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Nature of variability and character associations for cone and seed characteristics in *Pinus roxburghii* Sargent plus trees

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Abstract

Forty nine plus trees from the distributional range of *Chir* pine falling in different forest divisions of Himachal Pradesh were selected for growth form and high resin yield. Data were recorded on cone and seed characteristics and statistically analysed. The result showed significant variation for all the traits studied. Genetic coefficient of variation (GCV), phenotypic coefficient of variation (GCV), heritability estimates and genetic advance as per cent of mean were found higher for cone weight, seeds/cone and 100-seed weight. Seed length, seed thickness, seed width, cone width and cone weight reflected positive direct effect on 100-seed weight whereas, cone length and seed per cone showed negative direct and indirect effect via other traits. The study revealed that seed length, seed width, seed thickness, cone length, cone width and cone weight are important characters which showed direct effect on 100-seed weight.

Key words : *P. roxburghii*, *chir* pine, variability, character associations, heritability

Introduction

Chir pine (*Pinus roxburghii* Sargent) is one of the most important pines of Himalayan region. It occurs from Baluchistan in the west to Sikkim in the east, through Pakistan, India and Nepal, from an altitude of 600 m to 1800 m under varying climatic, topographic and edaphic conditions. Under certain conditions of soil like quartzite, it extends up to 2400m elevation in Himalaya. The species yields valuable timber and pulpwood and is the main source of oleo-resin which is used for production of rosin, turpentine oil, camphor and a host of chemical byproducts. Due to wide range of distribution of this species, there is a great variation in its growth form, resin yield and quality from locality to locality and, therefore, has a great potential for improvement through selection of plus trees both for growth form and high resin yield. The purpose of the present study was to analyse the variation, inheritance pattern, inter-relationships, direct and indirect influences of cone and seed characteristics on 100-seed weight.

Materials and methods

Forty nine plus trees from the distributional range of Chir pine zone in Himachal Pradesh (30° 31' to 32° 30'N latitude and 75°30' to 79°E longitude) were selected in natural forest stands with an average age of 60±15 years with the scoring method as suggested by Leding [1]. Thirty cones per tree were collected and randomly divided into three replications each consisting of ten cones and data were recorded on cone length (cm), cone width (cm), cone weight (g), seed/cone, seed length (mm), seed width (mm), seed thickness (mm) and seed weight(g). Mean values so obtained were subjected to statistical analysis in a randomised block design. Coefficients of variability, heritability in broad sense, genetic advance and genetic gain were calculated as per Burton and De Vane [2] and Johnsen *et al.* [3]. Correlation coefficients and path coefficients were worked out as per A1-Jibouri *et al.* [4] and Dewey and Lu [5].

Results and discussion

Plus trees are individuals of outstanding merit which are selected on the basis of certain phenotypic criteria for the establishment of seed orchards and for use in breeding programmes. In India the genetic improvement of *chir* pine has remained comparatively neglected because of easy natural regeneration in the natural stands. Present study is, therefore, an attempt in this direction to select and evaluate the plus trees for cone and seed characteristics. Details of plus trees from different forest divisions for growth and high resin yield is appended in table 1. The analysis of variance indicated significant differences among all plus trees for cone length, cone width, seed/cone, seed length, seed width, seed thickness and 100-seed weight

Mean performance of plus trees for different characteristics (Table 2) revealed that cone length varied from 9.36 cm to 19.35 with an over all mean of 14.19 cm. Cone width ranged from 4.72cm-7.73 cm. Cone weight ranged between 48.14 to 263.45g with overall

Table 1. Details of plus trees from different forest divisions for growth and high resin yield

