6. Hemanth Kumar, N. V., Narayanswamy, P. D., Theertha Prasad, Mukunda, G. K. and Sondur, S. N., Estimation of genetic diversity of commercial mango (*Mangifera indica* L.) cultivars using RAPD markers. *J. Hortic. Sci. Biotechnol.*, 2001, **76**, 529–533.
7. Karihaloo, J. L., Dwivedi, Y. K., Archak, S. and Gaikwad, A. B., Analysis of genetic diversity of Indian mango cultivars using RAPD markers. *J. Hortic. Sci. Biotechnol.*, 2003, **78**, 285–289.
8. Lopez-Valenzuela, J. A., Martinez, O. and Paredes-Lopez, O., Geographic differentiation and embryo type – Identification in *Mangifera indica* L. cultivars using RAPD markers. *Hortic. Sci.*, 1997, **32**, 1105–1108.
9. Ravishankar, K. V., Anand, L. and Dinesh, M. R., Assessment of genetic relatedness among mango cultivars of India using RAPD markers. *J. Hortic. Sci. Biotechnol.*, 2000, **75**, 198–201.
10. Ravishankar, K. V., Chandrashekara, P., Sreedhara, S. A., Dinesh, M. R., Anand, L. and Saiprasad, G. V. S., Diverse genetic bases of Indian polyembryonic and monoembryonic mango (*Mangifera indica* L.) cultivars. *Curr. Sci.*, 2004, **87**, 870–871.
11. Schnell, R. J., Ronning, C. M. and Knight, R. J., Identification of cultivars and validation of genetic-relationships in *Mangifera indica* L. using RAPD markers. *Theor. Appl. Genet.*, 1995, **90**, 269–274.
12. Srivastava, A. P., Chandra, R. and Ranade, S. A., Applicability of PCR based molecular markers for parentage analysis of mango (*Mangifera indica* L.) hybrids. *Indian J. Genet.*, 2005, **64**, 275–280.
13. Zietkiewicz, E., Rafalski, A. and Labuda, D., Genome fingerprinting by simple sequence repeat (SSR)-anchored polymerase chain-reaction amplification. *Genomics*, 1994, **20**, 176–183.
14. Gemas, V. J. V., Neves, L. O., Araújo, C. and Fevereiro, P., How can ISSR markers be useful in the management of genetic resources in a *Eucalyptus globulus* ssp. *globulus* baseline collection. In Eucalyptus in a changing World, International IUFRO Conference of the WP2.08.03 on Silviculture and Improvement of Eucalyptus, Aveiro, Portugal, 11–15 October 2004, pp. 373–379.
15. Doyle, J. J. and Doyle, J. L., Isolation of plant DNA from fresh tissue. *Focus*, 1990, **12**, 13–15.
16. Deshpande, A. U. *et al.*, Genetic diversity across natural populations of three montane plant species from the Western Ghats, India revealed by intersimple sequence repeats. *Mol. Ecol.*, 2001, **10**, 2397–2408.
17. Wetton, J. H., Carter, R. E., Parkin, D. T. and Walters, D., Demographic study of a wild house sparrow population by DNA fingerprinting. *Nature*, 1987, **327**, 147–149.
18. Ramakrishna, W., Chowdari, K. V., Lagu, M. D., Gupta, V. S. and Ranjekar, P. K., DNA-fingerprinting to detect genetic-variation in rice using hypervariable DNA sequences. *Theor. Appl. Genet.*, 1995, **90**, 1000–1006.
19. Kovach, W. L., MVSP – A multivariate statistical package for Windows, ver. 3.13, Kovach Computing Services, Wales, UK, 2002.
20. Yap, I. V. and Nelson, R. J., WINBOOT: A program for performing bootstrap analysis for binary data to determine the confidence limits of UPGMA-based dendrograms. International Rice Research Institute, Discussion Paper Series No. 14, 1996.
21. Felsenstein, J., Confidence limits on phylogenies – An approach using the bootstrap. *Evolution*, 1985, **39**, 783–791.

