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Phyto-chemical variation in gynodioecious *Valeriana jatamansi* Jones

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Abstract
Valeriana jatamansi Jones *syn. Valeriana wallichii* DC (popularly known as Indian Valerian in English, Sugandhbala or Mushkbala in hindi and Tagar in Sanskrit) is an important medicinal and aromatic plant belonging to family Valerianaceae. The species is a source of group of compounds known as valepotriates, which are responsible for sedative and tranquilizing activity of Valerian preperations. Dynamics of valepotriates (valtrate, acevaltrate, didrovaltrate, IVHD Valtrate) production in underground parts during different growing seasons in female and bisexual plants were aimed during present investigation. Phytochemical analysis using HPLC revealed that valtrate is the major compound followed by didrovaltrate, IVHD valtrate and acevaltrate. The total valepotriates content ranged between 1.019% to 1.852% in rhizomes, 1.193% to 1.829% in roots and 1.094% to 1.801% in rootstock during different months of growth in both sex types *i.e* female and bisexual plants. Valtrate (%) and acevaltrate (%) were recorded significantly higher in rootstock of female flowering plants in comparison to bisexual flowering plants. Higher content of valepotriates were recorded during September month after rainy season.

Keywords: *Valeriana jatamansi*, gynodioecious, valepotriates, valtrate, acevaltrate, didrovaltrate, IVHD Valtrate

Introduction
Valeriana jatamansi Jones *syn. Valeriana wallichii* DC popularly known as Indian Valerian in English, Sugandhbala or Mushkbala in Hindi and Tagar in Sanskrit is a perennial medicinal and aromatic plant distributed from Kashmir to Bhutan at an altitude of 1200 to 4000 m and in Khasi hills at an altitude of 1200 to 2000 m (Kirtikar and Basu, 1975) [8]. The species is mentioned in various traditional system of medicines *viz*. Ayurveda and Unani for its sedative and tranquilizing properties. Underground portion of the herb containing roots and rhizomes are the economic part and constitute the drug. Traditionally it is used for treating hysterical fits, insomnia, nervous tension, stress, anxiety and high blood pressure because of its sedative and tranquilizing properties (Kirtikar and Basu, 1975; Houghton, 1999) [8, 5]. The therapeutic properties of the plant are due to presence of group of natural compounds termed as Valepotriates (Wagner *et al*., 1980; Grusla *et al*., 1986) [20, 4] which belong to iridoid group containing epoxy group and are triesters. Due to over-exploitation of rhizomes for its medicinal value, habitat degradation and other biotic interferences in its distribution ranges the species is under threat category in the Himalayas. It has also been listed as endangered species on the list of National Medicinal Plant Board, New Delhi India. The species occur in different geographical locations and possess diverse morphological and genetic features, affecting also its content in active ingredients. There are reports of seasonal variation of plant growth, biomass and production of secondary metabolites in Valeriana spp (Bos *et al*., 1998; Singh *et al.*, 2000) [2, 15]. In *Valeriana jatamansi* several workers have studied the morphological and genetic diversity suggesting the influence of environmental and genetic factors on diversity of the plant and its chemical constituents (Sundaresan *et al.*, 2012; Jugran *et al*., 2013) [19, 7]. Although several studies have been reported in literature regarding influence of climatic factors on phytoconstituents of the species, however a thorough investigation on influence of different seasons on major phytochemicals *i.e* individual valepotriates is not completely known. As the phenomenon of gynodioecy has been reported in the species (Raina and Srivastava, 1992) [13] where female and bisexual flowering plants grows sympatrically in a population, hence the study regarding comparison between performance of both the sexes will be helpful in breeding programmes for development of elite strains. Thus keeping in kiew the above aspects, present study is attempted to investigate the effect of seasonal variation on valepotriate content and yield among two different sexes of the gynodioecious *Valeriana jatamansi*.

Material and Methods

Plant Material

The investigation was conducted at Medicinal and Aromatic Plants Research Farm, Shilly, Distt. Solan (altitude 1550m amsl, latitude-N 30 ^{0} 54´ 30´´ and longitude E 77^0 07´ 30´´) Himachal Pradesh, India. The experimental material comprised of seed raised plants of *Valeriana jatamansi*. The seed were sown in the month of June and the seed raised plants were transplanted to the field at a spacing of 30×45 cm during September month. At flowering stage, the female flowering plants and bisexual flowering plants were identified and tagged. Thereafter starting from the month of March, six randomly selected plants per replication for both sex types were harvested at two months interval and evaluated for phytochemical content and yield utilizing underground portion *i.e* rhizomes, roots and rootstock. The experiment was laid out in randomized block design.

