EX-SITU CULTIVATION OF MEDICINAL PLANT SPECIES IN HIGH ALTITUDES AT SWAT, PAKISTAN

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Abstract

An ex-situ experiment was conducted to evaluate the growth performance of six medicinal plant species (*Bergenia ciliata, Crocus sativa, Dioscorea deltoidea, Paeonia emodi, Polygonum amplexicaule* and *Viola serpense*) at four different locations in upper Swat valley during 2000-2001. The altitude of these locations ranged from 1200 to 1900 m.a.s.l. Suitability of ex-situ cultivation of these medicinal plant species and their economic feasibility was also worked out. The highest mean survival percentage of 80.7 across location was observed for *V.serpense* followed by 58.7 % for *C. sativa*. All the remaining four species exhibited very poor survival percentage. Except for *V. serpense* which revealed a decrease in sprouting percentage with increase in altitude, all other species indicated a positive relationship with altitude. More or less an increased trend in flower yield with increasing altitude for *C. sativa* and *V. serpense* was also observed. Cultivation of only two species, *C. sativa* and *V. serpense*, under farmland conditions at upper Swat appeared successful and economically viable.

Keywords: Ex-situ cultivation, Medicinal plant species, High altitudes, *Bergenia ciliata, Crocus sativa, Dioscorea deltoidea, Paeonia emodi, Polygonum amplexicaule, Viola serpense.*

Introduction

Any plant that contains chemical substances in one or more of its parts like root, leaves, stem, flower, fruit or seed which can be used for therapeutic purposes or serve as starting material for chemical pharmaceutical synthesis is medicinal plant (Khan, 1991). Man has been using various plants to cure diseases and provide relief from sufferings since time immemorial. The primitive people of all ages had knowledge of medicinal plants which they acquired as a result of long experience of trial and error. The knowledge is still alive and many of the plants are still used as herbal remedies in indigenous medicine system (Khan, 1985). Lange (1998) reported that some medicinal and aromatic plants like *Lavendula spp, Carum carvi, Foeniculum vulgare, Thymus vulgare, Althaea rosea* etc. are cultivated over an estimated area of 70,000 ha in the European Union and playing a significant role in its economy.

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Similarly, 100 species of medicinal plants are currently in cultivation in Peruvian Amazon region. Some of them are processed for making powders, ointments and other plant extracts. Goel *et al.* (1997) studied ex-situ conservation of *Encephalortus* species in botanical garden at Lakhnawo, India. They evaluated their economic value, horticultural importance, propagation, cultivation, ecology and conservation needs. Joshi and Rawat (1999) reported that medicinal and aromatic plants of alpine and sub-alpine areas of North-West Himalayas had been rapidly depleted and becoming rare due to deforestation, over-grazing and over-exploitation. They recommended an urgent need for ex-situ and in-situ conservation of such endangered medicinal plant species in various parts of Himalayan regions including Swat.

Traditionally forests and rangeland are the main sources of medicinal plants in Pakistan. However, heavy and persistent extraction of medicinal plants has resulted in depletion of existing population of many valuable species. At present most of them can be seen growing scattered in remote areas (Hussain and Sher, 1998). Khan (1989) has reported that medicinal species such as *Dioscorea deltoidea, Saussurea lappa* and *Colchicum luteum* were rapidly depleting and would become endangered in the near future. Being wild vegetation, their management and cultivation was neglected in the past. This factor too accelerated wiping out of medicinal plant species. However growing awareness about the importance of medicinal plants at national and international level has urged for conservation and cultivation of these valuable plant species. In Pakistan, a few attemps have been made for ex-situ cultivation of condiments and spices. For instance, Zaidi (1998) has conducted trials for ex-situ cultivation of 14 condiments and spices in various parts of Punjab and in plains of NWFP. Likewise, he also worked on the cultivation of *Althaea rosea* in Peshawar valley.