ACKNOWLEDGEMENTS. The Department of Scientific and Industrial Research, Government of India and Council of Scientific and Industrial Research (CSIR), New Delhi supported this work under the network programme on Cell and Tissue Engineering, to National Chemical Laboratory, Pune. We thank the staff members at RFRS, Vengurle, for maintaining the mango orchards. S.S.P thanks CSIR for Senior Research Fellowship.

Received 4 January 2007; revised accepted 9 August 2007

Economic viability of cultivation of the Himalayan herb *Angelica glauca* Edgew. at two different agro climatic zones

Rajiv Kumar Vashistha[1], B. P. Nautiyal[1,2] and M. C. Nautiyal[1,*]

[1]High Altitude Plant Physiology Research Centre, Post Box No. 14, HNB Garhwal University, Srinagar–Garhwal 246 174, India
[2]Present address: Department of HAMP, Mizoram University, Aizawl 796 001, India

***Angelica glauca* (Apiaceae), endemic to the Himalaya, is an endangered medicinal herb for which, besides *in situ* conservation, *ex situ* cultivation is also recommended. Observations were carried out for economic yield trails at two different agro-climatic zones in Garhwal Himalaya. Seedlings of different age groups were transplanted at 2200 m asl (Pothivasa, PV) and 3600 m asl (Tungnath, TN) to observe comparative yield as well as climate and land suitability for future cultivation. Yield was minimum in youngest seedlings (60-days-old) transplanted at TN in ordinary alpine soil (control) and maximum under polyhouse beds at PV after two years of growth. Results indicate that plants raised through younger seedlings (60-days-old) had minimum yield, while those raised through 90- or 120-days-old seedlings had better yield with no or very less variation in yield. In addition, economic yield was found maximum at lower altitude (PV, 2200 m) in comparison to higher altitude (TN, 3600 m). Observations on yield under different treatments at the two sites are presented here and on the basis of these observations, suggestions for commercial cultivation of the species are made.**

Keywords: Agroclimatic zone, cultivation, profit, yield.

ANGELICA *glauca* Edgew. (Choru, Gandhrayan) belonging to, family Apiaceae is a glabrous, aromatic herb, 90–190 cm in height, found in high altitudes of Himalaya (2600–3700 m asl). Roots and rhizomes of this herb are used as spices and condiments by indigenous communities[1]. The rhizomes are considered cardio-active, useful in constipation[2], for curing rheumatism and urinary disorders. The powdered root along with milk is used to treat bronchitis[3]. All parts of the herb are reported to be useful to cure stomach ailments, bilious complaints, menorrhagia, infantile atrophy and as a stimulant[2,4].

In the temperate and alpine zone of the Himalaya, increasing intensity of harvesting of medicinal plants and change in climatic conditions have adversely affected the habitats of many species, leading to a gradual loss in regeneration potential and diversity of many economically

*For correspondence. (e-mail: mcnautiyal@gmail.com)

Table 1. Soil pH and nutrient level (on % dry weight basis) in two nurseries

Nursery site	Soil depth (cm)	pH	Organic carbon	Nitrogen	Total or available phosphorus	Total or exchangeable potassium
Tungnath	0–10	4.49	3.83	0.16	0.016	0.005
	10–20	4.01	3.91	0.02	0.019	0.0049
	20–30	3.29	4.08	0.03	0.022	0.0053
Pothivasa	0–10	4.69	1.042	0.08	0.0203	0.0024
	10–20	5.01	1.002	0.23	0.0680	0.0033
	20–30	4.67	1.238	0.04	0.0073	0.024

Table 2. Experimental beds with different treatments

Treatment	Manure	Proportion (kg/sq. m/yr)
Control	–	–
Buffalo manure – 1 (BM1)	Buffalo manure	1
Leaf litter – 1 (L1)	Litter	1
Buffalo manure – 2 (BM2)	Buffalo manure	2
Leaf Litter – 2 (L2)	Litter	2
Earthing-up experiments		
Raise bed with horizontal bunds (HB)	Litter	1
Raise bed with vertical bund (VB)	Litter	1
Polyhouse beds (PB)	Manure and litter	0.5 (1 : 1)

valuable species. *A. glauca* has been categorized as an endangered species[5].

