International Journal of Biodiversity and Conservation Vol. 4(1), pp. 22-31, January 2012
Available online http://www.academicjournals.org/IJBC
DOI: 10.5897/IJBC11.113
ISSN 2141-243X ©2012 Academic Journals

Full Length Research Paper

Ex-situ conservation of *Polygonatum verticillatum* (L.) Allioni under different types of organic treatments

Nidhi Lohani[1], Ravi Kumar[1], Lalit M. Tewari[1]* and G. C. Joshi[2]

[1]Department of Botany, D. S. B. Campus, Kumaun University, Nainital 263001, Uttarakhand India.
[2]Research Officer Regional Research Institute of Himalayan Flora, Iran to CCRAS, Tarikhet Ranikhet india.

Accepted 28 November, 2011

Meda (*Polygonatum verticillatum)* belongs to the family Liliaceae. It is an important ingredient of Astvarga and known for its various medicinal uses. This is a herb which is used against many diseases and as a tonic. Due to great market potential of this plant, it is harvested in uncontrolled way which is causing the decline of the herb from its natural habitat. Thus, there is a need for its *in-situ* as well as, *ex-situ* conservation and propagation. Hence, the present study was conducted by putting different trials with different types of organic fertilizers and nursery beds to develop techniques for appropriate harvesting and cultivation practices for sustainable utilization of this plant.

Key words: *Polygonatum verticillatum, ex-situ* conservation, organic cultivation.

INTRODUCTION

In recent years, increasing attention is being paid to medicinal plant value both due to their economic and conservation concern (Dhar et al., 2000). Overexploitation of rhizome and other parts for medicinal use and consequent degradation of natural habitat are reported to be the major threat to these plants. Many species of Himalayan medicinal plants are considered as most endangered and listed in Red Data Book of Indian plants (Nayar and Sastary, 1987, 1988, 1990).

It has been envisaged earlier that a number of medicinal plants of high importance are depleting at alarming rate (Tewari and Bhattacharjee, 1975). Today, due to strict legislation and laws for preparation of authentic herbal medicines, the collection of desired medicinal plant species and type is becoming more and more difficult day by day (Anonymous, 1998). This is more realistic in case of plants whose root- rhizomes are used as ingredients for herbal medicine (Tiwari et al., 1992). In the aforesaid circumstances, their *in-situ* conservation and *ex-situ* production appears to be the only remedy. The latest policies are also being framed in this direction. *Polygonatum verticillatum* is an important ingredient of Astaverga and high value in medicinal herb is one of these Himalayan medicinal plants.

P. verticillatum (Plate 1) belonging to the family liliaceae, known as Meda Eng. whorled Solomons seal is distributed in temperate Himalaya at an altitude ranging between 2400 to 2800 m (Anonymous, 2008). Stem 2 to 4 feet, erect, angled and grooved, sometimes mottled. Leaves in whorls of 4 to 8, sessile, linear, 4 to 8 × ¼ to 1/2 inch, or lanceolate, 3½ × 3/4 inch, tips usually acute, sometimes obtuse or slightly in rolled, lower surface glaucous. Racemes whorled, 2 to 3 flowered. Perianth 1/3 inch, white, tinged with green. Berry 1/4 inch diameter (Collett, 1971). Distributed from montane to alpine Himalaya, Kashmir to Northeast States; Sikkim, Southeast Tibet, West Asia and Europe (Gaur, 1999) in temperate Himalayas at an altitude ranging between 2400 to 2800 m (Chauhan, 1999).

Used in diseases of Children, jaundice (Sharma et al., 1999) roots are eaten raw or cooked and powder is given in gastric complaints, paste applied on wounds (Gaur, 1999). Bala Ghrita, Mahapadmaka Taila, Triphaladi Ghrita are some of its important formulations (Sharma et al., 1999).

General information on *P. verticillatum* is also available in the literature (Gaur, 1999; Anonymous, 1969).

*Corresponding author. E-mail: lalit tewari l_tewari@rediffmail.com. Tel: 9412362085, (05942)237088.