Sr.	Beat/Compartment	Range	Division
1	Banikhet	Surkhigala	Dalhousie
2	Barog	Dharampur	Solan
3	Bassa	Nerwa	Chopal
4	Bassa C_1 C	Shahpur	Dharamshala
5	Bassa C_2 C	Shahpur	Dharamshala
6	Bharanu	Throach	Chopal
7	Binee	Ramshahar	Nalagarh
8	Chabbar	Dharampur	Solan
9	Chabutra	Hamirpur	Hamirpur
10	Chalsai	Bijhad	Hamirpur
11	Chamba	Kahu	Nalagarh
12	Chhandoli	Sarahan	Raigarh
13	Chillad	Ramshahar	Nalagarh
14	Chillad-Pangni C	B	Ramshahar
15	Deothi	Solan	Solan
16	Dradda DPFC-II	Surkigala	Dalhousie
17	Dradda-Naghuin C_4	Surkigala	Dalhousie
18	Ghandeer	Jhanduta	Bilaspur
19	Gallu	Jogindernagar	Jogindernagar
20	Goela	Jagitnagar	Solan
21	Gola-Umblidhar	Sihunta	Dalhousie
22	Hamirpur-Gaine Da	Hamirpur	Hamirpur
23	Harabag	Jogindernagar	Jogindernagar
24	Jagjitnagar	Jagjitnagar	Solan
25	Jandrana Platu Forest	Badsar	Hamirpur
26	Jharari	Aghar	Hamirpur
27	Kunnu C_2A	Drang	Mandi
28	Kunnu C_5 A	Drang	Mandi
29	Lallan	Throach	Chopal
30	Malan	Malan	Dharamshala
31	Mamul C_1	Bakloh	Dalhousie
32	Mamul C_2	Bakloh	Dalhousie
33	Mamul C_3	Bakloh	Dalhousie
34	Manhuta	Bhatiyat	Dalhousie
35	Manhuta C_2 B	Bhatiyat	Dalhousie
36	Matnoh	Swarghat	Bilaspur
37	MC	Hamirpur	Hamirpur
38	Nagali	Solan	Solan
39	Nihari	Bharari	Bilaspur
40	Ound-Kopra Forest	Nurpur	Nurpur
41	Poentra	Nerwa	Chopal
42	Ralli	Bijhad	Hamirpur
43	Ranital C_5 A	Kangra	Dharamshala
44	Ranital C_5 B	Kangra	Dharamshala
45	Seuri	Jogindernagar	Jogindernagar
46	Sharda	Drang	Mandi
47	Sheshan C_7 B	Sawra	Jubbal
48	Sheshan C_7 C	Sawra	Jubbal
49	Vrindaran	Nurpur	Nurpur

mean of 159.87g. Maximum number of seeds/cone ranged from 85.67 to 38.47. Sehgal *et al.* [6] recorded an overall mean of 13.44 cm, 7.19 cm and 183.87 cm for cone length, come width and cone weight, respectively in chir pine.

Maximum seed length was recorded for tree no. 7 (12.87 mm) and minimum for tree no. 16 (9,23 mm), whereas, overall mean was 11.42 mm. Tree no. 13 showed the highest seed width (7.33). Minimum seed width was exhibited by tree no. 16 (5.03 mm). Highest seed thickness was recorded for tree no. 12 (4.41 mm) and lowest was recorded for tree no. 16 (3.044 mm). Maximum 100-seed weight was recorded for tree no. 13 (15.54 g) and minimum seed weight 5.19, from tree no. 15. Similar trend was reported by Matziris [7] for cone length, cone width, seed length and seed width in *Pinus halepensis*.

Persual of table-4 revealed that cone weight recorded maximum PVC and GCV (30.37 and 27.43%, respectively). High heritability accompanied by expected high genetic gain was found for cone weight and 100-seed weight. High heritability with moderate expected genetic gain was also recorded for cone length and cone width. High heritability with low expected genetic gain was recorded for seed length, seed width and seed thickness. Based on the GCV, heritability and genetic gain, it is quite clear that cone weight and 100-seed weight are highly heritable characters, and simple selection may do for the improvement of these traits in *chir* pine.

Cone length exhibited highly significant association with cone width and 100-seed weight (Table 5). Seed width was significantly associated with all the traits except seed thickness. Cone weight also showed significant inter-relationship with seed length, seed width, 100-seed weight and seed/cone. The correlation coefficient between seed length and 100-seed weight was highly significant and positive. Seed width showed highly significant association with seed thickness and 100-seed weight. Similar trend was observed for seed thickness with 100-seed weight.

