotype or not before initiating the crossing programme. Duration of flowering period was observed in the research station (Table 2).

Table 1 Differences of flower morphology in *Valeriana jatamansi* Jones

In Terms	Hermaphrodite flower	Female flower
Size	Larger 7-9mm in length	Smaller 3-4mm in length.
Inflorescence	Terminal Corrymb	Terminal corrymb
Petals Actinomorphic, epipetalous	Five and four	Five and four
Androecium and Gynoecium	Present	Androecium- Absent, gynoecium- Present

Table Continued

In Terms	Hermaphrodite flower	Female flower
Stigma	Unifid. Stamens are three in number observed in between the gaps of petals inside the flower, not exactly opposite to the petals. ²¹ Stamens are found exactly opposite to the petals of the flower. ^{22,23}	Trifid. Stigma has three prongs extended from the upper portion of the style without any presence of stamens with anther sacs. ²¹ Three prongs are found in the middle portion of the style.
Petals	Larger	Smaller
Hymenopteran Insects	Rock bees, bumble bee insects, ²¹ dipteran and hemipteran species ²² are found to be visitors.	The same
Anthesis	Found in 6-8 AM, though asynchronous opening of flowers. In the Gulmarg, female and hermaphrodite flowers anthesis in the same time. ²²	Found 6-8 AM in Kalimpong (1210m asl) at regional research station, Uttar Banga Krishi Viswavidyalaya. ²¹ Anthesis was found 8-10 days earlier than hermaphrodite flowers in Kashmir University Botanical garden (KUBG), in Ferozpur, 4-5 days earlier than hermaphrodite flowers. ²²
Style	Heterostylous. Filaments bearing anthers is longer than the style. Stamen is 4-5mm in Length. Length of style is 3-4mm.	Have trifid stigma, is longer than the petal. 7-8 mm in length.

Table 2 Time of flowering and categorization of female and hermaphrodite population

Name of the female/hermaphrodite lines	Flowering time in each population	Categorization of population
KVJ-1-1-Female	1 st week of January - 1 st week of February	Early
KVJ-1-1 Hermaphrodite	1 st week of January - 1 st week of February	Early
KVJ-1-2 Female	2 nd week of February – 2 nd week of March	Mid
KVJ-1-2 Hermaphrodite	2 nd week of February – 2 nd week of March	Mid
KVJ-1-3 Female	3 rd week of March – 4 th week of April	Late
KVJ-1-3 Hermaphrodite	3 rd week of March – 4 th week of April	Late
KVJ-2-1 Female	1 st week of January – 1 st week of February	Early
KVJ-2-1 Hermaphrodite	1 st week of January – 1 st week of February	Early
KVJ-2-2 Female	2 nd week of February – 2 nd week of March	Mid
KVJ-2-2 Hermaphrodite	2 nd week of February – 2 nd week of March	Mid
KVJ-2-3 Female	3 rd week of March – 4 th week of April	Late
KVJ-2-3 Hermaphrodite	3 rd week of March – 4 th week of April	Late
KVJ-3-1 Female	1 st week of January- 1 st week of February	Early
KVJ-3-1 Hermaphrodite	1 st week of January- 1 st week of February	Early
KVJ-3-2 Female	2 nd week of February- 2 nd week of March	Mid
KVJ-3-2 Hermaphrodite	2 nd week of February- 2 nd week of March	Mid
KVJ-3-3 Female	3 rd week of March- 4 th week of April	Late
KVJ-3-3 Hermaphrodite	3 rd week of March- 4 th week of April	Late

KVJ stands for (Kalimpong Valeriana Jatamansi) as per direction of Indian Council of Agricultural research (ICAR) and Directorate of medicinal and Aromatic Plants Research (DMAPR) India.

KVJ-1-1(IC-0613939), KVJ-1-2(IC-0613940), KVJ-1-3(IC-0613941), KVJ-2-1(IC-0613942), KVJ-2-2 (IC-0613943), KVJ-2-3 (IC-0613944), KVJ-3-1 (IC-0613945), KVJ-3-2(IC-0613947) and KVJ-3-3 (IC-0613948) were developed in this research station for releasing composite varieties in future.²¹ IC (Indigenous Collection) numbers were given by NBPGR (National Bureau of Plant Genetic Resources), New Delhi, India as it is one of the initial important steps for registration of Protection of Plant Varieties and Farmers' Varieties Act of India (PPVR &FR Act, 2001).

Selection of the plants should be done on better root length, better

rhizome wt. and better seed wt per plant. This is because number of seeds per plant is one of the important quantitative characters of this plant. Besides active phytochemicals like sesquiterpenoids, valerinoids and jatamanins are found in maximum in root and rhizome part of the plant, so these plant parts are also important quantitative characters that should be chosen by a plant breeder in addition to seed wt per plant.

Conclusion

i. The plant has variable leaf margins and prefers shady place.

- ii. Composite variety can be made taking each genotype at a time in both female and hermaphrodite plants.
- iii. Root length, rhizome wt and seed wt per plant should be carefully noted and targeted by the breeder to evaluate, screen and select the varieties in both hermaphrodite and female plants as important phytochemicals are found in maximum amount in these parts of the plant.
- iv. Rhizome cutting should be practised for quick large scale propagation of this plant in any region of the world.
- v. The plant was observed to have reproductive phenological plasticity where different flowering seasons were observed in North Eastern and North Western Himalayan region.
- vi. Separate polyhouses or higher isolation distance is required to conserve the plant because it rapidly loses its population size of any of its variable genotypes due to rapid genetic drift if left open for few years in a region.

Acknowledgements

The authors are highly grateful to Ex-Director Professor Satyabrata Maiti and present Director Professor Jitendra Kumar, Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand, Gujarat, India for moral support and funding of the research for conservation of endangered plants in the regional research station, Kalimpong, Uttar Banga Krishi Viswavidyalaya.

Conflict of interest

The author declares no conflict of interest.

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