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Domestication and conservation of *Incarvillea emodi* – a potential ornamental wild plant*

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Incarvillea emodi (Wallich ex Royle) Chatterjee, is erect, unbranched, glabrous, perennial flowering herb with woody base. The flowering shoots are leafless (Hooker 1978). It has terminal, one-sided clusters of large pinkish-purple tubular flowers having yellow throat and have high potential for ornamental and medicinal purposes. The species is not common and low frequencies of *I. emodi* have been observed in nature (Sharma and Kachroo 1981, Dhaliwal and Sharma 1999). In the explored area it is occasionally found in crevices of rocks and therefore the taxon is listed among the rare plants of Himalayan region (Singh and Sharma 2006). Reproduction and regeneration of *I. emodi* in nature is slow due to ecological and morphological factors. It grows on steep slopes of mountains which are prone to frequent land slides. Further, pollination is entomophilous, and in the absence of suitable pollinator insects, pollination may not take place resulting in failure of fruit and seed set.

The Himalayan and Hengduan mountains are the centres of diversity of the genus *Incarvillea*, which comprises 15 species distributed in eastern and central Asia. The 4 sub-genera in the genus *Incarvillea* Juss. include *Amphicome*, *Incarvillea*, *Pteroscleris* and *Niedzwedzkia*. *Incarvillea emodi* (Wallich ex Royle) Chatterjee belongs to the sub-genus *Amphicome*. Most of the other related species occur in China but the distribution of *I. emodi* is restricted to Himalayan regions of Afghanistan, Pakistan, India and Nepal (Polunin and Stainton 1985, Bailey 1976). In India, the species is found at elevations ranging from 700 to 2 700 m in Chamba district (Singh and Sharma 2006) and 1 200 to 2 000 m in Kullu district of Himachal Pradesh (Dhaliwal and Sharma 1999). In the present study, plants were collected from Bhanjraru area of Chamba district of Himachal Pradesh at an altitude around 1 570 m for domestication at this Institute, which is located at an elevation of 1 320 m, 32°68'N latitude and 76° 38'E longitude.

I. emodi also has medicinal value and used for the treatment of mentally agitated patients and curing side effects of medicines. A compound, an orthorhombic polymorph of myo-inositol ($C_6H_{12}O_6$), has been obtained from the aerial part of the plant (Khan *et al*. 2007). Development of cultural practices will play significant role in conservation and utilization of *I. emodi* as an ornamental and medicinal plant.

The plants of *I. emodi* were collected from their natural habitats and planted in pots under polyhouse (fan-pad cooled) conditions at the Institute to observe their response to domestication process. All the collected plants were morphologically characterized, studied with respect to pollination biology and evaluated for their performance under polyhouse and field conditions. Suitable cultural practices and seed production techniques were also developed for cultivation and conservation of *I. emodi*. Colour description of flowers was done using RHS (Royal Horticultural Society) colour chart (1995).

During the first 2 years of domestication process, no fruit formation was observed under polyhouse conditions. Therefore, artificial pollination was carried out and seed set was obtained successfully. The average seed germination recorded during 2006 and 2007 was 75% and 71.66%, respectively. Potting mixture of well decomposed farmyard manure, sand and soil in 1 : 1 : 1 ratio was used throughout the experiment for seed sowing, planting and repotting of seedlings, cuttings and split plants for plant growth, flowering and seed production. Cuttings were raised during rainy season. Terminal shoots of 5–12 cm were cut and 2–4 pairs of lower leaves were removed from the selected cuttings, leaving 1–2 cm long stem which was inserted in the moist sand bed for rooting. Sand bed was kept moist throughout the rooting period for successful rooting of the cuttings. The success of rooting in cuttings was up to 80%.

Based on phenology it was observed that flowering in domesticated plants of *I. emodi* commences in the spring season and on an average continues for 68 days. The flowers of *I. emodi* were observed to be attractive 3.8–5.5 cm long,

*Short note

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Table 1 Year-wise performance of *Incarvillea emodi* in pots for different morphological traits (2003–04 to 2005–06)