Nevertheless, too limited information is available on the cultivation aspect of medicinal plant species in district Swat an area rich with such type of vegetation. The present study was therefore, initiated to evaluate the cultivation prospects of important medicinal plant species, viz. *Bergenia ciliata, Crocus sativa, Dioscorea deltoidea, Paeonia emodi, Polygonum amplexicaule* and *Viola serpense* and to assess their economic feasibility for their commercial cultivation.

Materials and methods

A field study was conducted for ex-situ cultivation of 6 medicinal plant species namely, *Bergenia ciliata, Crocus sativa, Dioscorea deltoidea, Paeonia emodi, Polygonum amplexicaule* and *Viola serpense* at four locations on farmers' fields in high altitudes of Swat valley during 2000-2001. The locations were

Gurrha, Chinkoli, Shingrai and Biakand with altitudes of 1200, 1400, 1600 and 1900 meters above sea level (m.a.s.l), respectively. Selection criteria of plant species were 1) they have high commercial value and over exploited in the area 2) becoming rare due to indiscriminate destruction of their natural habitat because of urbanization, 3) the local people were interested in their cultivation. The criteria for selection of sites were 1) people in these locations were interested in cultivation of medicinal plants, 2) in the vicinity an area under in-situ study was existed for comparison and reference and 3) these locations had well managed forest plantation as well as altitudinal variation (1200 to 1900 m.a.s.l.).

Rhizomes of *Paeonia emodi, Bergenia ciliata, Polygonum amplexicaule* and *Dioscorea deltoidea* were collected from the Shinko alpine pasture of Madyan. Furnished planting material was sown in the following day of field collection. The rhizomes were cut into small pieces (4 to 6 cm in size) with 2 to 3 active buds. *Viola serpense* was collected from village Biakand (its natural habitat) and replanted in the experimental plots. Bulbs of *Crocus sativa* were obtained from Agricultural Research Station, Mastung, Quetta during September, 2000 and planted in the experimental sites soon after shifting.

The plot size for each species was consisted of 3 X 3 meters at each location. Planting was carried out during mid-September, 2000 on a well prepared soil mixed with Farm Yard Manure. For *Crocus sativa* and *Viola serpense*, plant to plant distance was 4 cm and row to row 8 cm. For the remaining four species row-row and plant-plant distance was 30 cm and 15 cm, respectively. Soil analysis of each location was also carried out in the Soil Testing Laboratory of Agricultural Research Station, North Mingora, Swat.

Weeds were controlled by hand picking and hoeing during December, 2000 and April - May, 2001. Data were recorded for various parameters like number of days for 50 % sprouting, sprouting percentage, survival percentage, number of days from sprouting to flowering, plant height and yield of useable plant parts (rhizomes, shoots, leaves, flowers etc.). Harvesting of *C. sativa* and *V. serpense* was done during the months of April - May, 2001 while rhizomatous species, i.e. *P. emodi, B. ciliata, P. amplexicaule* and *D. deltoidea* were harvested in September - October, 2001.

Data were analyzed statistically using analysis of variance (ANOVA) procedures for multi-location experiment by MSTAT-C computer program. Individual means were compared using Least Significant Difference (LSD) test at 5 % probability level (Steel and Torrie, 1980).

Economic analyses of yield data were carried out to determine the net income for each medicinal plant species using prevailing market rates for land rent, costs of production and prices of useable plant parts of respective plant species. Two most widely cultivated cereal crops, *viz.* wheat & maize and a cash crop, tobacco were included for economic comparison.

Results

Data regarding plant growth, flowering and yield for six medicinal plant species under farm land conditions at four locations in Swat and their means across locations are presented in tables 1 to 5. Medicinal plant species varied significantly among themselves for sprouting duration and sprouting percentage within and among locations (Table 1). Although, most species took longer time to sprout at higher altitudes than that of low altitudes but that difference was statistically non-significant. A similar trend for increased sprouting percentage was also observed with respect to altitudinal height except *V. serpense* which showed a decreasing trend with the increment of altitude.