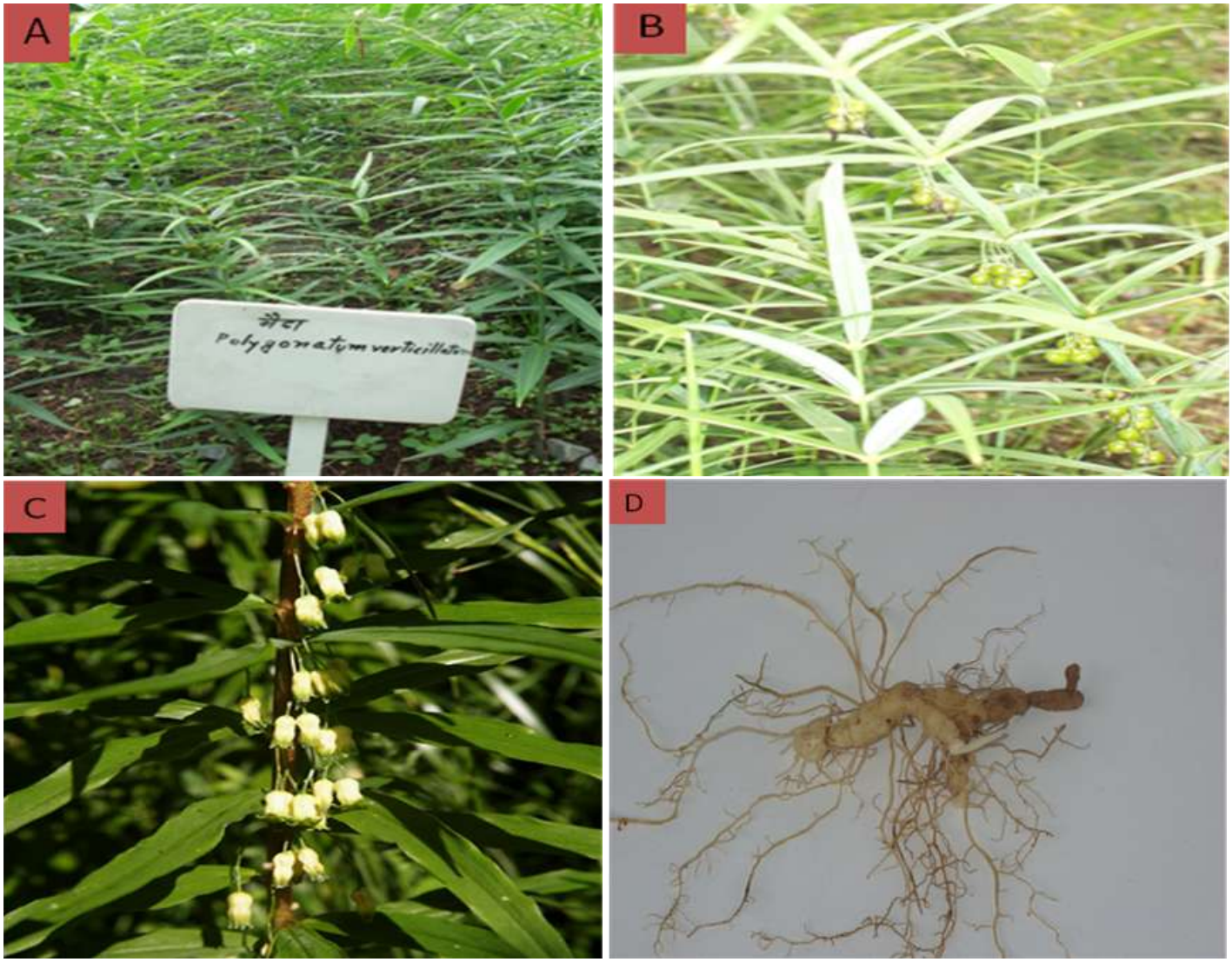

Plate 1. Different stages of *Polygonatum verticillatum* (L.) Allioni: (A) in cultivated stage (B) fruiting (C) flowering (D) harvested rhizome.

Previous work in the cultivation of *P. verticillatum* was done by Nautiyal and Nautiyal in 2004 in the Garhwal Himalaya. Here, we are presenting the agro- technique of this highly valuable and rare (Nautiyal and Nautiyal, 2004) medicinal plant which may be fruitful in future for farmers and medicinal plant growers. The main objective of our study is *ex-situ* conservation of this valuable herb as well as, upliftment of the economy of hill people by its cultivation.

MATERIALS AND METHODS

Germplasm of *P. verticillatum* has been collected from the nearby wild sources of Almora and Nainital district of Uttarakhand, India just before the onset of its dormancy. Only a small part of rhizome was uprooted for planting and the remaining part was lifted in the wild sources for further growth to avoid exploitation. Materials collected from these wild sources were planted at Medicinal Plant Garden of Central Council for Research in Ayurveda and Siddha (CCRAS), Ranikhet (29° 38' 60N, 79° 25' 0E). The garden is situated at an altitude of 1700 m and surrounded by thick pine forest, characterized by Deodar, *Myrica*, *Rhododendron*, *Quercus* and Shrubs like *Berberis*, *Rubus* sp. *Crataegus* sp. etc.

The land was dug up or ploughed twice or thrice until a fine tilth was obtained and then different types of experimental beds namely; plain beds and beds with rows and furrows of $1m^2$ area were prepared. Before plantation, these nursery beds were supplemented with different types of organic fertilizers. Three types of organic fertilizers namely; farmyard manure, forest litter and vermicompost were used to see their effect on the survival, growth and yield. The fertilizers at 60 qut/ha) were added in the beds in two doses, before plantation (at the time of bed preparation) and after sprouting (Nautiyal and Nautiyal, 2004)). In order to study the effect of fertilizers and nature of nursery beds on survival, growth, yield and other related parameters the experiment was designed in Randomize Block Design (RBD) with a total of twelve treatment combinations along with a control set and each treatment was

replicated three times. Previous studies shows that rhizome section is the best planting material for cultivation other than seed because the planting material raised by the seeds takes more time for crop maturity as well as, production (Nautiyal and Nautiyal 2004; Anonymous, 2008). A total 324 rhizome sections of about 1.5 to 2.00 inches long were selected. Before plantation, rhizomes were washed with natural spring water of Medicinal Plant Garden and dipped in cow's urine overnight to prevent them from soil borne diseases as suggested in "VARKSHAYURVEDA" (Vijyalashmi and Shyam, 1993). In morning hours those rhizome were cut into transverse sections at the intermodal portion with at least two nodes within each section and each rhizome section was planted laterally in different types of nursery beds on 15th November, 2007. A total of nine rhizome sections were planted in each bed. A row-to- row and plant- to-plant distance of 30 cm was followed by sowing the rhizomes. In all the treatments, irrigation was done at regular intervals through natural spring water (heavy metal free), depending upon weather condition and moisture requirements of the soil. The crop was irrigated once a week during dry months. During the dormancy period, irrigation was done in every twenty days. The beds were kept free from weeds manually.

To observe the yield, underground parts (rhizomes) from one replication of each treatment were uprooted at the end of each growing season for two consecutive growth seasons. These rhizomes were properly washed with running water to remove soil particles. Fresh weight was taken after removing rootlets. These rhizomes were then cut into small slices and kept in the partial shade for drying. After complete drying, dry weight of these rhizomes was taken. Data were recorded on both pre- harvest and post- harvest agronomic characters namely; days to sprout, days to flower, number of whorls, plant height, fresh weight of rhizomes, and dry weight of rhizomes and rate of fresh weight of rhizomes increased. Observations were recorded in 15 days interval. Statistical analysis was carried out to calculate mean values and correlation between different morphological traits. Standard deviation and ANOVA was calculated by Excel 2007 and correlation was calculated by using Karl Pearson's method (Kothari, 2005).