The relative importance of cone and seed component in determining 100-seed weight was achieved by partitioning the genotypic correlation coefficients into direct and indirect effects with the help of path coefficient analysis. The data (Table 6) revealed that seed length (0.45) exhibited the highest direct effect towards 100-seed weight followed by the seed thickness (0.373) and seed width (0.232). Maximum indirect effect towards 100-seed weight was recorded by seed length via seed width (0.337) followed by seed length via cone weight (0.300) and via cone length (0.276).

On the basis of analysis of eight cone and seed characteristcs in forty nine plus trees the following conclusions may be drawn :

Table 2. Mean performance of the plus trees with respect to different characters

Plus tree No.	Cone length (cm)	Cone width (cm)	Cone weight (g)	Seeds/cone	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Seed weight (g)
1	11.14	15.89	64.11	41.89	10.47	5.50	3.81	7.54
2	15.652	19.79	150.00	69.26	11.68	6.32	3.56	9.75
3	17.31	19.15	206.31	44.17	11.57	6.38	3.55	10.56
4	14.32	19.14	173.22	62.17	12.62	6.37	3.82	12.14
5	13.42	17.64	146.89	59.08	10.57	6.03	3.67	9.00
6	13.55	17.48	137.39	54.58	10.27	5.47	3.75	8.81
7	14.88	19.44	212.64	50.53	12.87	6.62	3.99	12.50
8	16.25	19.86	159.33	74.92	12.13	6.12	3.80	11.97
9	13.19	18.83	142.47	62.94	11.85	5.85	3.58	9.12
10	15.04	17.94	178.33	51.78	11.73	6.60	4.17	11.62
11	14.88	19.10	182.19	68.00	11.38	6.30	3.76	10.89
12	19.35	24.28	196.00	82.59	11.58	6.10	3.93	11.61
13	14.21	18.54	185.94	61.83	12.60	7.33	4.41	15.54
14	14.32	19.41	197.33	50.67	12.32	6.85	3.49	11.13
15	12.35	17.87	135.78	75.31	9.67	5.82	3.87	9.12
16	11.04	14.87	69.55	41.11	9.23	5.03	3.04	5.19
17	11.33	17.83	120.75	49.47	11.47	5.92	3.45	9.24
18	14.83	18.64	166.45	53.36	11.57	7.13	3.84	11.45
19	16.28	19.85	162.42	44.25	10.86	5.05	3.02	7.60
20	14.19	19.70	149.22	52.76	11.15	6.17	3.86	10.94
21	15.13	19.07	199.25	76.92	11.20	6.17	4.29	9.03
22	12.69	17.65	122.83	70.39	11.68	5.88	3.75	9.16
23	12.86	16.91	112.19	38.47	11.12	6.37	3.86	9.44
24	18.98	24.01	204.67	62.17	11.93	6.90	3.85	11.34
25	12.29	17.90	147.33	66.44	11.42	6.33	3.83	10.30
26	13.01	18.23	147.61	43.72	10.80	5.75	3.77	9.72
27	15.21	19.16	188.72	64.45	11.00	6.37	3.71	9.55
28	11.20	17.18	107.06	55.14	9.93	5.97	3.91	8.73
29	16.78	19.63	245.28	48.22	12.13	6.77	3.57	11.51
30	9.36	14.82	48.14	41.33	9.63	5.33	3.63	6.75
31	13.49	18.32	157.75	45.53	11.25	6.27	3.92	11.16
32	12.40	18.00	140.39	50.19	11.97	5.83	4.15	12.42
33	13.61	16.88	134.58	56.94	11.77	6.30	4.14	11.50
34	11.82	19.24	165.89	64.94	11.52	5.92	3.62	9.70
35	12.18	19.97	155.50	75.33	10.60	6.00	3.86	9.29
36	14.58	19.03	171.60	67.92	12.57	6.72	3.81	12.32
37	13.01	17.32	131.14	27.11	11.18	6.43	3.70	11.00
38	14.19	18.32	142.58	52.17	10.93	6.13	3.72	9.26
39	16.79	18.68	198.94	76.64	11.72	6.47	3.93	11.33
40	15.60	18.79	155.97	50.50	12.58	6.35	3.70	10.53
41	17.70	20.68	263.45	59.56	12.53	7.30	3.71	10.77
42	15.58	19.57	201.80	65.33	11.47	6.78	4.01	13.23
43	13.32	19.21	150.50	71.33	9.67	5.18	3.12	6.90
44	14.12	17.99	155.67	70.39	11.87	6.30	3.47	10.24
45	11.03	17.28	99.42	49.22	10.07	6.00	3.70	9.24
46	14.82	17.99	168.31	57.28	12.77	6.43	3.98	11.86
47	16.07	19.71	212.53	85.67	12.65	6.48	3.79	11.40
48	18.26	18.89	262.86	63.61	11.80	5.77	3.53	9.99
49	13.94	15.53	108.05	52.61	11.92	6.43	3.85	10.72
Mean	14.19	18.57	159.87	58.67	11.42	6.23	3.78	10.34
C.V.	6.08	4.32	13.04	15.68	3.21	3.35	2.15	5.34
SE (d)	0.71	0.65	17.02	7.52	0.30	0.17	0.07	0.48
CD	1.40	1.30	33.87	14.95	0.60	0.40	0.13	0.95