Plant no.	No. of days first flower remain fresh			Duration of f lowering (days)			Flowering shoots/ plant			Flowers/ shoot			Flowers/ plant			Average length of flowering shoots (cm)			Plant height (cm)		
	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06	2003–04	2004–05	2005–06
1	6	7	8	89	23	93	9	4	6	12.0	14.0	19.5	108	56	117	26.1	17.4	24.0	50.0	34.0	50.0
2	6	7	8	76	78	109	5	9	7	15.2	13.9	11.9	76	125	83	15.5	18.3	23.1	45.5	37.0	42.0
3	12	6	8	66	27	102	8	7	6	11.0	12.7	18.3	88	89	110	19.1	16.8	27.3	35.4	39.0	59.0
4	11	6	6	89	17	87	11	2	7	10.3	6.0	16.3	113	12	114	15.0	6.5	21.0	55.2	20.0	45.0
5	17	8	6	61	53	106	5	7	6	10.0	9.4	17.7	50	66	106	21.2	14.1	30.0	35.3	37.0	41.0
6	8	7	8	24	75	81	1	10	3	8.0	10.5	18.3	8	105	55	26.0	13.2	26.7	26.5	29.0	46.0
7	5	6	7	15	94	87	1	8	6	10.0	9.6	18.8	10	77	113	20.0	16.0	21.2	30.5	33.0	43.0
8	13	9	8	70	62	77	4	9	6	13.8	13.1	14.8	55	118	89	29.5	17.1	20.0	40.5	35.0	32.0
9	10	7	6	47	43	81	4	4	8	12.5	15.0	15.3	50	60	122	29.5	22.6	25.5	33.0	36.0	51.0
10	9	12	5	62	100	66	4	12	5	14.0	13.7	12.4	56	164	62	26.8	16.9	21.6	39.0	58.0	39.0
11	6	8	5	50	98	101	3	11	6	8.6	13.6	15.7	26	150	94	31.3	18.7	29.2	32.2	56.0	48.0
12	7	11	4	32	86	78	2	10	6	11.5	13.9	15.0	23	139	90	33.5	20.1	31.3	26.2	32.0	47.0
13	6	8	5	43	40	63	3	6	5	8.0	14.3	18.2	24	86	91	33.0	18.8	23.2	29.5	38.0	43.0
Mean	8.9	7.8	6.0	56	61	87	5.0	7.6	6.0	11.1	12.3	16.3	52.8	96	96	25.1	16.7	24.9	36.8	37	45.1

pinkish-purple 'RHS 78D' with tubular structure, having yellow throat 'RHS 14A' (Fig 1). The position of anthers in flowers is around the style, nearly 2–3 cm below the stigma and inside the corolla tube. The pollen sacs of anthers are placid and do not rupture during anthesis. There are spines on the undersurface of pollen sacs which require mechanical movement to rupture the pollen sacs and release of pollen. It is hypothesized that under natural conditions, insects (honeybees, syrphids etc.) which collect pollen and nectar, possibly enter the corolla tube and rub against the spine of pollen sac resulting in release of pollen and subsequent pollination of the stigma. Pollinator-induced anther dehiscence in *I. emodi* has also been confirmed by recent observations under *ex situ* conditions (Verma *et al*. 2008). Further, either low population size of the pollinator insects or scattered distribution of plants in nature providing little visual attraction have led to restricted spread of the species in nature. In a recent exploration (first and second week of April 2008) by the author in 7 districts of Himachal Pradesh at altitudes ranging from 540 to 3 220 m it was found in only one location at an altitude of 1 053 m, which conforms with earlier observations regarding its rare and occasional occurrence in nature (Sharma and Kachroo 1981, Dhaliwal and Sharma 1999, Singh and Sharma 2006).

Two experiments were conducted to evaluate fully grown plants, cuttings and seedlings. In the first experiment, performance of 13 plants of *I. emodi* collected from their natural habitat was evaluated in pots over 3 years (2003–04 to 2005–06). The plants were repotted in fresh soil mixture every year to sustain the growth of plants. Observations were recorded on the number of days first flower remains fresh, duration of flowering in days, flowering shoots/plant, flowers/shoot, flowers/plant, average length of flowering shoots and plant height (cm) and their mean values were calculated. Data were analyzed using F-test. In the second experiment (2005–06), 25 seedlings grown in pots under polyhouse conditions were compared with 25 field grown seedlings as well as 51 plants raised by cuttings in pots under polyhouse conditions for morphological traits. The average yearly temperature during 2005–06 were 24.6/13.8 (max./ min. °C) and humidity 61% in field, and 25.6/16.5 (max./ min. °C) and 71.8% humidity in the polyhouse, respectively. The data were analyzed using Student's t-test. Pooled standard deviations were used for the test in the former case (comparison of 25 seedlings each under polyhouse and field conditions), whereas common standard deviation were used (comparing mean performance of 25 seedlings with 51 cuttings under polyhouse condition) in the latter case.