Quantitative estimation of Valepotriates

For estimation of valepotriates content, 1 gram of well dried and finely powdered material was kept for 12 hours in dichloromethane (20 ml) at room temperature in conical flask. After 12 hours, the contents of the flask were sonicated for 5 minutes on a sonicator and then filtered. The residue after filtration was again re-extracted with dichloromethane (2×5 minutes) and subsequently sonicated. After each extraction, the contents were filtered under vacuum using Whattman filter paper and residue was washed thoroughly with dichloromethane. All the filterates were combined and then solvent was completely evaporated under vacuum. The residue in each case was dissolved in HPLC grade methanol and made to a final volume of 10 ml. The samples were filtered through 0.22 micron filter and injected in HPLC for analysis of individual valepotriates namely valtrate, acevaltrate, didrovaltrate and IVHD valtrate.

HPLC conditions for estimation of valepotriates

The quantitative estimation of valepotriates *viz* (valtrate, acevaltrate, didrovaltrate and IVHD valtrate) were done through HPLC. The chromatographic system for quantitative analysis consisted of Waters binary HPLC unit with Waters HPLC pump 515 and dual absorbance detector 2487. The chromatographic separation was carried out on X bridge (4.6×250 mm, 5µm) column and column temperature was maintained at 28ºC. The mobile phase consisting of Acetonitrile and water (80:20) was run with gradient mode of elution at a flow rate of 1.5 ml/min. UV absorption was monitored at 254 nm for diene type valepotriates (valtrate and acevaltrate) and 203 nm for monoene type of valepotriates (didrovaltrate and IVHD valtrate).The identification of the valepotriates was done with respect to retention time of the corresponding external standards.

Results

Valepotriates content

The individual valepotriates *viz* valtrate, acevaltrate, didrovaltrate and IVHD valtrate were estimated in roots, rhizomes and rootstock of female and bisexual plants of *Valeriana jatamansi* during different periods of growth *i.e* March, May, July, September and November months so as to find out seasonal variation for valepotriates content. The results were found to be significant and the data is presented in Table 1 to 3. In rhizomes, the valtrate content ranged between 0.827% to 1.474%, acevaltrate content between 0.145% to 0.528%, didrovaltrate between 0.183% to 0.683% and IVHD valtrate content between 0.464% to 0.731%. The total valepotriates content varied between 1.019% to 1.852% during different months of growth in female and bisexual plants. Among female and bisexual plants, the mean acevaltrate content in rhizomes was recorded higher (0.400%) in female plants than bisexual plants (0.284%). During different months of growth the mean values of individual valepotriates content in rhizomes were recorded maximum in the months of September and November (values being statistically at par with each other). Minimum values of total valepotriates content were recorded in the month of July. The results are depicted in Fig 1. In roots the valtrate content ranged from 1.019% to 1.479%, acevaltrate content between 0.206% to 0.538%, didrovaltrate content between 0.130% to 0.641%, IVHD valtrate content between 0.284% to 0.721% and the total valepotriates content ranged between 1.193% to 1.829% during different months of growth in female and bisexual plants. On comparison between female and bisexual plants, the mean value of acevaltrate content (0.421%) was recorded significantly higher in female plants than bisexual plants (0.380%). November month showed maximum mean value for total valepotriates content in roots and July showed minimum mean value for total valepotriates content in roots. The results are depicted in Fig 2. In rootstock when roots and rhizome portion are combined together, the valtrate content ranged between 0.915% to 1.464%, acevaltrate content between 0.174% to 0.491%, didrovaltrate content between 0.224% to 0.623% and IVHD valtrate content between 0.408% to 0.702%. The total valepotriates content varied between 1.094% to 1.801%during different months of growth in rootstock of female and bisexual plants. For monoene type of valepotriates *i.e* valtrate and acevaltrate content and total valepotriate content significant difference has been observed in rootstock of female and bisexual plants. The maximum mean values for valtrate content (1.256%), acevaltrate content (0.418%) and total valepotriates content (1.524%) were recorded significantly higherin female plants in comparison to bisexual plants. Among different months of growth, maximum mean value for individual valepotriates content was recorded in the month of September. The results are depicted in Fig 3.

