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Production technology for endangered medicinal plants of Kashmir Himalayas II. Cultivation profile of *Inula racemosa* Hook.f.

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Production technology of *Inula racemosa* Hook.f., an endangered medicinal plant has been standardized for commercial exploitation in the farmer's field. The crop plants were raised through transplantation of seedlings during the months of November-December and early March with a planting density of 40,000 plants/ha. Besides, planting geometry, the nutritional requirements vis-a-vis crude production of the crop have been worked out. The optimum yield of the crude drug was obtained by supplementing the crop with 200 kg of nitrogen, 150 kg of phosphorus and 50 kg of potassium/ha. Resource allocation pattern worked out for the crop indicated that maximum biomass is accumulated with rootstocks during the month of October and therefore harvesting of the crude drug should be accomplished in this month.

Keywords: Cultivation, Endangered, Kashmir Himalayas, Medicinal plants, *Inula racemosa* Hook.f.

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Introduction

Inula racemosa Hook.f. is one of the important but threatened herbs being beneficial for cardiovascular system, angina, dyspnea and general health of individuals. The main phytochemical ingredients of the herb include: alantolactone, isoalantolactone, dihydroisoalantolactone, β-sitostyerol, daucosterol and inunolide. Alantalactone is strongly anthelmintic, antiseptic, expectorant and diuretic. The alantolactone obtained from roots of *I. racemosa* Hook.f. enhances insulin sensitivity and thus proves beneficial in fat reduction[1]. Isoalantolactone possesses antimicrobial activity[2]. Roots of *I. racemosa* Hook.f. are also useful in treating pulmonary and cardiovascular disorders[3]. The seeds of the species are bitter and aphrodisiac. The herb finds use in a large number of preparations including pushkarmuladi churna, dev darvadi kwatha, sudarshan-churna, punarnand mandoor, puskavedi churna and bukuvadi churma etc. Due to its multipurpose uses, the herb has been wild-harvested indiscriminately resulting in the extirpation of its populations in nature. The herb can however be revived by attempting its cultivation into regular farming systems. This has already been done in some related species like *I. helenium* L. where the introduction into cultivation was reported to have no adverse effects on the accumulation or physical properties of the essential oil[4]. Though some cursory observations on the cultivation of *I. racemosa* Hook.f. have been made earlier[5], yet a complete cultivation profile of the herb is lacking. Successful attempt however, has been made to work out the cultivation strategy in another species of the genus *Inula* i.e., *I. helenium* L.[6].

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Materials and Methods

Meteorological observation

The study has been conducted under temperate climatic conditions having average minimum temperature 2.22 to 3.55 °C in the month of January during all the three years (2009-2011). The mercury showed a maximum increase in the months of July-August with average temperatures reaching upto 24 °C. The relative humidity oscillated between 55.85 and 81.63 %. Data regarding precipitation and evaporation recorded all along these years are presented in Table 1.

Physico-chemical evaluation

The trials were laid on the Shalimar campus of the University. The soil of the experimental site was clayey loam in texture with a pH of 7.10; electrical

Table 1—Meteorological data pertaining to Shalimar Campus

Month/Year	Temperature (°C)			Relative humidity (%)			Precipitation (mm)			Evaporation (mm)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
January	2.5	3.63	3.11	81.63	68.00	77.35	2.97	1.23	1.30	0.35	0.27	0.21
February	4.7	6.01	3.82	77.84	67.00	55.85	1.79	0.41	4.21	0.84	0.41	0.16
March	8.2	9.54	9.70	68.18	61.00	62.60	2.09	1.48	3.51	0.50	1.85	1.82
April	14.5	14.03	13.16	62.43	64.56	67.16	0.89	2.46	2.44	2.58	2.78	3.02
May	21.62	20.17	17.81	61.40	60.09	63.01	0.79	1.5	1.18	4.69	4.47	4.5
June	25.04	26.41	28.19	64.72	68.05	65.30	1.38	2.13	2.94	4.66	4.99	5.31
July	27.40	29.30	30.00	73.16	71.90	70.35	2.07	3.07	0.53	5.48	5.90	5.78
August	24.51	26.38	26.30	71.10	72.00	76.46	1.01	0.68	2.18	5.37	5.51	5.37
September	20.70	20.44	21.19	71.45	66.05	73.43	0.97	2.02	1.32	4.58	4.30	3.75
October	14.98	15.60	17.68	63.35	67.00	75.45	0.00	0.34	0.76	2.73	3.11	2.70
November	9.68	8.10	9.16	70.55	75.10	67.56	0.40	1.49	0.00	1.70	1.36	1.82
December	04.70	5.12	4.52	75.40	68.35	75.67	0.66	0.61	0.00	0.38	0.44	0.63