Large-scale cultivation of threatened and economically important wild plants is the most effective way to 'sustainable utilization and conservation' of biodiversity. Till date no report of cultivation is available for this species, although information is available on taxonomy, general distribution, uses and phytochemical properties[2,3]. This study is an attempt to domesticate and develop cultivation practices for *A. glauca*.

Studies were conducted in climatically and topographically different zones, viz. Tungnath (TN; 3600 m, 30°14′N lat. and 79°13′E long.), an alpine region and Pothivasa (PV; 2200 m, 30°28′N lat. and 79°16′E long.), a typical temperate region, in Rudraprayag District, Garhwal Himalaya, Uttarakhand, India. Soil characteristics of the two nurseries are given in Table 1.

For all treatments, experimental beds of 1 m × 1 m area (1.5 m × 1.5 m area for spacing beds condition) were prepared by digging or ploughing the land three–four times using the replication method, with three replicates at both sites. For organic manuring, buffalo manure commonly available in alpine during summer and the rest of the year near village fringes having forest for fodder and grazing, and leaf litter found abundantly on the forest floor were used for the present observations. Different doses of manure were used initially and different treatments were considered for further observations (Table 2). Manure was employed prior to seedling transplantation.

Seedlings of *A.glauca* were raised in a glasshouse using Styrofoam seedling containers having sand and forest litter in the ratio 2:1. Seedlings of different ages (60, 90 and 120 days old) were transplanted in the nursery beds at both altitudes in the above-mentioned treatments. Each treatment was examined for economic yield of plants at the end of every growing season for two consecutive growing seasons (October–November).

In addition, cultural practices like weed removing and irrigation were performed whenever necessary during the observation period.

To observe the economic yield of plants, underground parts of five plants from each treatment were uprooted at the end of the growing season in 2005. These plants were brought to the laboratory, washed with running water; surface-dried and fresh weight was recorded. Further, all samples were dried at 80°C for 24 h or until constant weight (at 40°C in case of seedlings) to measure dry weight (g/plant). Variation in economic yield during two consecutive years among different treatments was analysed using ANOVA.

Total investment on infrastructure development, land preparation, manure cost, irrigation facilities, harvesting, post-harvesting cost, etc. was calculated for two years. Total cost for land preparation was estimated at Rs 7500 (@ Rs 0.75/sq. m), planting cost at Rs 480 for 6 days (@ Rs 80/day), manure cost at Rs 7000 for two years in BM1 treatment and Rs 14,000 in BM2 treatment (@ Rs 35/quintal), Rs 800 for L1 and Rs 1600 for L2 (@ Rs 80/day/labour). Post-harvesting cost, including harvesting of rhizomes, drying and packing for this species was estimated at Rs 4500, besides Rs 500 as cost of insecticides. Labour charge of Rs 10,560 (@ Rs 80/day/labour) on the basis of 6 days per month for two years was also included in the cultivation cost. This includes cost of polyhouse construction as well. Plant yield was multiplied with plant density and economic yield per hectare was calculated as projected yield for different treatments. Considering the survival percentage of plants, actual yield was also calculated. Commercial viability of cultivation was calculated on the basis of expenditure on cultivation during two years for *A. glauca* and considering the present market rate of Rs 150/kg prevailing in the market of the region.

Table 3. Economic yield of *Angelica glauca* transplanted seedlings of different age groups