Valepotriates yield

The individual valepotriates *viz* (valtrate, acevaltrate, didrovaltrate and IVHD valtrate) yield is also estimated in roots, rhizomes and rootstock of female and bisexual plants of *Valeriana jatamansi* during different periods of growth *i.e* March, May, July, September and November months. The results were found to be significant and the data is presented in Table 4 to 6. The valtrate yield per plant in rhizomes ranged between 48.653mg to 252.337mg, acevaltrate yield between 1.570mg to 35.618mg, didrovaltrate yield between 2.599mg to 103.586mg, IVHD valtrate yield between 13.462mg to 117.238mg during different months of growth between female and bisexual plants. The total valepotriates yield ranged between 74.952mg to 473.799mg. Between female and bisexual plants, the mean value of acevaltrate yield in rhizomes was found significantly higher (19.125mg) in female plants than bisexual plants (9.366mg). Among different months of growth, maximum mean value for individual valepotriates yield per plant in rhizomes was recorded in the month of November. Minimum mean value for total valepotriates yield per plant in rhizomes was recorded in the month of July. In case of roots, the valtrate yield per plant ranged between 53.545mg to 377.547mg,

acevaltrate yield per plant ranged between 2.533 mg to 31.986 mg, didrovaltrate yield per plant between 1.875mg to 30.854mg, IVHD valtrate yield per plant ranged between 6.992mg to 47.798mg. Total valepotriates yield per plant in roots ranged between 73.726mg to 464.308mg during different months of growth between female and bisexual plants. In rootstock containing rhizomes and roots, valtrate yield per plant ranged between 102.199mg to 614.112mg.The acevaltrate yield per plant between 4.103mg to 67.605mg, didrovaltrate yield per plant between 6.224mg to 120.294mg, and IVHD valtrate yield per plant between 27.561mg to 165.036mg. The total valepotriates yield per plant in rootstock ranged between 148.680mg to 938.107mg during different months of growth between female and bisexual plants. On comparison between female and bisexual plants, the mean value of acevaltrate yield in rootstock was found significantly higher (33.963mg) in female plants than bisexual plants (22.805mg). Among different months of growth, maximum mean value for individual valepotriates yield per plant in rootstock was recorded in the month of November and minimum mean value for total valepotriates yield per plant in rootstock was recorded in the month of July.

Discussion

Medicinal plants show a marked variation in active principles during different seasons, as these have been widely distributed to variation in environment variables such as temperature and rainfall. Concentration of valepotriates has also been found to vary with growth and development of plant. The results of the present investigation showed that September is ideal month for obtaining higher valepotriates content and start of winter period *i.e* November month is appropriate time for obtaining higher valepotriates yield in *Valeriana jatamansi*. The variation in chemical content is generally appeared to be strongly affected by increase in plant age as well as change in environmental conditions during different seasons. Significant increase in the amount of valepotriates content and yield during the months of September and November could be because of growth after monsoon period *i.e* in July, August months in Himachal Pradesh. These results are in conformity with Igleasis and Vila (1985) [6], Singh *et al*., (2010) [16] in *V.jatamansi* and Omidbaigi (1998) [11] in *Valeriana officinalis.* Igleasis and Vila (1985) [6] observed highest concentrations of valepotriates (3-4%) in roots and rhizomes of *Valeriana wallichii* in the month of September. Singh *et al*., (2010) [16] reported that enriched fraction of valepotriates were recorded during dormancy period in winters *i.e* in January followed by October and November. Omidbaigi, (1998) [11] reported that autumn period (October to December) is the best time to harvest *Valeriana officinalis* for higher root yield and active substance didrovaltrate, whereas Bos *et al.,* (1998) [2] have reported highest valepotriate content in *V. officinalis* during February-March. Sobotkma-Wierzbowicz (1972) [17] is of the view that the amount of valtrate content in *Valeriana officinalis* was found to depend on the year of plant harvesting. In another study by Jugran *et al*., (2016) regarding impact of altitudes and habitats on valerenic acid, total phenolics, flavonoids, tannins and antioxidant activity of *Valeriana jatamansi* considerable variation have been observed. Similar studies on seasonal variation of phytochemical content were conducted on many medicinal plants species such as *Adhatoda vasica* (Pandita *et al*., 1983) [12]; *Mentha pulegium* (Stengele and Stahl Biskup, 1993) [18]; *Glycyrriza glabra* (Alfredo *et. al*., 2011) [1]; *Pelargonium graveolens* (Mittal *et al*., 2013) [10]. The results also emphasized that female and bisexual plants exhibited significant variation in phytochemical content where female plants outperformed bisexual plants in terms acevaltrate content, valtrate content and total valepotriates content. Acevaltrate content were recorded to be significantly higher in rhizomes, roots and rootstock of female flowering plants in comparison to bisexual flowering plants. In rootstock too, significantly higher values were observed in female flowering plants for valtrate and total valepotriates content in comparison to bisexual flowering plants. Similarly acevaltrate yield was recorded significantly higher in rhizomes and rootstock of female flowering plants. Therefore on the basis of present results we can say that acevaltrate appeared to be sex linked character, with more presence in female flowering plants. In a gynodioecious population, progeny of female plants perform better than their counterparts raised from hermaphrodite plants, as female plants have an advantage over hermaphrodite because of their avoidance of inbreeding (Charlesworth, 1981) [3]; (Ross and Gregorius, 1985) [14]. The results summarized in tables 1 to 6 are indicative of the fact that variation in valepotriates content and yield in *Valeriana jatamansi* exists within species (female and bisexual plants) during different seasons of growth.