conductivity: 250 ds/m; organic Carbon: 1.05; ex.ca. 11.50 cmol (P^+) Kg/ha; ex.Mg. 3.60 cmol (P^+) Kg; available N: 350 Kg/ha; available P: 18.0 Kg/ha; available K: 325 kg/ha and av. S: 7.60 ppm.

Results and Discussion

The cultivation schedule

Sowing Time

Seed sowing was done at regular fortnightly intervals during two consecutive growing seasons. Optimum sowing time was computed on the basis of parameters like days taken to seed germination, days taken to seedling maturation (transplantation stage), percentage seed germination and field survival (Fig. 1, 2). Pre-winter sown seeds did not exhibit any evidence of germination before the outset of spring months whence the germination took place during March. The seedlings however, acquired the transplantation stage during the last week of April or mid May. Percentage of seed germination oscillated between 75 and 90 % for sowings affected before the month of August (Fig. 3). Afterwards, the germination potential was considerably lowered (25-30 % seed germination observed). Seeds sown in underground cellars took lesser time to germinate and reach the transplantation stage. The seedlings may therefore, be raised in underground cellars during winter months and transplanted in the field during early spring.

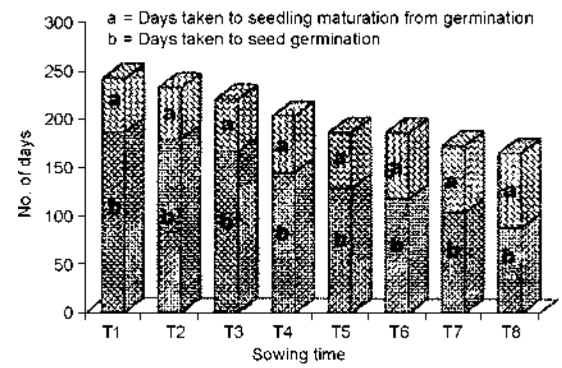

Fig. 1—Standardization of sowing time in *I. racemosa* Hook.f. (pre-winter sowing).

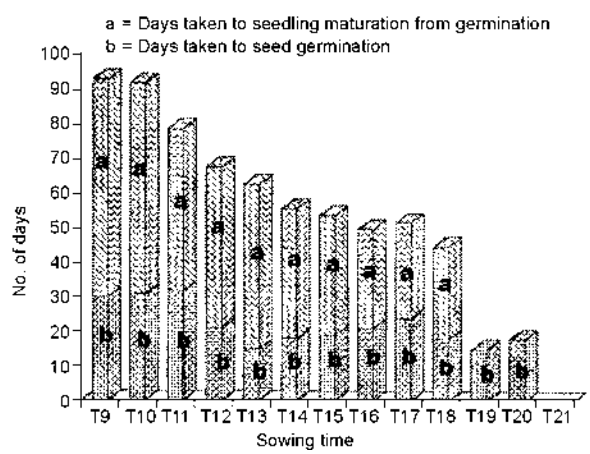

Fig. 2—Standardization of sowing time in *I. racemosa* Hook.f. (post-winter sowing).

Planting geometry

The crop was grown at three density levels (i.e., 40,000; 60,000 and 80,000 plants/ha). Data reveal that on an average the lowest density level (i.e., 40,000 plants/ha) proved significantly superior over others in term of all the parameters tested (Table 2). As such the stature of the plants, their spread, fresh and dry biomass production exhibited downward trend with increase in planting density (Fig. 4, 5).

The crude drug production ranged from 601.90±27.21 to 1753.50±51.03 g/plant. However, on dry weight basis the biomass production was maximum (501.11± 31.54 g/plant) at the minimum density of 40,000 plants/ha. Based on dry matter accumulation in the rootstocks, the plants may therefore be grown at this density level.