Table 3. Estimates of parameters of variability, heritbility and genetic advance for different characters in *Pinus roxburghii*

Trait	PCV (%)	GCV (%)	h^2	GA	GG (%)
Cone length (cm)	16.03	14.83	85.6	4.01	28.26
Cone width (cm)	10.00	9.02	81.3	3.11	16.75
Cone weight (g)	30.37	27.43	81.6	81.59	51.03
Seeds/cone	24.96	19.42	60.5	18.26	31.13
Seed length (mm)	8.37	7.73	85.2	1.68	14.70
Seed width (mm)	8.39	7.69	84.0	0.90	14.46
Seed thickness (mm)	6.87	6.52	90.2	0.48	12.71
100 seed weight (g)	17.82	16.90	90.0	3.42	33.06

Table 4. Phenotypic correlation coefficients among different traits in *Pinus roxburghii*

Trait	Cone width	Cone weight	Seeds/cone	Seed length	Seed width	Seed thickness	100 seed weight
Cone length	0.749**	0.829**	0.280	0.536**	0.507**	0.127	0.465**
Cone width		0.708**	0.395**	0.395**	0.393**	0.112	0.382**
Cone weight			0.289*	0.555**	0.548**	0.150	0.507**
Seeds/cone				0.169	0.035	0.140	0.138
Seed length					0.678**	0.319*	0.722**
Seed width						0.423**	0.736**
Seed thickness							0.592**

**Significant at 1% level of significance; *Significant at 5% level of significance

Table 6. Direct and indirect effect of cone and seed traits on 100 seed weight

Trait	Cone length	Cone width	Cone weight	Seeds/cone	Seed length	Seed width	Seed thickness	Correlation coefficient
Cone length	**–0.087**	0.137	0.078	–0.046	0.276	0.134	0.057	0.548**
Cone width	–0.067	**0.179**	0.066	–0.062	0.205	0.105	0.051	0.478**
Cone weight	–0.073	0.127	**0.093**	–0.048	0.301	0.153	0.067	0.619**
Seeds/cone	–0.040	0.109	0.045	**–0.101**	0.098	0.027	0.059	0.197
Seed length	–0.053	0.081	0.062	–0.022	**0.451**	0.173	0.138	0.831**
Seed width	–0.050	0.081	0.061	–0.012	0.337	**0.232**	0.178	0.827**
Seed thickness	–0.013	0.024	0.017	–0.016	0.167	0.111	**0.373**	0.663**

Residual effect = 0.1099; Figures in bold are the direct effects; **Significant at 1% level of significance

1. Variation among plus trees was found significant for all the characters studied.

2. Most of the cone and seed characters were found highly heritable viz; cone length, cone weight, seeds/cone and 100-seed weight. The heritability value along with GCV indicated that production and quality of seed of chir pine may be improved by simple selection for these traits. Therefore, attention must be given to these traits while establishing a seed orchard.

3. Path-coefficient analysis indicated that seed length, seed thickness, seed width, cone width and cone weight are the traits which showed positive direct effect upon 100-seed weight.

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