Intercultural operations

The following fertilizer doses and spacing was used to standardize the agro-technique for commercial cultivation of this herb:

Design: Randomized Block Design (RBD)
Fertilizer: S_1- Forest Litter
S_2- Vermi Compost
S_3- FYM (Farmyard Manure)
S_4- Control
(Quantity of fertilizer: 600 gm per bed at 60 qut/ha)

Nursery Beds: B_1- Plain
B_2- Rows
B_3- Furrows

Replications: 3
Spacing: - 30 X 30 cm.
No. of Treatment Combinations: 4 × 3 = 12
Total No. of Plots: 36

Plot size: 1 × 1 square meter
No. of rhizome cuttings planted in each bed: 9

RESULTS

Data analyzed for mean values showed that in the first year of cultivation *P. verticillatum* (Table 1) takes about 163.56 to 178 days to sprout from the date of plantation and flowering was not observed. The percentage of survival was observed 100% in all type of beds. Average height 40.41 cm per plant, average number of whorls 8.44 per plant, fresh weight of rhizomes harvested 5.89 qut/ha, dry weight of rhizomes obtained 1.53 qut/ha and rate of fresh weight of rhizomes increased 197.40% was observed maximum in the bed T_3 (furrows + forest litter) and average plant height 22.77 cm per plant, average number of whorls 4.44 per plant, rate of fresh weight of rhizomes increased 92.12% was observed minimum in the bed T_{11} (row + control) while fresh weight of rhizomes harvested 3.89 qut/ha and dry weight of rhizomes obtained 1.00 qut/ha was observed minimum in the bed T_8 (row + FYM). In the first year of cultivation of *P. verticillatum* ANOVA was found significant for all the pre-harvest and post- harvest agronomic characters viz. days to sprout, avg. height per plant (cm), average number of whorls per plant, fresh weight of rhizomes harvested (qut/ha), and dry weight of rhizomes obtained (qut/ha) with F value (20.85, 107.65, 20.39, 9.77, and 9.52 respectively at $p < 0.001$); fresh weight of rhizomes planted (qut/ha) with F value (2.40 at $p < 0.05$) and rate of fresh weight of rhizomes increased (%) with F value (3.05 at $p < 0.01$).

In the second year of cultivation (Table 2), this plant takes about 158.11 to 171.11 days to sprout and 171.33 to 190 days to flower from the date of dormancy and 100% survival was recorded in all type of beds. Average height 45.28 cm per plant, average number of whorls 9.72 per plant, fresh weight of rhizome harvested 16.33 qut/ha dry weight of rhizomes obtained 4.30 qut/ha and rate of fresh weight of rhizomes increase 709.75% was observed maximum in the bed T_3 (furrows + forest litter) and average plant height 25.70 cm per plant, average number of whorls 5.61 per plant, fresh weight of rhizomes harvested 8.17 qut/ha, dry weight of rhizomes obtained 2.15 qut/ha and rate of fresh weight of rhizomes increased of rhizomes 271.67% was observed minimum in the bed T_{11} (row + control). In the second year of cultivation, ANOVA was found significant for days to sprout, days to flower, average height per plant (cm), average number of whorls per plant, fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) with F value (11.65, 13.62, 51.02, 14.36, 27.55, 27.54 and 11.36 respectively at $p < 0.001$); whereas it was found non- significant for fresh weight of rhizomes planted (qt/ha) with F value (1.70 at $p > 0.05$).

In the third year of cultivation (Table 3), this plant takes about 159.11 to 168.89 days to sprout and 170.11 to 186.67 days to flower from the date of dormancy and 100% survival was recorded. Average height 46.76 cm per plant, average number of whorls 11.33 per plant, fresh weight of rhizomes harvested 22.49 qut/ha, dry weight of rhizomes obtained 5.91 qut/ha and rate of fresh

Table 1. Shows pre-harvest and post-harvest agronomic characters of *Polygonatum- verticillatum* under different types of nursery beds and fertilizer treatments for I year of cultivation.