Nutritional requirements

Optimization of fertilizer schedule is one of the essential criteria for commercialization of any crop. As such four levels of nitrogen (50, 100, 150 and 200 kg/ha), three levels of phosphorus (50, 100 and 150 kg/ha) together with a uniform dose of potassium (50 kg/ha) were tested for their influence on the growth performance of this crop.

Stature of the plants

The plants attained a height in the range of 193.02±14.0 cm (in control) to 261.05±10.91 cm when supplied with highest levels of fertilizer ($N_{200}P_{150}K_{50}$ kg/ha). This treatment however, produced effects similar to that of $N_{200}P_{150}K_{50}$ kg/ha.

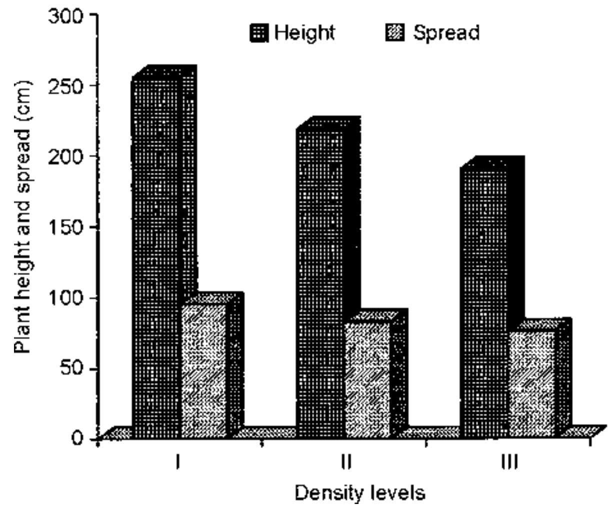

Fig. 4—Influence of different planting densities on growth *I. racemosa* Hook.f.

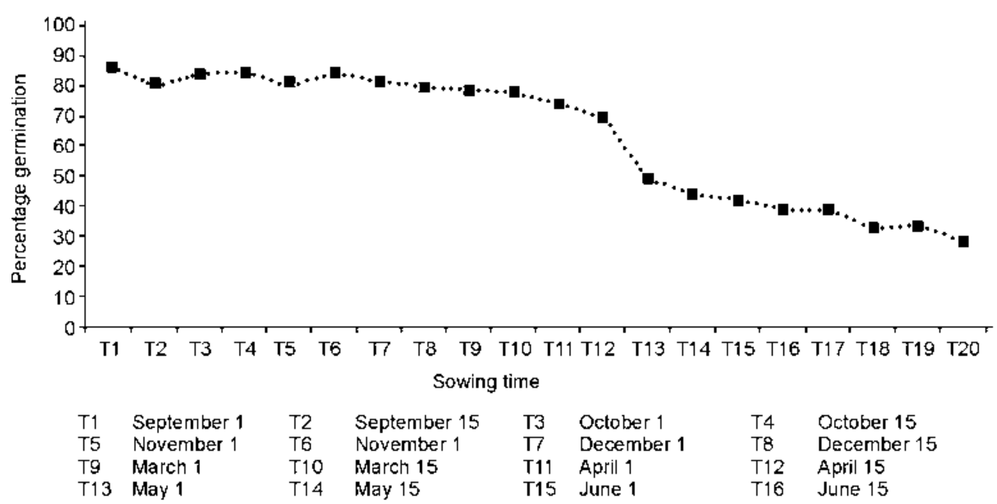

Fig. 3—Percentage of seed germination in *I. racemosa* Hook.f.

Table 2—Influence of planting densities on crop production in *I. racemosa* Hook.f.

Density level	Plant stature (cm)	Plant spread (cm)	Biomass (g/plant) Fresh	Biomass (g/plant) Dry
I	255.37 ± 33.21	95.2 ± 12.42	1753.50 ± 51.03	501.11 ± 31.54
II	218.32 ± 22.13	82.71 ± 11.50	967.12 ± 39.29	330.01 ± 27.23
III	190.14 ± 19.92	75.82 ± 9.01	601.90 ± 27.21	209.19 ± 20.19

Spread of plants

Maximum fertilizer levels ($N_{200}P_{150}K_{50}$) resulted in lush growth and plants exhibited a maximum spread of 97.4±7.60 cm/plant which equals more than two fold increase over the control.

Crude drug production

Fresh biomass

Maximum biomass of the rootstocks (1786.97±14.71 g/plant) was obtained at highest fertilizer level compared to a minimum of 1067.23±20.10 g/plant in case of control (Table 2).