C. sativa took mean minimum number of days (29 days) and was significantly different from other test species. Sprouting duration of this species was the least (25 days) at Shingrai. The highest mean sprouting of 80% was observed for *P. amplexicaule* followed by *V. serpense* (75 %) and significantly different from all other under trial species. *D. deltoidea, P. emodi* and *B. ciliata* displayed very poor sprouting, i.e. 3.7 %, 6.2 % and 8.5 %, respectively.

Significant difference among species for survival after sprouting was observed (Table 2). *V. serpense* exhibited the highest survival (mean 81.8 %) followed by *C. sativa* (mean 58.7 %) and were significantly different from all other test species. Survival percentage of *D. deltoidea, B. ciliata* and *P. emodi* was very poor under farmland conditions (0.2 %, 1.7 % and 3.7 %, respectively) across the locations.

Overall significant difference was recorded among species for days to flowering after sprouting (Table 3). *C. sativa* and *P. amplexicaule* were significantly late in flowering as compared to other species. A general trend of delayed flowering of species with increase in altitude was found.

Variation among species for plant height was significantly high across the locations as well as within a location (Table 4). *P. amplexicaule* had the highest mean value of 37.2 cm followed by *P. emodi* Plant height of these two etc. species was comparatively more at Chinkoli and Shingrai as compared to other two locations. *C. sativa* attained a maximum plant height of 19 cm at Shingrai.

Yield data (rhizome, flower and leaf/shoot) for the six medicinal plant at four test locations are given in table 5. Due to poor sprouting and/or no survival, no rhizome yield for *D. deltoidea* at any of the four sites was obtained. Similarly, *P. emodi* failed to give any rhizome yield at 3 out of 4 sites. Whereas, *Bergenia ciliata* was found to have no rhizome at two locations (Chinkoli & Biakand). In case of *P. amplexicaule* yield was a reverse trend in exhibited. Maximum (1386 kg $^{ha-}$1) and minimum (853 kg ha^{-1}) rhizome yield, was recorded at 1900 m.a.s.l and 1200 m.a.s.l., respectively. Moreover, flower yield of *V. serpense* increased from 373 kg/ha at 1200 m.a.s.l (Gurrha) to 533 kg/ha at 1900 m.a.s.l (Biakand), while there was no such trend of increased flower yield with altitude was evident in *C.sativa*. Escalation of shoot/leaf yield of *V. serpense* with increasing in altitude was similar to its flower yield.

Results of economic analyses of the data indicated that only two out of six medicinal plant species (*C. sativa* with net income of Rs. 18,930 and *V. serpense* with net income of Rs. 27,810) had higher net income than that of cereal crops (Rs.13,440 net income for maize and Rs.15000 for wheat). However, all the test species were less profitable than the cash crop (tobacco).

Table 1. Days to sprouting and sprouting percentage for different plant species at four locations under farmland conditions at Swat.

Species	Days to Sprouting					Sprouting Percentage				
	Locations					Locations				
	Gurrha	Chin koli	Shingrai	Biakand	Means	Gurrha	Chin koli	Shingrai	Biakand	Means
B. ciliata	160	160	170	165	164^{b}	4	5	5	20	8.5^{c}
C. sativa	35	35	25	20	29^{c}	20	70	90	40	55.0^{b}
D. deltoidea	170	170	150	190	170^{eb}	0	3	7	5	3.7^{c}
P. emodi	160	165	165	175	166^{ab}	5	5	5	10	6.2^{c}
P. amplexicaule	165	175	175	175	173^{ab}	70	80	80	90	80.0^{a}
V. serpense	170	175	175	190	178^{a}	90	75	75	60	75.0^{ab}
LSD					11.58					22.38

Figures in the mean coloumn sharing same alphabets are non-significant among themselves (P.0.05).

Table 2. Survival percentage of different medicinal plant species at locations under farmland conditions at Swat

Plant Species	Locations				
	Gurrha	Chinkoli	Shingrai	Biakand	Means
Bergenia ciliata	6	0	0	0	1.7^{c}
Crocus sativa	57	17	71	90	58.7^{b}
Dioscorea deltoidea	0	0	1	0	0.2^{c}
Paeonia emodi	0	0	0	15	3.7^{c}
Polygonum amplexicaule	15	10	15	20	15.0^{c}
Viola serpense	84	80	88	75	81.8^{a}
L.S.D					19.19

Figures in the mean coloumn sharing same alphabets are non-significant among themselves (P.0.05).