		Pre- harvest agronomic characters						Post- harvest agronomic characters			
Beds	**Treatments**	**Spacing (cm)**	**% of survival**	**Days to sprout**	**Days to flower**	**Avg. height/ plant (cm)**	**Avg. no. of whorls/ plant**	**Fresh weight of rhizomes planted (qut/ha)**	**Fresh weight of rhizomes harvested (qut/ha)**	**Dry weight of rhizomes obtained (qut/ha)**	**Rate of fresh weight of rhizomes increased (%)**
T_1	Plain + Litter	30 × 30	100	171.78 ± 2.77	NIL	31.62 ± 2.37	6.33 ± 1.47	2.34 ± 0.21	5.49 ± 0.77	1.41 ± 0.19	135.91 ± 34.27
T_2	Row + Litter	30 × 30	100	163.56 ± 2.83	NIL	27.81 ± 1.46	5.00 ± 1.44	2.41 ± 0.24	5.15 ± 0.70	1.35 ± 0.19	114.07 ± 28.31
T_3	Furrow + Litter	30 × 30	100	165.00 ± 4.58	NIL	40.41 ± 2.17	8.44 ± 1.28	2.06 ± 0.38	5.89 ± 0.36	1.53 ± 0.10	197.40 ± 72.80
T_4	Plain + Vermi	30 × 30	100	168.00 ± 3.20	NIL	30.34 ± 1.67	6.19 ± 1.49	2.29 ± 0.28	5.23 ± 0.74	1.36 ± 0.19	134.24 ± 61.38
T_5	Row + Vermi	30 × 30	100	174.11 ± 3.48	NIL	26.40 ± 2.53	4.70 ± 1.38	1.97 ± 0.36	3.98 ± 0.72	1.03 ± 0.18	111.94 ± 70.07
T_6	Furrow + Vermi	30 × 30	100	171.11 ± 2.52	NIL	38.66 ± 3.15	8.26 ± 1.75	2.04 ± 0.42	5.50 ± 0.58	1.42 ± 0.16	178.02 ± 57.98
T_7	Plain + F.Y.M.	30 × 30	100	168.11 ± 2.98	NIL	29.95 ± 2.69	5.93 ± 2.00	2.25 ± 0.29	5.05 ± 0.47	1.30 ± 0.13	129.91 ± 51.06
T_8	Row + F.Y.M.	30 × 30	100	173.00 ± 3.57	NIL	26.13 ± 2.81	4.52 ± 1.60	1.95 ± 0.33	3.89 ±0 .49	1.00 ± 0.12	106.49 ± 53.62
T_9	Furrow + F.Y.M.	30 × 30	100	176.00 ± 2.87	NIL	34.41 ± 3.09	7.15 ± 1.73	2.00 ± 0.40	5.14 ± 0.44	1.34 ± 0.12	166.98 ± 59.21
T_{10}	Plain + Control	30 × 30	100	178.00 ± 3.00	NIL	28.79 ± 2.56	5.11 ± 1.76	2.37 ± 0.24	5.20 ± 0.51	1.35 ± 0.13	122.70 ± 44.31
T_{11}	Row + Control	30 × 30	100	177.11 ± 2.52	NIL	22.77 ± 2.14	4.44 ± 1.37	2.27 ± 0.31	4.25 ± 0.75	1.11 ± 0.20	92.12 ± 48.09
T_{12}	Furrow + Control	30 × 30	100	176.00 ± 2.78	NIL	32.23 ± 3.45	6.44 ± 1.58	2.19 ± 0.33	5.32 ± 0.55	1.38 ± 0.15	147.03 ± 42.72
		DF		11	-	11	11	11	11	11	11
	ANOVA	MS		205.72	-	710.58	51.08	0.25	3.58	0.24	8744.30
		F-value		20.85***	-	107.65***	20.39***	2.40*	9.77***	9.52***	3.05**

Abbreviations: Significant levels (* = P<0.05; ** = P<0.01; *** = P<0.001).

Table 2. Shows the pre-harvest and post-harvest agronomic characters of *Polygonatum- verticillatum* under different types of nursery beds and fertilizer treatments for II year of cultivation.

		Pre- harvest agronomic characters						Post- harvest agronomic characters			
Beds	**Treatments**	**Spacing (cm)**	**% of Survival**	**Days to sprout**	**Days to flower**	**Avg. height/ plant (cm)**	**Avg. no. of whorls/ plant**	**Fresh weight of rhizomes planted (qt/ha)**	**Fresh weight of rhizomes harvested (qut/ha)**	**Dry weight of rhizomes obtained (qt/ha)**	**Rate of fresh weight of rhizomes increased (%)**
T_1	Plain + Litter	30 × 30	100	168.44 ± 5.20	184.78 ± 4.76	34.77 ± 1.96	7.44 ± 1.29	2.32 ± 0.23	12.13 ± 1.71	3.19 ± 0.44	430.85 ± 114.15
T_2	Row + Litter	30 × 30	100	161.33 ± 2.78	182.78 ± 4.49	29.22 ± 2.22	6.00 ± 1.37	2.29 ± 0.27	10.21 ± 1.38	2.68 ± 0.35	351.27 ± 79.40
T_3	Furrow + Litter	30 × 30	100	158.11 ± 3.48	171.33 ± 3.08	45.28 ± 1.23	9.72 ± 1.27	2.0 ± 50.34	16.33 ± 1.01	4.30 ± 0.26	709.75 ± 136.77
T_4	Plain + Vermi	30 × 30	100	162.00 ± 2.78	183.00 ± 3.57	33.03 ± 1.38	7.28 ± 1.45	1.98 ± 0.39	12.50 ± 1.77	3.28 ± 0.47	536.36 ± 104.94
T_5	Row + Vermi	30 × 30	100	167.44 ± 2.60	186.11 ± 2.93	28.98 ± 2.34	5.89 ± 1.13	1.95 ± 0.39	14.58 ± 2.63	3.86 ± 0.73	661.14 ± 177.25
T_6	Furrow + Vermi	30 × 30	100	166.33 ± 3.28	180.33 ± 3.81	41.53 ± 2.09	8.28 ± 1.64	1.97 ± 0.35	14.45 ± 1.55	3.80 ± 0.39	658.93 ± 180.91
T_7	Plain + F.Y.M.	30 × 30	100	163.11 ± 2.93	184.89 ± 3.06	31.33 ± 2.70	6.83 ± 1.89	2.22 ± 0.30	12.72 ± 1.17	3.33 ± 0.30	483.10 ± 102.01
T_8	Row + F.Y.M.	30 × 30	100	166.89 ± 2.37	184.89 ± 2.98	27.60 ± 2.31	5.72 ± 1.64	2.15 ± 0.34	8.18 ± 1.01	2.16 ± 0.28	290.21 ± 97.04
T_9	Furrow + F.Y.M	30 × 30	100	167.33 ± 3.04	182.33 ± 3 .32	38.48 ± 1.23	8.22 ± 1.44	2.28 ± 0.28	15.68 ± 1.37	4.12 ± 0.35	603.81 ± 157.98
T_{10}	Plain + Control	30 × 30	100	167.11 ± 4.04	183.33 ± 3.50	30.54 ± 2.08	6.56 ± 1.76	2.30 ± 0.25	12.19 ± 1.21	3.21 ± 0.32	439.53 ± 111.77

Table 2 Contd.