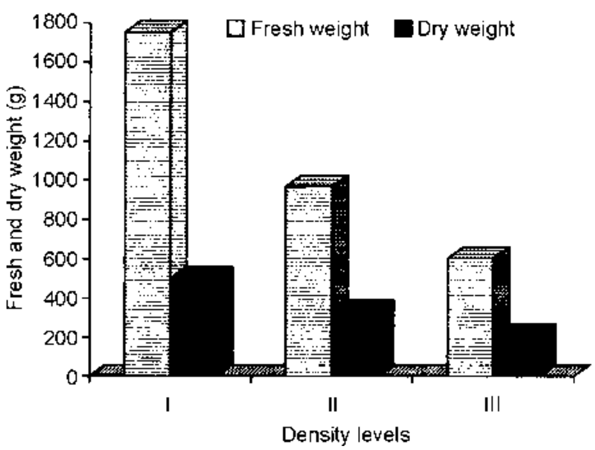

Fig. 5—Influence of different planting densities on crude drug production of *I. racemosa* Hook.f.

Dry biomass

On a dry weight basis the crop revealed highest biomass production (510.23±17.32 g/plant) at $N_{200}P_{150}K_{50}$ kg/ha (Table 3); thus displaying a 45 % increase over control wherein plants were grown without any exogenous supply of fertilizers.

Harvesting schedule

The plants enter into the reproductive phase of development during the second year of growth as is even true of *I. grandiflora* Willd.[7]. The harvesting schedule was standardized on the basis of dry matter (crude drug) production based on periodic harvests carried out during two consecutive growing seasons (Table 4).

Data reveals that plants continue to allocate resources towards the rootstocks till their senescence. During the first year, dry matter production reached the level of 149.7±3.80 g/plant. However, during the subsequent year, the crude drug production increased to as much as 394.5±14.7 g/plant (Fig. 6, Plate 1). Therefore, the crop accumulates maximum biomass in the rootstocks towards the end of October under temperate climatic conditions. It has been reported that the yield increases whereas the essential oil content decreases with age in case of *I. helenium* L.[4].

Table 3—Influence of different fertilizer levels on crude drug production of *I. racemosa* Hook.f.

S. No.	Treatment	Plant stature (cm)	Plant spread (cm)	Crude drug production (g/plant)	
				Fresh biomass	Dry biomass
1.	$N_1P_1K_1$	223.14± 19.93	45.14 ± 4.22	1228.14 ± 20.50	421.12 ± 20.01
2.	$N_1P_2K_1$	227.02 ± 17.21	43.23 ± 6.21	1430.14 ± 20.27	430.17 ± 16.72
3.	$N_1P_3K_1$	229.35 ± 19.73	46.11 ± 9.01	1467.34 ± 10.72	440.10 ± 13.21
4.	$N_2P_1K_1$	232.17 ± 16.21	47.15 ± 4.32	1687.10 ± 12.84	458.22 ± 15.21
5.	$N_2P_2K_1$	240.29 ± 21.12	51.22 ± 8.95	1691.19 ± 19.12	460.93 ± 6.49
6.	$N_2P_3K_1$	242.15 ± 13.29	54.43 ± 6.24	1709.02 ± 20.17	470.47 ± 14.19
7.	$N_3P_1K_1$	251.70 ± 12.85	58.77 ± 9.70	1720.14 ± 17.21	480.95 ± 13.72
8.	$N_3P_2K_1$	255.18 ± 25.12	63.03 ± 8.21	1734.12 ± 12.29	487.74 ± 7.95
9.	$N_3P_3K_1$	256.99 ± 18.79	65.14 ± 5.47	1749.27 ± 20.99	499.18 ± 11.74
10.	$N_4P_1K_1$	257.28 ± 17.72	79.12 ± 6.59	1751.14 ± 29.30	500.19 ± 11.74
11	$N_4P_2K_1$	259.37 ± 13.74	83.32 ± 8.74	1760.17 ± 27.29	507.29 ± 10.19
12.	$N_4P_3K_1$	261.05 ± 10.91	97.4 ± 7.60	1786.97 ± 14.71	510.23 ± 17.23
13.	$N_0P_0K_0$	193.02 ± 14.01	41.54 ± 5.43	1067.23 ± 20.10	350.13 ± 10.24

Table 4—Resource allocation pattern in *I. racemosa* Hook.f.