Conclusion

From the data it is significant to note that *Valeriana jatamansi* showed variation in valepotriates content and yield during different periods of months and also between different sexes. Since harvesting of plants with higher concentration of active principles is a prerequisite in preparation of efficacious drugs, present investigation revealed that harvesting the plant during the month of September can be considered as best stage for harvesting of the species.

Table 1: Seasonal variation of valepotriate content in rhizomes of female and bisexual plants of *Valeriana jatamansi*

Plant type/Months	Valtrate (%)			Acevaltrate (%)			Didrovaltrate (%)			IVHD valtrate (%)			Total valepotriates (%)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	0.990	1.199	1.095	0.363	0.372	0.368	0.544	0.575	0.560	0.464	0.521	0.493	1.278	1.479	1.378
May	1.233	1.266	1.250	0.324	0.383	0.354	0.552	0.403	0.477	0.609	0.543	0.576	1.539	1.486	1.512
July	1.002	0.829	0.916	0.336	0.145	0.241	0.355	0.183	0.269	0.517	0.509	0.513	1.231	1.019	1.125
Sep	1.474	0.827	1.151	0.528	0.258	0.393	0.668	0.564	0.616	0.663	0.622	0.642	1.852	1.213	1.532
Nov	1.004	1.049	1.026	0.450	0.262	0.356	0.627	0.683	0.655	0.656	0.731	0.694	1.440	1.485	1.462
Mean	1.141	1.034		0.400	0.284		0.549	0.482		0.582	0.585		1.468	1.336	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	0.207	0.072		0.086	0.030		0.118	0.041		0.110	0.038		0.229	0.080	
Plant type	N/A	0.046		0.055	0.019		N/A	0.026		N/A	0.024		N/A	0.051	
Months × Plant type	0.293	0.102		0.122	0.043		N/A	0.058		N/A	0.054		0.325	0.114	

Table 2: Seasonal variation of valepotriate content in roots of female and bisexual plants of *Valeriana jatamansi*

Plant type/Months	Valtrate (%)			Acevaltrate (%)			Didrovaltrate (%)			IVHD valtrate (%)			Total valepotriates (%)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	1.477	1.272	1.375	0.433	0.384	0.408	0.328	0.130	0.229	0.448	0.284	0.366	1.641	1.365	1.503
May	1.329	1.479	1.404	0.350	0.454	0.402	0.193	0.464	0.329	0.542	0.603	0.573	1.496	1.725	1.610
July	1.109	1.019	1.064	0.375	0.206	0.291	0.272	0.270	0.271	0.452	0.507	0.479	1.286	1.193	1.240
Sep	1.455	1.431	1.443	0.427	0.538	0.482	0.517	0.641	0.579	0.655	0.721	0.688	1.737	1.829	1.783
Nov	1.281	1.443	1.362	0.520	0.317	0.419	0.255	0.301	0.278	0.529	0.511	0.520	1.517	1.596	1.557
Mean	1.330	1.329		0.421	0.380		0.313	0.361		0.525	0.525		1.535	1.541	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	0.140	0.049		0.060	0.021		0.102	0.036		0.093	0.032		0.158	0.055	
Plant type	N/A	0.031		0.038	0.013		N/A	0.023		N/A	0.021		N/A	0.035	
Months×plant type	0.197	0.069		0.085	0.030		0.144	0.051		N/A	0.046		0.223	0.078	