T_{11}	Row + Control	30 × 30	100	171.11 ± 3.55	190.00 ± 3 .12	25.70 ± 2.22	5.61 ± 1.46	2.23 ± 0.31	8.17 ± 1.43	2.15 ± 0.38	271.67 ± 90.65
T_{12}	Furrow + Control	30 × 30	100	169.44 ± 2.83	182.33 ± 3.77	37.60 ± 2.43	7.89 ± 1.88	2.28 ± 0.27	14.51 ± 1.52	3.85 ± 0.39	555.42 ± 162.94
		DF		11	11	11	11	11	11	11	11
	ANOVA	MS		128.78	174.47	644.97	33.84	0.17	65.19	4.53	194213.08
		F-value		11.65***	13.62***	151.02***	14.36***	1.70^{NS}	27.55***	27.54***	11.36***

Abbreviations: Significant levels (* = P<0.05; ** = P<0.01; ***P<0.001); NS = non significant.

Table 3. Shows the pre-harvest and post-harvest agronomic characters of *Polygonatum- verticillatum* under different types of nursery beds and fertilizer treatments for III year of cultivation.

		Pre- harvest agronomic characters						**Post- harvest agronomic characters**			
Beds	**Treatments**	**Spacing (cm)**	**% of survival**	**Days to sprout**	**Days to flower**	**Avg. height/ plant (cm)**	**Avg. no. of whorls/ plant**	**Fresh weight of rhizomes planted (qut/ha)**	**Fresh weight of rhizomes harvested (qut/ha)**	**Dry weight of rhizomes obtained (qut/ha)**	**Rate of fresh weight of rhizomes increased (%)**
T_1	Plain + litter	30 × 30	100	166.11 ± 4.94	183.00 ± 5.24	37.27 ± 2.15	8.67 ± 1.12	2.21 ± 0.31	18.69 ± 1.97	4.92 ± 0.52	768.16 ± 192.70
T_2	Row + litter	30 × 30	100	159.33 ±3 .91	180.00 ± 4.44	32.68 ± 1.63	7.11 ± 0.93	2.33 ± 0.21	16.27 ± 2.10	4.32 ± 0.56	601.54 ± 89.97
T_3	Furrow + litter	30 × 30	100	159.11 ± 5.40	170.11 ± 3.41	46.76 ± 1.02	11.33 ± 1.12	2.06 ± 0.41	22.49 ± 1.92	5.91 ± 0.50	1028.02 ± 208.53
T_4	Plain + vermi	30 × 30	100	163.78 ± 4.58	182.00 ± 4.00	35.69 ± 1.38	8.00 ± 0.71	2.29 ± 0.22	18.32 ± 2.15	4.80 ± 0.56	707.71 ± 129.63
T_5	Row+ vermi	30 × 30	100	166.33 ± 4.03	185.00 ± 3.00	31.52 ± 2.04	7.22 ± 0.83	2.03 ± 0.39	19.55 ± 2.89	5.14 ± 0.76	896.85 ± 234.16
T_6	Furrow + vermi	30 × 30	100	164.11 ± 3.89	178.33 ± 3.94	43.29 ± 2.23	10.22 ± 0.83	1.96 ± 0.38	19.36 ± 1.62	5.15 ± 0.43	922.67 ± 205.97
T_7	Plain + F.Y.M.	30 × 30	100	160.00 ± 3.67	181.89 ± 3.52	33.41 ± 2.28	7.56 ± 0.88	2.36 ± 0.22	17.42 ± 1.34	4.59 ± 0.35	642.67 ± 70.65
T_8	Row + F.Y.M.	30 × 30	100	165.00 ± 3.57	183.44 ± 2.88	30.60 ± 2.11	7.00 ± 0.87	2.00 ± 0.34	12.72 ± 1.38	3.31 ± 0.36	558.56 ± 158.48
T_9	Furrow + F.Y.M.	30 × 30	100	164.22 ± 4.99	183.22 ± 3.49	40.39 ± 1.28	9.33 ± 0.71	2.39 ± 0.23	21.05 ± 2.03	5.49 ± 0.53	791.20 ± 136.97
T_{10}	Plain + control	30 × 30	100	164.89 ± 4.20	182.22 ± 4.09	33.1 ± 71.96	7.33 ± 0.87	2.30 ± 0.24	17.31 ± 1.28	4.52 ± 0.34	658.55 ± 101.74
T_{11}	Row + control	30 × 30	100	168.89 ± 4.68	186.67 ± 5.07	28.12 ± 2.35	6.67 ± 0.71	2.00 ± 0.34	12.77 ± 0.94	3.34 ± 0.25	557.34 ± 122.18
T_{12}	Furrow + control	30 × 30	100	168.00 ± 3.61	181.00 ± 3.12	38.18 ± 2.12	9.00 ± 0.71	2.15 ± 0.27	19.44 ± 1.49	5.15 ± 0.39	814.98 ± 120.32
		DF		11	11	11	11	11	11	11	11
	ANOVA	MS		92.55	156.27		18.90	0.23	77.97	5.49	206331.76
		F-value		4.94***	10.17***	73.05***	25.12***	2.46^{NS}	23.34***	23.75***	8.50***

Abbreviations: Significant levels (* = P<0.05; ** = P<0.01; ***P<0.001); NS = non significant.

weight of rhizomes increased 1028.02% was observed maximum in the bed T_3 (Furrows + Forest litter) and average plant height 28.12 cm per plant, average number of whorls 6.67 per plant, rate of fresh weight of rhizomes increased 557.34% was observed minimum in the bed T_{11} (row + control) while fresh weight of rhizomes harvested 12.72 qut/ha and dry weight of rhizomes obtained 3.31 qut/ha was observed minimum in the bed T_8 (row + FYM). In the third year of cultivation ANOVA was found significant for days to sprout, days to flower, average height per plant (cm), average number of whorls per plant, fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qt/ha) and rate

Table 4. Correlation between different morphological traits of *Polygonatum verticillatum* for I year of cultivation.