	Dry weight (g/plant)					
	60 Days		90 Days		120 Days	
Treatment	1st year	2nd year	1st year	2nd year	1st year	2nd year
Pothivasa nursery						
Control	0.8 ± 0.2	1.3 ± 0.3	1.3 ± 0.1	1.8 ± 0.2	2.2 ± 0.8	2.7 ± 0.8
L1	3.9 ± 1.5*	4.4 ± 1.5*	7.2 ± 2.0*	8.1 ± 2.3*	7.7 ± 2.3*	8.2 ± 1.7*
BM1	2.4 ± 0.2*	3.4 ± 0.4*	4.0 ± 2.1	4.2 ± 2.1 ns	4.6 ± 1.6	5.0 ± 1.1*
L2	–	–	7.6 ± 2.2*	8.5 ± 2.4*	–	–
BM2	–	–	4.5 ± 2.9*	4.7 ± 3.1*	–	–
PB	6.5 ± 2.6*	7.7 ± 2.9*	11.7 ± 4.7*	13.7 ± 5.2*	12.7 ± 4.9*	14.5 ± 5.3*
HB	–	–	7.8 ± 1.9*	8.2 ± 2.6*	–	–
VB	–	–	7.3 ± 1.6*	7.5 ± 1.4*	–	–
Shade	–	–	3.6 ± 0.7	3.9 ± 0.7	–	–
F-value LSD	15.4*	27.2*	5.8*	8.2*	12.8*	45.3*
	1.6	1.3	2.9	2.8	3.2	1.9
Tungnath nursery						
Control	0.4 ± 0.2	0.5 ± 0.0	0.5 ± 0.1	0.8 ± 0.2	0.5 ± 0.	0.9 ± 0.4
L1	3.1 ± 0.7*	3.4 ± 0.8*	3.9 ± 0.8*	4.5 ± 0.4*	4.2 ± 0.6*	4.4 ± 0.5*
L2	3.7 ± 0.5*	4.2 ± 0.4*	4.1 ± 0.9*	4.9 ± 0.2*	4.5 ± 0.5*	4.7 ± 0.3*
PB	4.1 ± 0.8*	4.5 ± 0.4*	5.1 ± 0.7*	6.4 ± 1.1*	5.4 ± 0.6*	6.6 ± 1.5*
HB	–	–	4.1 ± 0.8*	4.9 ± 0.2*	–	–
VB	–	–	3.8 ± 0.7*	4.4 ± 0.6*	–	–
F-value LSD	26.4*	42.3*	14.6*	36.5*	53.3*	23.9*
	0.8	0.7	1.0	0.7	0.7	1.2

*Significant at ($P < 0.05$); ±, Standard deviation.

Observations recorded for two successive growth seasons for rhizome yield of plants raised through different aged seedlings at PV are presented in Table 3. Economic yield varied with different treatments and with increased doses of manure and litter. Maximum economic yield of 6.5 g/plant was found after the first growth season and 7.7 g/plant after the second growth season in PB condition in plants raised through 60-day-old seedlings. PB condition was found to be the best for yield of rhizomes and there was nearly 67% and 76.48% increase in yield than L1 treatment, which other wise gave better yield among manure treatments. Variation in economic yield during two consecutive growth seasons was found to be significant among different treatments on the basis of ANOVA. Compared to control, yield was also found to be significant in all treatments (LSD = 1.6 and 1.3; $P < 0.05$ for first and second year respectively).

Ninety days age onwards, seedlings performed better with maximum survival. At the end of the first growth season, maximum yield of 11.7 g/plant was observed, which increased up to 13.7 g/plant after the second growth season under PB condition. Variation was found to be significant for both seasons for all treatments. Compared to control, variation was also found to be significant for L1, L2, PB, HB, VB and BM2 treatments during two growing seasons. In plants raised through 120-day-old seedlings, maximum yield was recorded (12.7 g/plant) after the first growth season which further increased by 13.77% after the second year growth in PB condition compared to manure treatments. Variation in yield was found to be significant for both growth seasons on the basis of ANOVA. However, compared to control (LSD = 3.2 and 1.9; $P < 0.05$), yield improved significantly only in L1 treatment and PB condition during the first growth season, while it improved significantly in all treatments after the second growth season.

Yield of crops raised through seedlings of different ages was also observed at TN. As in the case of PV nursery, economic yield varied in different treatments during the two growth seasons. PB condition produced maximum economic yield of 4.1 and 4.5 g/plant respectively, for two consecutive growth seasons of crop raised through 60-day-old seedlings (Table 3). PB condition was also found to be the best for maximum yield in the case of crops raised through 90 and 120-day-old seedlings. Yield reached up to 6.4 g/plant in crops raised through 90-day-old seedlings and 6.6 g/plant with 21.97% increment by the end of the second growth season in the crops raised through 120-day-old seedlings. In addition, all treatments showed significant improvement in yield during the first and second growth seasons compared to control (Table 3).