Table 3. Number of days to flowering after sprouting of different medicinal plant species at four locations under farmland conditions at Swat

Plant Species	Locations				
	Gurrha	Chinkoli	Shingrai	Biakand	Means
Bergenia ciliata	18	0	22	0	10.0^{b}
Crocus sativa	35	35	35	30	33.7^{a}
Dioscorea deltoidea	0	0	0	0	0.0^{b}
Paeonia emodi	0	0	0	30	7.5^{b}
Polygonum amplexicaule	25	35	25	40	31.3^{a}
Viola serpense	10	10	10	15	11.3^{b}
L.S.D (0.05%)					13.35

Figures in the mean coloumn sharing same alphabets are non-significant among themselves (P.0.05).

Table 4. Plant height (cm) of different medicinal plant species at four locations under farmland conditions at Swat

Plant Species	Locations				
	Gurrha	Chinkoli	Shingrai	Biakand	Means
Bergenia ciliata	15	0	20	0	8.8^{b}
Crocus sativa	13	13	19	15	15.0^{ab}
Dioscorea deltoidea	0	0	0	0	0.0^{b}
Paeonia emodi	0	0	0	70	17.5^{ab}
Polygonum amplexicaule	35	40	40	35	37.2^{a}
Viola serpense	11	15	18	14	14.5^{ab}
L.S.D (0.05%)					23.42

Figures in the mean coloumn sharing same alphabets are non-significant among themselves (P.0.05).

Table 5. Rhizome / flower / Shoot yield (kg/ha) of different medicinal plant species at four locations under farmland conditions at Swat

Plant species	Plant Organ	Locations				
		Gurrha	Chinkoli	Shingrai	Biakand	Means
Bergenia ciliata	Rhizome	96	0	49	0	36.3
Crocus sativa	Flower	21	16	24	5	16.5
Dioscorea deltoidea	Rhizome	0	0	0	0	0.0
Paeonia emodi	Rhizome	0	0	0	90	22.5
Polygonum amplexicaule	Rhizome	853	1066	709	1386	1003.5
Viola serpense	Flower	873	320	533	426	413.0
Viola serpense	Shoot/Leaf	1066	746	1280	960	1013.0
L.S.D						23.42

Table 6. Economic analysis of yield data of different medicinal plant species versus Cereal and Cash crops at four different locations under farmland conditions at Swat

Plant Species	Yield (kg/ha)	Sale Rate (Rs/kg)	Income/ha (Rs/kg)	Cost/ha (Rs/ha)	Net Income (Rs/ha)
A. Medicinal Plants					
B. ciliata	90	30	2700	31680	-28980
C. sativa	24	3000	72000	53070	18930
D. deltoidea	0	30	0	31680	-31680
P. emodi	90	20	1800	31680	-29880
P. amplexicaule	1386	20	27720	31680	-3960
V. serpense	533*,1280**	100#,4.8$	59,444	31680	27764
B. Cereal Crops					
Maize	5760	8	46080	32640	13440
Wheat	4800	10	48000	33000	15000
C. Cash Crop					
Tobacco	2162	30	64860	34000	30860

*: Flower Yield **: Leaf/Shoot Yield #: Sale Rate of Flower
$: Sale Rate of Shoot

Table 7. Physical and chemical properties of soils of four experimental locations at Swat.