Variable	Days to sprout	Avg.height /plant (cm)	Avg. no. of whorls/plant	Fresh weight of rhizomes planted (qut/ha)	Fresh weight of rhizomes harvested (qut/ha)	Dry weight of rhizomes obtained (qut/ha)	Rate of fresh weight of rhizomes increased (%)
Days to sprout	1.00						
Avg. height/plant (cm)	-0.34	1.00					
Avg. no. of whorls/plant	-0.31	0.98*	1.00				
Fresh weight of rhizomes planted (qut/ha)	-0.17	-0.28	-0.27	1.00			
Fresh weight of rhizomes harvested (qut/ha)	-0.40	0.80*	0.80*	0.33	1.00		
Dry weight of rhizomes obtained (qut/ ha)	-0.40	0.79*	0.79*	0.34	1.00*	1.00	
Rate of fresh weight of rhizomes increased (%)	-0.28	0.99*	0.98*	-0.33	0.77*	0.77*	1.00

DF=10; p= 0.05; r= 0.576.

of fresh weight of rhizomes increased (%) with F value (4.94, 10.17, 73.05, 25.12, 23.34, 23.75, and 8.50 respectively at $p < 0.001$); whereas it was found non- significant for fresh weight of rhizomes planted (qut/ha) with F value (2.46 at $p > 0.05$).

Correlation in morphological traits

In the first year of cultivation of *P. verticillatum* (Table 4) average height/plant (cm) showed significant positive correlation with average number of whorls/plant, fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = 0.98, 0.80, 0.79 and 0.99 respectively at p = 0.05). Average number of whorls/plant was significant and positively correlated with fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = 0.80, 0.79 and 0.98 respectively at p = 0.05). Fresh weight of rhizomes harvested showed perfect significant positive correlation withdry weight of rhizomes obtained (qut/ha) (r = 1.00 at p = 0.05) and it was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.77 at p = 0.05) and dry weight of rhizomes obtained (qut/ha) was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.77 at p = 0.05).

In the second year of cultivation (Table 5) days to sprout showed significant positive correlation with days to flower (r = 0.71 at p = 0.05). Days to flowering showed significant negative correlation with average height/plant (cm), average number of whorls/plant, fresh weight of rhizomes harvested (qt/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = -0.85, -0.85, -0.65, -0.65 and -0.65 respectively at p = 0.05). Average height/plant (cm) was significantly and positively correlated with, average number of whorls/plant, fresh weight of rhizomes harvested (qt/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = 0.98, 0.81, 0.81 and 0.78 respectively at p = 0.05). Average number of whorls/plant was significantly and positively correlated with fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh

Table 5. Correlation between different morphological traits of *Polygonatum verticillatum* for II year of cultivation.

Variable	Days to sprout	Days to flower	Avg. height/ plant (cm)	Avg. no. of whorls/plant	Fresh weight of rhizomes planted (qut/ha)	Fresh weight of rhizomes harvested (qut/ha)	Dry weight of rhizomes obtained (qut/ha)	Rate of fresh weight of rhizomes increased (%)
Days to sprout	1.00							
Days to flower	0.67*	1.00						
Avg. height/plant (cm)	-0.36	-0.80*	1.00					
Avg. no. of whorls/plant	-0.29	-0.79*	0.99*	1.00				
Fresh weight of rhizomes planted (qut/ha)	-0.39	0.09	-0.03	-0.14	1.00			
Fresh weight of rhizomes harvested (qut/ha)	-0.30	-0.59*	0.83*	0.80*	0.20	1.00		
Dry weight of rhizomes obtained (qut/ ha)	-0.31	-0.60*	0.83*	0.80*	0.19	1.00*	1.00	
Rate of fresh weight of rhizomes increased (%)	-0.14	-0.64*	0.82*	0.84*	-0.28	0.88*	0.89*	1.00

weight of rhizomes increased (%) (r =0.80, 0.80 and 0.74 respectively at p = 0.05). Fresh weight of rhizomes planted showed significant but negative correlation with rate of fresh weight of rhizomes increased (%) (r = -0.58 at p = 0.05). Fresh weight of rhizomes harvested showed prefect significant positive correlation with dry weight of rhizomes obtained (qut/ha) (r = 1.00 at p = 0.05) and it was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.96 at p = 0.05) and dry weight of rhizomes obtained (qt/ha) was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.96 at p = 0.05).

In the third year of cultivation (Table 6) days to sprouting showed significant positive correlation with days to flower (r = 0.67 at p = 0.05). Days to flowering showed significant negative correlation with avg. height/plant (cm), avg. no. of whorls/plant, fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = -0.80, -0.79, -0.59, -0.60 and -0.64 respectively at p = 0.05). Average height/plant (cm) was significantly and positively correlated with average number of whorls/plant, fresh weight of rhizomes harvested (qt/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = 0.99, 0.83, 0.83 and 0.82 respectively at p = 0.05). Average number of whorls/plant was significantly and positively correlated with fresh weight of rhizomes harvested (qut/ha), dry weight of rhizomes obtained (qut/ha) and rate of fresh weight of rhizomes increased (%) (r = 0.80, 0.80 and 0.84 respectively at p = 0.05). Fresh weight of rhizomes harvested showed perfect significant positive correlation with dry weight of rhizomes obtained (qut/ha) (r = 1.00 at p = 0.05) and it was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.88 at p = 0.05) and dry weight of rhizomes obtained (qut/ha) was significantly and positively correlated with rate of fresh weight of rhizomes increased (%) (r = 0.89 at p = 0.05). (Figure 1)

DISCUSSION

In all type of beds prepared in rows, furrows and plain, the yield was found to be lower under control beds as compared to litter, farmyard manure and vermi compost. In control conditions, minerals are not enough for proper growth and development of plants. Chauhan and Nautiyal (2005) found that economic yield increased with addition of manure (FYM) in all treatments as compared to control. Addition of 5 to 10 tons/ha of FYM was added to resolve nutritional problems of various hill crops and deteriorating physical condition of soil (Chauhan and Bhatt, 2000). In our study, plants grown under different treatments showed much higher economic yield as compared to control beds. However, yield was highest at T_3 (furrow + forest litter) as compared to other beds, this difference may be due to low level of mineral

Table 6. Correlation between different morphological traits of *Polygonatum verticillatum* for III year of cultivation.