In general, results indicate that plants raised through 60-days-old seedlings had minimum yield, while those raised through either 90- or 120-days-old seedlings had better yield, with no or very less variation in yield. Thus seedlings of age beyond 90 days can be recommended for transplantation for commercial cultivation. In addition, economic yield was also maximum at lower altitude (PV, 2200 m) in comparison to higher altitude (TN, 3600 m). These observations suggested that lower altitude, up to

Table 4. Commercial viability of *A. glauca* crop in Pothivasa nursery

Treatment	Cultivation cost (Rs/ha)	Projected production (kg/ha)	Projected value (Rs/ha)	Projected benefit (Rs/ha)	Actual production (kg/ha)	Actual value (Rs/ha)	Actual benefit (Rs/ha)
Crops of 60-day-old seedlings							
Control	16,040	63.50	9,525	–6515	37.63	5,644.5	–10,395.5
L1	16,840	219.00	32,850	16,010	149.64	22,446	5,606
BM1	23,040	162.50	24,375	1,335	111.03	16,654.5	–6385.5
PB	19,940	386.50	57,975	38,035	322.07	48,310.5	28,370.5
Crops of 90-day-old seedlings							
Control	16,040	92.00	13,800	–2240	61.33	9,199.5	–6,840.5
L1	16,840	404.00	60,600	43,760	336.65	50,497.5	33,657.5
BM1	23,040	212.00	31,800	8,760	169.50	25,425	2,385
L2	17,640	426.00	63,900	46,260	354.98	53,247	35,607
BM2	30,040	236.00	35,400	5,360	196.65	29,497.5	–542.5
PB	19,940	683.00	102,450	82,510	626.10	93,915	73,975
HB	16,840	410.50	61,575	44,35	342.06	51,309	34,469
VB	16,840	375.50	56,325	39,485	294.12	44,118	27,278
Shade	16,840	193.00	28,950	12,110	157.62	23,643	6,803
Crops of 120-day-old seedlings							
Control	16,040	136.00	20,400	4,360	95.20	14,280	–1760
L1	16,840	408.00	61,200	44,360	339.98	50,937	34097
BM1	23,040	251.50	37,725	14,685	205.40	30,810	7770
PB	19,940	722.50	108,375	88,435	662.31	99,346.5	79,406.5

2200 m, is suitable for commercial cultivation than alpine sites – (TN in the present observations) native to *A. glauca*.

Age of seedlings at the time of transplantation influenced yield and viability of crops. In the PV nursery, plants transplanted at the age of 60 days have projected profit of Rs 16,010/ha in L1, Rs 1335/ha in BM1 and Rs 38,035/ha in PB. However, based on plant survival and actual yield, profit was recorded at Rs 5606/ha in L1 and Rs 28,370.5/ha in PB. Plants raised through 90-day-old seedlings had minimum projected profit of Rs 5360/ha in BM2 and maximum Rs 82,510/ha in PB condition by the end of the second year. However maximal actual profit of Rs 73,975/ha was found in PB and minimum, Rs 2385/ha in BM1. Projected profit by the end of the second year in crops raised through 120-day-old seedlings at this site was maximum of Rs 88,435/ha in PB, and minimum of Rs 4360/ha in control. However, actual profit was recorded between Rs 7770 and 79,406.5/ha in these conditions at the end of the second year. Comparatively, actual net profit was recorded maximum from the plants raised by 120-day-old seedlings in PV nursery (Table 4).