Location	Altitude (m.a.s.l)	$CaCO_3$	Organic Matter	PH	Textural Classes	WHC (%)	N (%)	P (%)	K (%)
Gurrha	1200	0.27	3.61	7.3	Silt loam	23.11	5.7	4.2	5.3
Chinkoli	1400	0.49	4.91	7.0	Silt loam	22.24	6.9	6.9	7.
Shingrai	1600	0.86	2.31	7.5	Sandy loam	21.20	3.6	3.7	4.4
Biakand	1900	0.36	4.62	7.4	Silt loam	19.11	6.2	7.1	7.7

WHC – Water Holding Capacity

Discussion

The differential sprouting percentage and number of days from sowing to sprouting of medicinal plant species at four locations indicate that habitat factors such as altitude, temperature, soil, water, air and time of sowing generally affect the germination. All of the test species have taken more time for sprouting at the

higher elevations than at lower elevations. This agrees with the results of Onwuerne (1973) who stated that *D. deltoidea* and *B. ciliata* sprouted late at high altitude due to snow and cool weather conditions. The present findings are also in agreement with those of Goel, *et al.* (1997) who reported that *D. deltoidea, C. luteum* and *B. ciliata* sprouted in early spring at high altitude when the air and soil temperatures were low. The study shows that *C. sativa* has taken minimum number of days for sprouting in sandy loam soil and maximum number of days in silt clay soil. Similar results were obtained by Khan (1998) who reported that sandy soil and dry climate is more suitable for saffron cultivation.

In present study, *V. serpense* indicates better sprouting percentage in early spring (March/ April). These findings agree with those of Khan (1989) and Zaidi (1998) who reported that seed germination/sprouting of several Umbellifers and *V. serpense* responded positively to cold temperatures in the early spring. The sprouting percentage of *D. deltoidea, B. ciliata* and *P. emodi* under farmland conditions is poor. These results disagree with those of Verlet and Lecleroq (1997) who reported that farmland habitats are favorable and suitable for some medicinal plants like *V. officinale* and *R. serpentiana.* This descripancy of results may be due to different plant species and ecological conditions.

Among six medicinal plant species, *D. deltoidea, B. ciliata* and *P. emodi* almost fail to survive under farmland conditions nearly at all test locations. This might be due to shallow and poor soil and non availability of the nursing species that are commonly present in nature (in-situ conditions). Joshi and Rawat (1999) also observed that alpine medicinal plants such as *C. luteum, D. deltoidea* and *P. emodi* prefer to grow in forest habitat having humus rich soils and high moisture content. Khan (1989) reported that perennial medicinal plant species like *Lavetaria, Dioscorea, Saussurea* and *Podophyllum* grow best in humus rich soil with high pH value.

The under trial medicinal plant species flower earlier in lower elevations than that at higher elevations. Lower temperatures at higher elevations can be the plausible explanation for delayed flowering of these species. The present findings are in corroboration with those of Thakur and Bhatt (1980) who reported that plants remain dormant for longer period and exhibit delayed flowering primarily due to low temperatures at higher elevations. Zaidi (1998) reported that low temperature treatment delay flowering in *Althaea rosea.* Our findings also conform with those of Singh, *et al* (1998) where they found that due to low temperature at high altitudes, the alpine medicinal plants remain dormant in early spring (March/ April) which intern flowering until May and June.

The plant height of *P.* amplexicaule and *V. serpense* is maximum in shady habitat with sufficient soil moisture at Chinkoli. This agrees with findings of Khan (1995) who reported that plant height of the alpine medicinal plants was greatly affected by the fertility and moisture contents of the soil. *C. sativa* attaines maximum plant height in dry and sandy soil at Shingrai. Khan (1998) had also reported that sandy soil and dry climate were more suitable for saffron cultivation.

The rhizome yield of *P. amplexicaule.* the flowers/leaves yield of *V. serpense* and flower/stigma of *C. sativa* are not very much encouraging despite their survival at farm land. However, *D. deltoidea, P. emodi* and *B. ciliata,* more or less failed to survive. This may be attributed to unfavorable soil and environmental conditions during growth period. This agrees with the findings of Joshi and Rawat (1999) who observed that, beside other factors, fertility of the soil affected the productivity of medicinal plant species.