Variable	Days to sprout	Days to flower	Avg. height/plant (cm)	Avg. no. of whorls/plant	Fresh weight of rhizomes planted (qut/ha)	Fresh weight of rhizomes harvested (qut/ha)	Dry weight of rhizomes obtained (qut/ ha)	Rate of fresh weight of rhizomes increased (%)
Days to sprout	1.00							
Days to flower	0.71*	1.00						
Avg. height/plant(cm)	-0.37	-0.85*	1.00					
Avg. no. of whorls/plant	-0.40	-0.85*	0.98*	1.00				
Fresh weight of rhizomes planted (qt/ha)	0.38	0.34	-0.28	-0.23	1.00			
Fresh weight of rhizomes harvested (qt/ha)	-0.29	-0.65*	0.81*	0.80*	-0.33	1.00		
Dry weight of rhizomes obtained (qt/ ha)	-0.28	-0.65*	0.81*	0.80*	-0.33	1.00*	1.00	
Rate of fresh weight of rhizomes increased (%)	-0.33	-0.65*	0.78*	0.74*	-0.58*	0.96*	0.96*	1.00

DF=10; p= 0 .05; r= 0.576. DF=10; p= 0.05; r= 0.576.

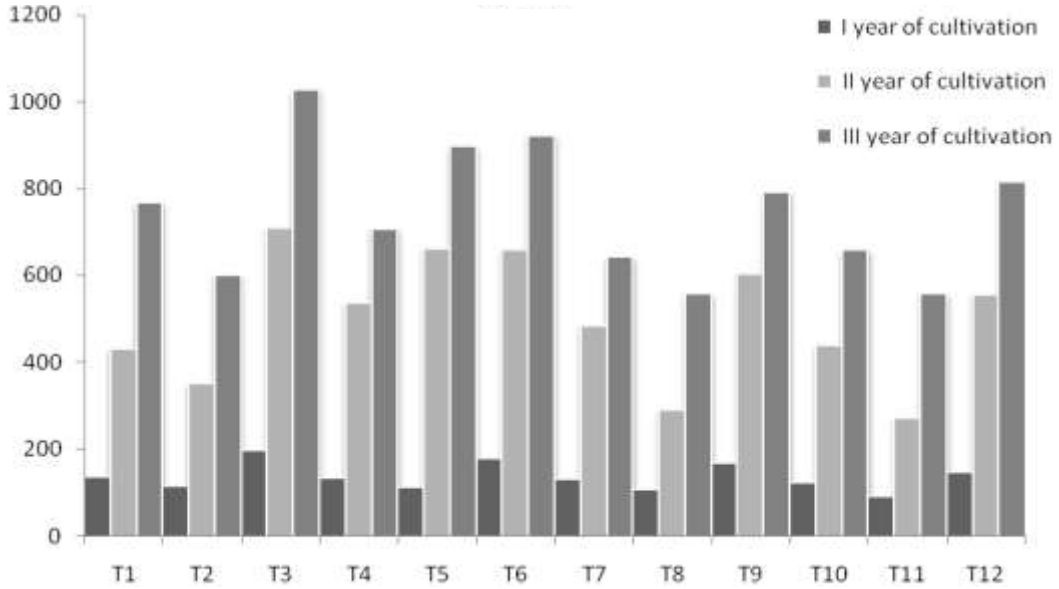

Figure 1. Showing rate of fresh weight of rhizomes increased under experimental cultivation of *P. verticillatum* in different types of treatments for first, second and third year.

nutrient in the soil. Application of FYM and forest litter in cultivated field is traditional practices in Kumaun Himalaya for the better yield and production. Several workers (Patidar and Mali, 2001; Saharan et al., 2001; Kasera and Sharan, 2002) also found increase in biomass production with the use of FYM in different crops, while in our study highest increment in biomass is obtained with the use of forest litter. Higher economic yield in manure as well as, litter beds could become possible only due to availability of essential mineral nutrients, which were needed for growth and development of the plants. Addition of manure, forest litter and vermi compost increased moisture content of soil and retained it for quite some time. It also improved physical, chemical and microbial properties of soil and thereby its productivity. Increased soil fertility enhanced vegetative growth of plants and additional food got stored in underground rhizomes, which improved economic yield of plants. Ramamurthy et al. (1998); Phirke (2001) and Sharma (2002) also supported the addition of biofertilizer for improvement of soil quality. Several studies have shown that application of organic fertilizers also reduces the incidence of soil-borne diseases and pathogens (Faqir et al., 1995; Vanlauwe et al., 1996; Sarathchandra et al., 2001; Graham and Haynes, 2005).

Generally, spacing treatment does not have any significant effect on economic yield. Spacing shows effect on biomass when population density increased at per unit area and plants compete for space, moisture, mineral nutrient or sunlight. But during short period of three years, spacing could not show significant difference in economic yield production due to low density during two-year growth, therefore we used same spacing during two growth seasons. However, spacing will certainly affect economic yield in latter stages of development due to increase in above ground and below ground surface area per plant in per unit area. Maturity stage is 7 to 8 years for high altitude species and maximum gain can be obtained by fully matured plants (Rai et al., 2000; Nautiyal et al., 2002b). Such study will require long time for fruitful result due to long maturation time.

Conclusion

From the present study, it may be concluded that the T_3 beds that is to say, beds with plantation in furrows and supplemented with forest litter shows best morphological growth and maximum yield in comparison to other treatments. The use of organic fertilizers can increase soil fertility and enhance vegetative growth of plant without leaving any harmful residue in the soil as well as in harvested rhizomes which improves quality and yield. The study shows that yield increased with addition of organic fertilizers in all treatments compared to control and the beds with plantation in furrows, supplemented with forest litter shows best morphological growth and maximum yield in comparison to other treatments. Thus, cultivation of *P. verticillatum* (L.) Allioni should be done in beds with rows and furrows (plantation in furrows) and supplemented with forest litter.