In TN nursery, projected profit by the end of the second year recorded a minimum of Rs 8810/ha in L1, and a maximum of Rs 13,960/ha in PB crop, raised through transplanting 60-day-old seedlings. Contrary to this, actual profit was recorded with a maximum of Rs 2095/ha in PB. Projected profit of Rs 16,910/ha in L1, Rs 19,710/ha in L2, Rs 28,285/ha in PB, Rs 19,685/ha in HB, and Rs 16,160/ha in VB was observed at the end of the second year through 90-day-old seedlings. Actual profit was recorded at Rs 17,834.5/ha in PB and minimum at Rs 4610/ha in VB. Likewise, projected profit by the end of the second year was calculated between Rs 29,185/ha in PB and Rs 15,935/ha in L1 crops raised through 120-day-old seedlings. Maximum actual profit was recorded at Rs 19,360/ha in PB and minimum at Rs 5555/ha in L1 at TN nursery (Table 5).

During the course of the present observations, economic yield was enhanced by the addition of manure and litter in both the nurseries. Earlier studies also suggested addition of 5–10 tons/ha of farmyard manure (FYM) to resolve nutritional problems of various hill crops and deteriorating physical conditions of the soil[6–10]. Application of FYM in cultivated fields is a traditional practice in Garhwal Himalaya for better yield and production. Further, yield was higher at PV (2200 masl) compared to TN (3600 masl). Higher economic yield at PV could be possible due to favourable environment, long growth period (April–November) and favourable temperature regimes, whereas low level of mineral nutrients in alpine soil may contribute to low yield[11]. Further, with increase in manure and litter concentration, economic yield again increased at both PV and TN. Higher economic yield with higher doses of manure as well as litter could be due to supply of essential mineral nutrients, proper aeration and availability of moisture for longer periods, which is necessary for better growth and development. It also improved microbial properties of the soil and thereby its productivity. Similar observations have also been made earlier by several workers[12–14].

Plants grown under polyhouse condition at TN showed much higher economic yield compared to nursery beds. Such increase in productivity of plants may be due to in-

Table 5. Commercial viability of *A. glauca* crop in Tungnath nursery

Treatment	Cultivation cost (Rs/ha)	Projected production (kg/ha)	Projected value (Rs/ha)	Projected benefit (Rs/ha)	Actual production (kg/ha)	Actual value (Rs/ha)	Actual benefit (Rs/ha)
Crops of 60-day-old seedlings							
Control	16,040	26.00	3,900	–12140	7.36	1,104	–14,936
L1	16,840	171.00	25,650	8810	102.60	15,390	–1,450
L2	17,640	211.00	31,650	14010	130.12	19,518	1,878
PB	19,940	226.00	33,900	13960	146.90	22,035	2,095
Crops of 90-day-old seedlings							
Control	16,040	37.50	5,625	–10415	15.62	2,343	–13,697
L1	16,840	225.00	33,750	16,910	153.74	23,061	6,221
L2	17,640	249.00	37,350	19,710	190.94	28,641	11,001
PB	19,940	321.50	48,225	28,285	251.83	37,774.5	17,834.5
HB	16,840	243.50	36,525	19,685	166.38	24,957	8,117
VB	16,840	220.00	33,000	16,160	143.00	21,450	4,610
Crops of 120-day-old seedlings							
Control	16,040	43.00	6,450	–9,590	20.06	3,009	–13,031
L1	16,840	218.50	32,775	15,935	149.30	22,395	5,555
L2	17,640	237.00	35,550	17,910	181.70	27,255	9,615
PB	19,940	327.50	49,125	29,185	262.00	39,300	19,360

creased temperature condition and long growth period (early emergence and late senescence) compared to open environment where low temperature restricted early growth and frosting caused earlier senescence. Temperature is the most important factor in different phenological phases[15]. Plants under polyhouse condition sprouted 15 days earlier and senescence was also delayed by 15 days compared to nursery-grown plants. Similar results for polyhouse-grown plants of *Aconitum* species have also been reported earlier[16].

In addition, economic yield of the species also increased significantly under ridge/bund conditions at TN as well as PV, with maximum yield under horizontal ridge as reported earlier[7,17]. Alpine site earthing up in ridges escaped plants from waterlogging and thus increased survival of plants and economic yield. However, at lower altitudes plain beds are better for cultivation[18] compared to ridged fields or polyhouse.