Table 3: Seasonal variation of valepotriate content in rootstock of female and bisexual plants of *Valeriana jatamansi*

Plant Type/Months	Valtrate (%)			Acevaltrate (%)			Didrovaltrate (%)			IVHD valtrate (%)			Total valepotriates (%)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	1.272	1.244	1.258	0.405	0.380	0.392	0.468	0.392	0.430	0.465	0.408	0.436	1.492	1.420	1.456
May	1.367	1.348	1.358	0.363	0.410	0.387	0.438	0.426	0.432	0.588	0.565	0.577	1.602	1.577	1.589
July	1.040	0.915	0.977	0.351	0.174	0.262	0.333	0.224	0.278	0.498	0.508	0.503	1.251	1.094	1.172
Sep	1.464	1.083	1.273	0.491	0.384	0.438	0.620	0.623	0.622	0.658	0.702	0.680	1.801	1.486	1.644
Nov	1.135	1.245	1.190	0.480	0.289	0.384	0.507	0.540	0.523	0.608	0.645	0.626	1.476	1.537	1.507
Mean	1.256	1.167		0.418	0.328		0.473	0.441		0.563	0.565		1.524	1.423	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	0.091	0.032		0.063	0.022		0.083	0.029		0.071	0.025		0.108	0.038	
Plant type	0.058	0.020		0.040	0.014		N/A	0.018		N/A	0.016		0.068	0.024	
Months×plant type	0.129	0.045		0.089	0.031		N/A	0.041		N/A	0.035		0.153	0.053	

Table 4: Seasonal variation of valepotriates yield (mg/plant) in rhizomes of female and bisexual plants of *Valeriana jatamansi*

Plant type/Months	Valtrate (mg/plant)			Acevaltrate (mg/plant)			Didrovaltrate (mg/plant)			IVHD valtrate (mg/plant)			Total valepotriates (mg/plant)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	62.775	101.209	81.992	9.300	9.831	9.565	19.952	23.926	21.939	13.462	20.569	17.015	105.488	155.534	130.511
May	109.075	125.666	117.370	8.220	11.147	9.683	22.256	12.968	17.612	22.418	23.133	22.775	161.968	172.913	167.441
July	90.813	48.653	69.733	9.939	1.570	5.755	11.133	2.599	6.866	23.713	22.130	22.922	135.599	74.952	105.275
Sep	252.337	83.514	167.925	32.550	7.871	20.210	84.775	38.922	61.848	61.769	54.696	58.233	431.430	185.002	308.216
Nov	163.375	236.564	199.969	35.618	16.413	26.016	66.197	103.586	84.891	70.656	117.238	93.947	335.847	473.799	404.823
Mean	135.675	119.121		19.125	9.366		40.863	36.400		38.403	47.553		234.066	212.440	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	52.070	18.220		8.560	2.995		25.159	8.804		24.596	8.607		3.556	32.738	
Plant type	N/A	11.524		5.414	1.894		N/A	5.568		N/A	5.443		N/A	20.705	
Months×plant type	73.637	25.768		12.105	4.236		35.580	12.450		N/A	12.172		132.309	46.298	

Table 5: Seasonal variation of valepotriates yield (mg/plant) in roots of female and bisexual plants of *Valeriana jatamansi*

Plant Type/Months	Valtrate (mg/plant)			Acevaltrate (mg/plant)			Didrovaltrate (mg/plant)			IVHD valtrate (mg/plant)			Total valepotriates (mg/plant)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	150.182	139.273	144.728	12.923	12.723	12.823	8.073	1.875	4.974	14.293	6.992	10.643	185.470	160.864	173.167
May	138.588	116.493	127.541	9.346	11.008	10.177	4.548	11.619	8.084	25.655	18.655	22.155	178.135	157.777	167.956
July	61.773	53.545	57.659	7.044	2.533	4.788	4.195	3.625	3.910	10.710	14.023	12.366	83.723	73.726	78.724
Sep	191.435	130.442	160.938	12.888	18.680	15.784	24.635	30.854	27.744	38.379	35.916	37.147	267.336	215.891	241.613
Nov	207.225	377.547	292.386	31.986	22.253	27.120	9.499	16.708	13.103	32.998	47.798	40.398	281.709	464.308	373.009
Mean	149.841	163.460		14.838	13.439		10.190	12.936		24.407	24.677		199.275	214.513	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	69.740	24.404		7.302	2.555		8.949	3.131		12.602	4.410		89.628	31.363	
Plant type	N/A	15.434		N/A	1.616		N/A	1.981		N/A	2.789		N/A	19.836	
Months×plant type	98.627	34.512		N/A	3.613		N/A	4.429		N/A	6.236		N/A	44.354	