ACKNOWLEDGEMENT

The authors are thankful to Director CCRAS, New Delhi, for providing necessary facilities and encouragement. We are also thankful to Mr. Rajeev Kumar Vashishtha, working at Patanjali Yogpeeth, Haridwar, India for providing his guidance during our work.

REFERENCES

Anonymous (1969). The Wealth of India, CSIR, New Delhi. 8: 14.

Anonymous (1998). Uttaranchal Mein Jari-Butiyan: Paridrashya wa Sambhavanayain, Workshop Papers, Centre for Development Studies, U.P. Academy of Administration, Nainital, (in Hindi). 2(4) :132.

Anonymous (2008). Healing Herbs of Himalaya- A Pictorial & Herbaria Guide, C.C.R.A.S.,Dept. of AYUSH, Ministry of Health and Family Welfare, Govt. of India, Jawaharlal Nehru Bhartiya Chikitsa Evam Homeopathy Anusandhan Bhavan, New Delhi-110058.

Chauhan NS (1999). Medicinal and Aromatic Plants of Himachal Pradesh. Indus Publication Company, New Delhi.

Chauhan RS, Nautiyal MC (2005). Commercial viability of cultivation of an endangered medicinal herb *Nardostachys jatamansi* at three different agro climatic zones. Curr. Sci., 89(9): 1481-1488.

Chauhan VS, Bhatt JC (2000). Agriculture in Uttarakhand**:** From subsistence towards self-sufficiency. In- Uttarakhand statehood**:** Dimensions of Development. (Editors-. Sati MC, Sati SP). Indus Pub Co. New Delhi. pp. 168-180.

Collett H (1971). Flowering Plants of Simla and The Neighbourhood. Bishen Singh Mahendra Pal Singh, Dehradun. P. 524.

Dhar U, Rawat RS, Uprety J (2000). Setting Priorities for Conservation of Medicinal Plants- A case Study in the Indian Himalaya. Biol. Cons., 95: 57-65.

Faqir M, Bajwa MN, Nasir MA, Muhammed F (1995). Effect of different soil amendments on the incidence of common scab of potato. Pak. J. Phytopathol., 7: 202-203.

Gaur RD (1999). Flora of District Garhwal North West Himalaya, Transmedia, Srinagar Garhwal. p. 715.

Graham MH, Haynes RJ (2005). Organic matter accumulation and fertilizer-induced acidification interact to affect soil microbial and enzyme activity on a long term sugar cane management experiment. J. Biol. Fertil. Soils, 41: 249-256.

Kasera PK, Sharan P (2002). Economics of *Evolvus alsinoides* (Sankhpusphi) from Indian Thar Desert. Ann. For., 10(1): 167-171.

Kothari CR (2005). Research methodology, methods and techniques. New Age International Publisher.

Nautiyal MC, Nautiyal BP (2004). Agrotechniques of High Altitude Medicinal and Aromatic Plants. Bishen Singh Mahendra Pal Singh, Dehradun.

Nautiyal MC, Prakash V, Nautiyal BP (2002b). Cultivation technique of some high altitude medicinal herbs. Ann. For., 10(1): 62-67.

Nayar MP, Sastary ARK (1987, 1988, 1990). Red Data Book of Indian Plants. Botanical Survey of India, Calcutta. Pp. 1-3.

Patidar M, Mali AL (2001). Integrated nutrient management in sorghum (*Sorghum bicolour*) and its residual effect on wheat (*Triticum aestivum*). Ind. J. Agri. Sci., 71: 587-590.

Phirke NV (2001). Biotech inputs for improving the yield of Banana. D. Phil. Thesis. North Maharastra Univ. Jalgawn. pp. 1-154.

Rai LK, Prasad P, Sharma E (2000). Conservation threats to some important medicinal plants of the Sikkim Himalaya. Biol. Conserv., 93: 27-33.

Ramamurthy V, Sharma RK, Kothari RM (1998). Microbial conservation

of Ligno-Cellulosic waste into soil conditioner. In- Advances in Biotechnology (Editor- Pandey A). Educational Pub. NewDelhi. pp. 433-438.
Saharan P, Shkula JK, Kesera PK, Chawan DD (2001). Effect of different nutritional treatments on growth and biomass of Sankhpushpi. Ind. J. Bot. Soc., 80: 127-131.
Sarathchandra SU, Ghani AA, Yeates GW, Burch G, Cox NR (2001). Effect of nitrogen and phosphate fertilizers on microbial and nematode diversity in pasture soils. J. Biol. Biochem., 33: 953-964.
Sharma R (2002). Aushdhiya Avyam Sugandhiya Paudhon Ki Krishi Technique (Agro-technique of Medicinal and Aromatic Plants). Daya Publishing House Delhi.
Sharma SK, Chunekar KC, Hota NP (1999). Plants of Bhav Prakash Rashtiya Ayurved Vidyapittha. National Academy of Ayurveda, Ministry of Health and Family Welfare, Govt. of India. New Delhi.
Tewari KC, Bhattacharjee S (1975). Green Development of Central Himalayan Hills. Proc. Assoc. Scientific Workers (CSIR): pp. 1-4.
Tiwari KC, Tiwari RN, Pandey NK, Pandey G, Joshi GC (1992). Saving Endangered Medicinal Plant Resources of Hill. Uttarakhand, 5(3): 173-179.
Vanlauwe B, Dendooven L, Merckx R, Vanlangenhove G, Sanginga N (1996). Residue quality and decomposition of plant material under controlled and field conditions. IITA Res., 12: 1-6.
Vijyalashmi SS Shyam S (1993). Varkshayurveda-An Introduction to Indian Plant Science, LSPSS Monograph No. 9. Lok Swasthya Parampara Samvardhan Samithi, South Madras- 600086.