1. Collet, H., *Flora Simlensis, A Hand Book of the Flowering Plants of Shimla and Neighbourhood*, Bishen Singh Mahendra Pal Singh, Dehradun, 1980.
2. Anon., *The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. Vol. I: A* (revised), 1985, pp. 275–276.
3. Gaur, R. D., *Flora of the District Garhwal North–West Himalaya* (*With Ethnobotanical notes*), Transmedia , Srinagar (Garhwal), 1999.
4. Chopra, R. N., Nayar, S. L. and Chopra, I. C., *Glossary of Indian Medicinal Plants*, Publication and Information Directorate, CSIR, New Delhi, 1956.
5. CAMP Workshop, Shimla, 22–26 May 2003.
6. Chauhan, V. S. and Bhatt, J. C., Agriculture in Uttarakhand: From subsistence towards self-sufficiency. In *Uttarakhand Statehood: Dimensions of Development* (eds Sati, M. C. and Sati, S. P.), Indus Pub Co New Delhi, 2000, pp. 168–180.
7. Chauhan, R. S. and Nautiyal, M. C., Commercial viability of cultivation of an endangered medicinal herb *Nardostachys jatamansi* at three different agro climatic zones. *Curr. Sci.*, 2005, **89**, 1481–1488.
8. Patidar, M. and Mali, A. L., Integrated nutrient management in sorghum (*Sorghum bicolor*) and its residual effect on wheat (*Triticum aestivum*). *Indian J. Agric. Sci.*, 2001, **71**, 587–590.
9. Saharan, P., Shkula, J. K., Kesera, P. K. and Chawan, D. D., Effect of different nutritional treatments on growth and biomass of Sankhpushpi. *Indian J. Bot. Soc.*, 2001, **80**, 127–131.
10. Kasera, P. K. and Sharan, P., Economics of *Evolvus alsinoides* (Sankhpusphi) from Indian Thar Desert. *Ann. For.*, 2002, **10**, 167–171.
11. Chapin, F. S., The mineral nutrient nutrition of wild plants: A review. *Ecol. Syst.*, 1980, **11**, 233–260.
12. Ramamurthy, V., Sharma, R. K. and Kothari, R. M., Microbial conservation of ligno-cellulosic waste into soil conditioner. In *Advances in Biotechnology* (ed. Pandey, A.), Educational Publ., New Delhi, 1998, pp. 433–438.
13. Phirke, N. V., Biotech inputs for improving the yield of banana. D Phil thesis, North Maharastra University, Jalgawn, 2001, pp. 1–154.
14. Sharma, R., *Aushdhiya Avyam Sugandhiya Paudhon Ki Krishi Technique* (Agro-technique of Medicinal and Aromatic Plants), Daya Publishing House, Delhi, 2002.
15. Holway, J. G. and Ward, R. T., Phenology of alpine plants in northern Colorado. Ecology, 1965, **46**, 73.
16. Nautiyal, M. C. and Purohit, A. N., Cultivation of Himalayan Aconites under polyhouse conditions. *Curr. Sci.*, 2000, **78**, 1062–1063.
17. Nautiyal, M. C., Cultivation of medicinal plants and biosphere reserve management in alpine zone. In *Conservation and Management of Biological Resources in Himalaya* (eds Ramakrishnan, P. S. *et al.*), GBPIHED and Oxford and IBH, New Delhi, 1994, pp. 570–582.
18. Nautiyal, B. P., Prakash, V., Chauhan, R. S., Purohit, H. and Nautiyal, M. C., Assessment of germinability, productivity and cost–benefit analysis of *Picrorhiza kurrooa* cultivated at lower altitude. *Curr. Sci.*, 2001, **81**, 579–585.

ACKNOWLEDGEMENTS. We thank Prof. A. N. Purohit, former Director and Prof. A. R. Nautiyal, Director HAPPRC, Srinagar–Garhwal for providing facilities and encouragement. Financial support from DBT, New Delhi, National Medicinal Plants Board (NMPB), Ministry of Health and Family Welfare and CSIR, New Delhi is acknowledged.

Received 23 November 2006; revised accepted 20 August 2007