Treatments	Biomass production (g/plant)	
	Fresh	Dry
T_1	1.10 + 0.18	0.11 +0.02
T_2	1.14 + 0.30	0.13 + 0.01
T_3	1.34 + 0.38	0.33 + 0.01
T_4	8.77 + 0.38	2.20 + 0.26
T_5	11.25 + 1.08	2.20 + 0.12
T_6	47.72 + 1.53	9.07 + 1.11
T_7	96.35 + 4.50	21.68 + 2.69
T_8	162.60 + 2.99	45.52 + 3.08
T_9	254.55 + 2.82	64.75 + 4.07
T_{10}	263.62 + 5.79	76.20 + 4.46
T_{11}	384.97 + 0.80	112.92 + 5.73
T_{12}	401.42 + 2.10	149.70 + 3.80
T_{13}	543.47 + 1.32	184.22 + 2.14
T_{14}	544.12 + 2.12	185.00 + 2.98
T_{15}	544.05 + 4.53	185.05 + 1.92
T_{16}	212.43 + 12.12	44.96 + 8.97
T_{17}	229.43 + 11.87	51.80 + 10.88
T_{18}	435.10 + 13.59	85.56 + 14.20
T_{19}	488.73 + 22.97	102.93 + 21.80
T_{20}	568.30 + 24.60	122.80 + 13.70
T_{21}	645.43 + 24.30	167.03 + 25.20
T_{22}	817.70 + 31.98	209.53 + 12.30
T_{23}	850.23 + 33.21	231.20 + 14.90
T_{24}	938.10 + 34.92	243.42 + 23.20
T_{25}	1058.56 + 43.98	266.40 + 21.40
T_{26}	1143.50 + 43.67	299.82 + 23.40
T_{27}	1247.13 + 49.67	384.60 + 22.99
T_{28}	1252.21 + 41.21	388.20 + 15.80
T_{29}	1260.10 + 22.77	394.50 + 14.70

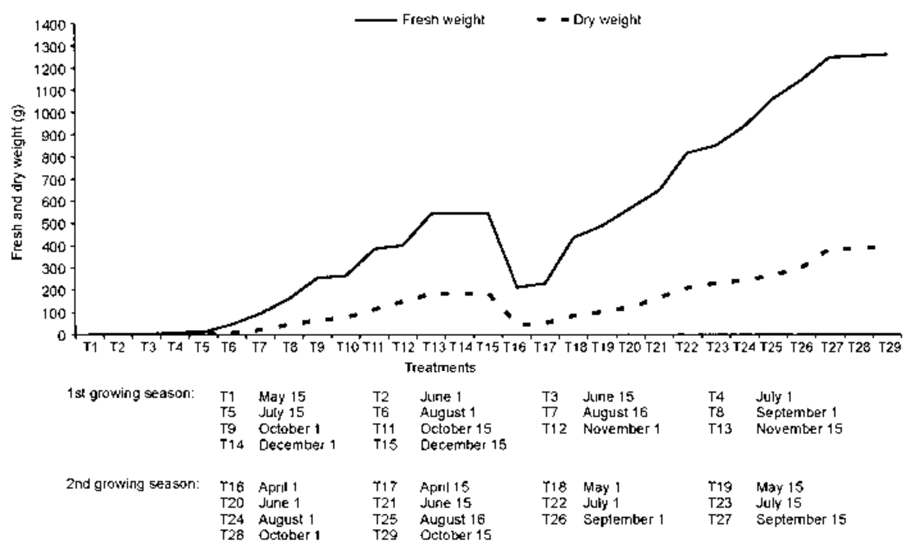

Fig. 6—Resource allocation pattern in relation to crude drug (rootstock) production in *I. racemosa* Hook.f.

Plate 1—The drug (source of genuine) of commerce - as it appears after second year of crop growth.

Conclusion

An overview of the cultivation schedule of *I. racemosa* Hook.f. under temperate climatic conditions is provided. The crop may be raised by sowing the seeds during the months of November-December or early March. Transplantation is recommended during spring season and the crop is to be grown at a planting density of 40,000 plants/ha. In order to obtain optimum yield, the crop may be supplied with fertilizers @ $N_{200}P_{150}K_{50}$ kg/ha and the crude drug may be harvested during the month of October.

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