Mean values for all the traits over 3 years is presented in Table 1. Based on analysis of variance no significant variation was observed among plants for most of the traits under observation (Table 2). Low variations were observed for morphological traits among plants in the present study. Lack of variation for different traits in the population may be

Table 2 Analysis of variance of morphological traits of *Incarvillea emodi* plants over 3 years in pots

Source of variations	df	Mean square values						
		No. of days first flower remain fresh	Duration of flowering (days)	Flowering shoots/plant	Flowers/ shoot	Flowers/ plant	Average length of flowering shoots (cm)	Plant height (cm)
Plants	12	5.45	325.63	2.26	3.49	487.08	40.43	53.87
Years	2	19.79	3628.95	29.41	96.00*	8026.69	305.32*	281.06
Error	24	6.35	650.81	9.49	2.868	1508.8	14.31	84.78

*P=0.05

Table 3 Comparison of morphological traits of *Incarvillea emodi* seedling plants grown under polyhouse and field conditions

	No. of days first flower remain fresh	Duration of flowering (days)	Flowering shoots/plant	Flowers/ shoot	Flowers/ plant	Average length of flowering shoots (cm)	Plant height (cm)
X1	6.64	55.72	1.88	13.44	23.44	22.72	33.84
X2	6.96	32.84	2.72	8.43	22.28	14.69	23.22
Difference	0.32	22.88	0.84	5.01	1.16	8.03	10.62
Pooled SD	1.21	2.91	1.20	3.67	11.79	5.00	5.99
t (calculated)	0.90	27.20*	0.20	4.72*	0.34	5.55*	6.13*
t (tabulated)	1.96	1.96	1.96	1.96	1.96	1.96	1.96

*P=0.05

X1, Mean performance of 25 seedlings grown in polyhouse; X2, mean performance of 25 seedlings grown in field

Fig 1 (a) Flowers of *Incarvillea emodi*; (b) Seed pod formation (c) Rooting in stem cuttings (d) Flowering in stem cuttings

Table 4 Comparison of morphological traits of *Incarvillea emodi* seedling plants and cuttings grown under polyhouse conditions

	No. of days first flower remain fresh	Duration of flowering (days)	Flowering shoots/plant	Flowers/ shoot	Flowers/ plant	Average length of flowering shoots (cm)	Plant height (cm)
X1	6.64	55.72	1.88	13.44	23.44	22.72	33.84
X3	6.64	109.05	6.00	16.21	94.35	21.93	37.41
Difference	0.00	53.33	4.12	2.77	70.91	0.79	3.57
Common SD	2.79	25.65	1.43	4.47	26.12	5.77	7.53
t (calculated)	0.00	8.47*	11.78*	2.53*	11.10*	0.55	1.93
t (tabulated)	1.96	1.96	1.96	1.96	1.96	1.96	1.96

*P=0.05

X1, Mean performance of 25 seedlings grown in polyhouse; X3, mean performance of 51 cuttings grown in polyhouse

considered as an impediment in fitness of the population and thereby making *I. emodi* vulnerable to the vagaries of nature as well as endangering its natural existence. Two of the traits, viz flowers/shoot and average length of flowering shoots showed significant variations over years suggesting influence of environmental conditions on these traits. These two traits responded differentially over years suggesting their phenotypically plastic behaviour to varying environmental conditions. Perennial plant species exhibit such growth behaviours in response to climatic variations over years and account for adaptive feature of the species. However, for the widespread prevalence in nature, it is the genetic variations in the species which confer fitness to the population. *I. emodi* is considered to be a primitive species in the genus *Incarvillea* and its distribution is scarce and restricted to rocky regions of the western Himalaya compared to other related species in the family Bignoniaceae (Chen *et al*. 2004).

In the second experiment, polyhouse-grown seedling plants were significantly superior for duration of flowering in days, flowers/shoot, average length of flowering shoots and plant height as compared to seedlings grown under field conditions (Table 3). However plants raised by cuttings performed significantly better under polyhouse conditions compared with the seedling plants (Table 4). Under controlled conditions the study suggests better prospects of plants raised through cuttings as compared to seedling plants.

SUMMARY

Evaluation studies indicate that *I. emodi* is a potential ornamental plant, which can be utilized as indoor flowering and foliage pot plant because of its beautiful pink flowers, year-round shining green foliage and is also suitable as a bedding plant for gardens at shady places. Low variations were observed among the collected plants for different morphological parameters evaluated, while 2 of the traits, viz flowers/shoot and average length of flowering shoots exhibited variations over the years but not among the plants evaluated. The plants performed better under polyhouse as compared to field conditions and further under controlled conditions the study indicates better prospects of plants raised through cuttings as compared to seedling plants. The present studies of domestication reveal that *I. emodi* can be successfully conserved by seed production and vegetative multiplication of shoot cuttings for their utilization as an ornamental and medicinal plant.

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