The economic analyses of yield data reveal that *V. serpense* and *C. sativa* have good economic potential for supplementing the farmers' income. These two species appear more economical as compared with cereals crops in Swat. The short growing period of these medicinal plant species coupled with their high market value in relation to cereal or cash crop of the area can be an added advantage in their commercial production. Zaidi (1998) reported that cultivation of *Althaea officinales* has good potential for supplementing the farmers' income as compared to other crops. Similar results were also reported by Khan (1998). Fuller (1991) long ago described methods of cultivation of *Colchicum autumunale* to supplement cash income of the farmers in the USA.

Conclusion

Based on the results of present investigation, it is concluded that these perennial medicinal plant species as such can not be recommended for cultivation as cash crops on farmlands in upper Swat. However, their Ex-situ propagation on the margins of the farmlands, in-situ protection, management and conservation in their natural habitat can be more fruitful.

References

Fuller, D. 1991. Medicines from the wild. TRAFFIC. USA. Washington D.C. In Lewington, A. (1993) Ed. Med. plants and plants extracts. A review of their importance into Europe TRAFFIC International, Cambridge, U.K. 101- 111.

Goel, A.K., S. G. Sharma and A.S. Rajendran 1997. Ex-situ conservation of Encephalortus lehm in Botanic garden, National Botanical Research Institute, Lukhnawo, India. Indian J. of Fores: 20(3): 259-264.

Hussain, F. and H. Sher. 1998. Income generation from the trade and cultivation of wild medicinal plants. Distt. Swat. Proc. of wild plants resources of Northern Pakistan. Pak. Forest Instt. Peshawar, Pakistan. May 11-12, 1998. PP: 41-48.

Joshi, D.I.V. and C.S. Rawat 1999. Need for conservation and propagation of alpine medicinal plants. Indian. J. of Forest;123 (9):811-814.

Khan, A.A. 1985. Marketing of natural Drug plants of Pakistan. Pak. Jour. Forest, 26(2): 131-139.

Khan, A.A. 1989. Propagation and regeneration technology of pharmacopoeial medicinal plants of temperate regions of Pakistan. Pak. Forest. Instt. Peshawar, Pakistan. Bulletin No. 3.

Khan, A.A. 1991. Marketing of herbal drugs and its problems, Proc. Nat. Worksh. NIH. Islamabad, Pakistan. November 20-21, 1991, PP: 69-72.

Khan, M. 1995. Report of participatory rural appraisal on agriculture at Bayun, Kalam. A joint Pak/Swiss Govt. Venture. PP: 11-20.

Khan, M.H. 1998. Biodiversity of medicinal and economic plants in Northern Himalayan region, Azad Kashmir. Proc. of wild plant resources of Northern Pakistan. Pak. Forest. Instt. Peshawar, Pakistan. May 11-12, 1998. PP: 6-10.

Lange, D. 1998. European medicinal and aromatic plants, their uses, trade and conservation. TRAFFIC Inter-Cambridge. U.K. PP: 20-21.

Onwuerne, I.C. 1973. Sprouting process in Dioscorea spp., tuber pieces. Jour. Agric. Sci., 88(2): 375-379.

Singh, V.K., Z.A. Ali and M.K. Siddiqui, 1998. Folk Medicinal plants of the Gorhwal and Kuman forests of Uttar Pradesh, India. Hamdard Medicines, 40: 35-47.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics. A biometrical Approach. 2nd ed., McGraw-Hill Book Co., New York.

Thakur, R.N. and B.K. Bhatt, 1980. Phytophthora root rot of *Atropa belladonna* in Kashmir valley. Indian Jour. Mycol. and Plant pathol., 9(1): 82-89.

Verlet, N. and G. Lecleroq, 1997. Towards a model of technical and economic optimization of specialist minor crops converted action AIR.3 CT 94, 2076. 1995-96. Commission European Direction General del' Agric. D.G VI F. II.3.

Zaidi, S.H. 1998. Cultivation of condiments and spices in Punjab and Pakistan. Pak. Forest. Instt. Peshawar, Pakistan. Bulletin No. 3. PP: 14-24.