Table 6: Seasonal variation of valepotriates yield (mg/plant) in rootstock of female and bisexual plants of *Valeriana jatamansi*

Plant type/ Months	Valtrate (mg/plant)			Acevaltrate (mg/plant)			Didrovaltrate (mg/plant)			IVHD valtrate (mg/plant)			Total valepotriates (mg/plant)		
	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean	Female	Bisexual	Mean
March	212.956	240.482	226.719	22.223	22.554	22.389	28.025	25.801	26.913	27.755	27.561	27.658	290.957	316.398	303.678
May	247.661	242.160	244.911	17.566	22.155	19.860	26.804	24.588	25.696	48.072	41.788	44.930	340.103	330.690	335.397
July	152.588	102.199	127.393	16.983	4.103	10.543	15.329	6.224	10.776	34.423	36.153	35.288	219.323	148.680	184.002
Sep	443.770	213.955	328.863	45.438	26.550	35.994	109.410	69.775	89.593	100.148	90.612	95.380	698.765	400.893	549.829
Nov	370.601	614.112	492.356	67.605	38.666	53.135	75.696	120.294	97.995	103.654	165.036	134.345	617.555	938.107	777.831
Mean	285.515	282.582		33.963	22.805		51.053	49.336		62.810	72.230		433.341	426.954	
	CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±		CD 0.05	SE±	
Months	101.990	35.689		14.536	5.087		30.066	10.521		29.883	10.457		157.96	55.274	
Plant type	N/A	22.572		9.194	3.217		N/A	6.654		N/A	6.614		N/A	34.958	
Months× plant type	144.235	50.471		N/A	7.194		N/A	14.879		N/A	14.788		223.389	78.170	

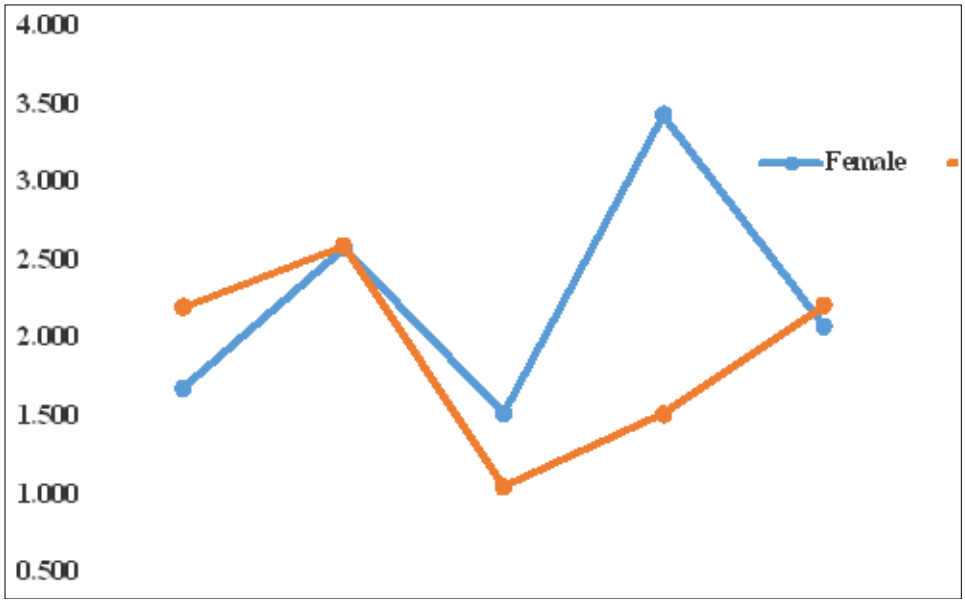

Fig 1: Seasonal variation of total valepotriates content (%) in rhizome of female and bisexual plants of *V.jatamansi*

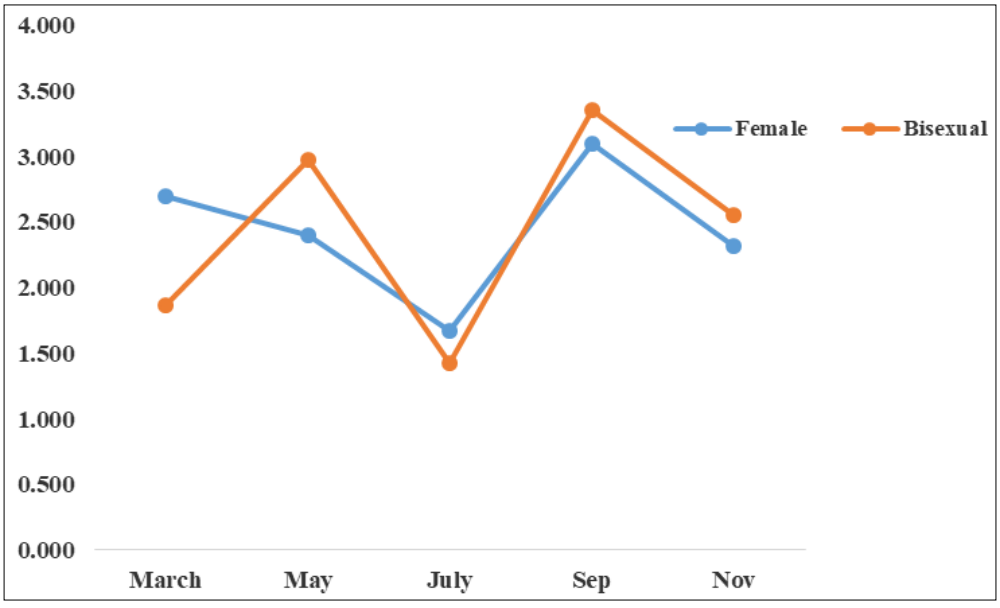

Fig 2: Seasonal variation of total valepotriates content (%) in roots of female and bisexual plants of *V.jatamansi*

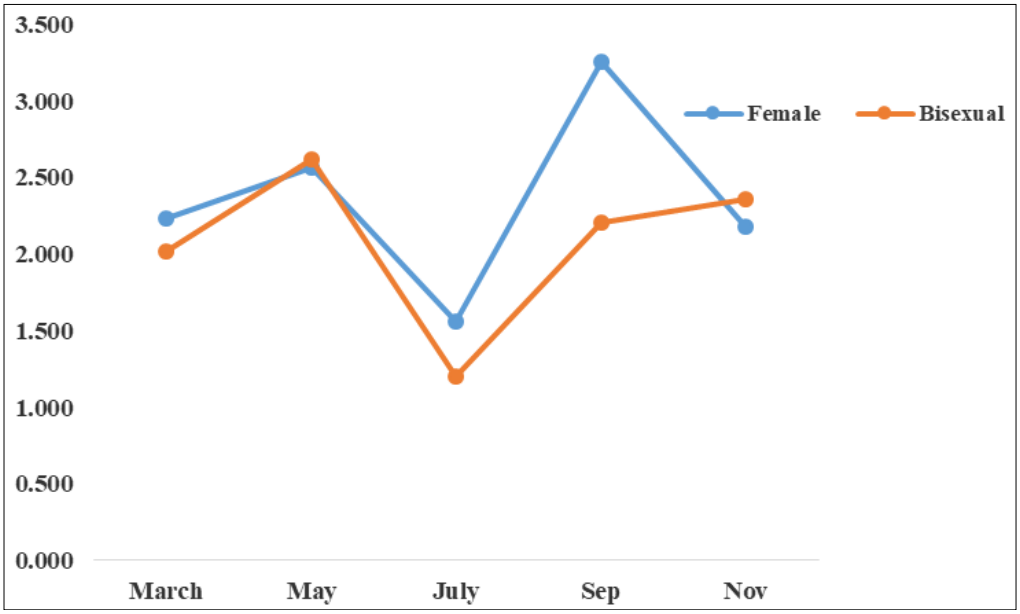

Fig 3: Seasonal variation of total valepotriates content (%) in rootstock of female and bisexual plants of *V. jatamansi*

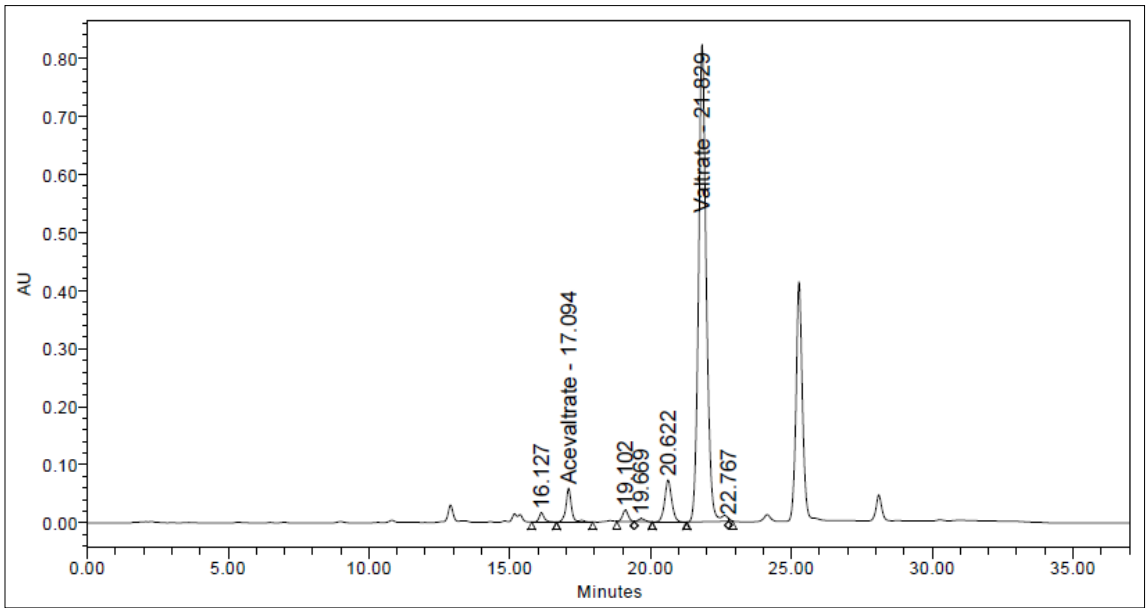

Fig 4: HPLC Chromatogram showing diene type valepotriates (Acevaltrate and Valtrate)

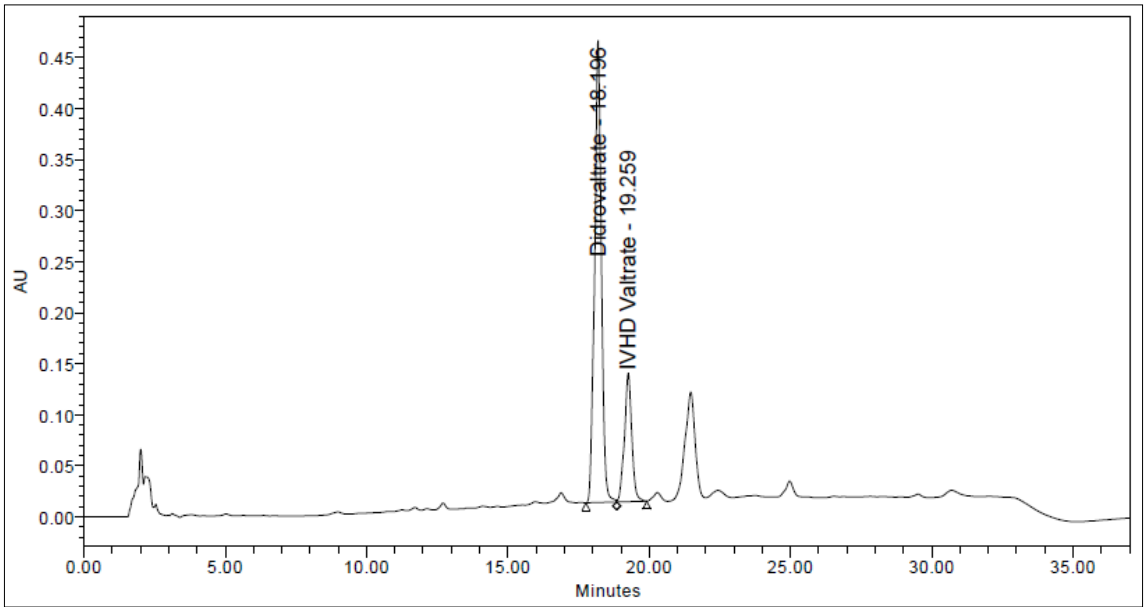

Fig 5: HPLC Chromatogram showing monoene type valepotriates (Didrovaltrate and IVHD Valtrate)

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