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Genetic variability and association studies in *Pongamia pinnata* (L.) Pierre

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Abstract

Seventeen seed sources of *Pongamia pinnata* were selected from natural populations on the basis of morphometric characters to identify suitable seed sources for incorporation in mass afforestation programmes. Significant genetic variability and association was observed among seed sources for pod, seed and seedling traits**.** High estimates of heritability and high genetic advance for germination percentage, 100-seed weight and 100-pod weight was recorded. Pod thickness, 100-pod weight, seed length, seed breadth, and seed thickness showed high and positive correlation with 100-seed weight. Path analysis revealed that number of branches; seed thickness, internodal distance and pod breadth had the highest direct effect on 100-seed weight and can be collectively used as selection criteria for improvement of this tree species. Seed sources PB-7, PB-2 and PB-16 were found to be best on the basis of most of the characters.

Key words: Biofuel, Correlation, Genetic gain, Heritability, Variation, Path analysis, *Pongamia pinnata*

Introduction

Pongamia pinnata (L.) Pierre, commonly known as karanja tree, Indian-beech, pongam tree, is indigenous to Indian sub-continent and south-east Asia and is a member of Leguminosae family. This tree species has recently drawn the attention for its potential as a viable source of oil in the biofuel industry. Its oil can be used as a fuel for cooking and lamps, as a lubricant, water paint binder, pesticide and tanning industry (Burkill, 1966). For future success of *P. pinnata* as a sustainable source of biofuels, research should be targeted to maximize the plant growth as it relates to oil biosynthesis (Scott *et al.,* 2008).

The effective tree improvement programme depends upon the nature and magnitude of existing genetic variability and also on the degree of transmission of the desired traits. The assessment of genetic variability is vital to tree improvement (Zobel, 1971). Knowledge about the nature and extent of source variation in relation to seed, pod and seedling characteristics is very useful for the production of good quality planting stock. In the present investigation, genetic variability and association studies were carried out among different seed sources for different pod, seed and seedling characters.

Materials and Methods

Seventeen seed sources exhibiting distinct morphometric characteristics were selected from the natural populations of *Pongamia pinnata* from the various districts of Punjab in the first week of July 2007 (Table 1). The ripened fruits (pods) collected from each of these sources were measured for pod length, pod breadth, pod thickness, and 100-pod weight. The seeds were extracted from pods and measured for seed length, seed breadth, seed thickness and 100-seed weight. A total of one hundred pods of each seed source in each replication with a total of three replications were taken and average was calculated for pod and seed characters. For each seed source progeny, seeds were sown in polythene bags having equal proportion of farm yard manure, sand and soil in second week of July 2007. Measurements of five months old seedlings were recorded on plant height, collar diameter, number of branches, number of leaves, internodal length and height of first branch above ground level. Analysis of variance was carried out as per the method suggested by Panse and Sukhatme (1978). Genotypic and phenotypic coefficients of variations, heritability in broad sense and genetic advance were estimated by the formulae suggested by Burton (1952), Johnson *et al.* (1955) and Lush (1949), respectively.

Results and Discussion

The mean sums of square due to genotypes for all the characters were significant which indicated that there was significant variability among seed sources for different characters.

Maximum 100-pod weight (464.0g), pod length (5.77cm) and pod thickness (1.22cm) was observed in PB-7. Highest pod breadth (2.55cm) was recorded in PB-2 closely followed by PB-3. Seed traits also varied significantly among all the accessions. 100-seed weight varied from 87.54g in PB-9 to 230.0g in PB-7. Highest seed length (2.21cm), seed breadth (1.74cm) and seed thickness (0.84cm) was recorded in PB-3, PB-2 and PB-7, respectively. Variation in pod and seed characters among seventeen seed sources is depicted in Fig. 1 and Fig. 2, respectively. Seed germination ranged from 15.48% in PB-13 to 100.00% in PB-2. Plant height (38.14cm), collar diameter (6.03mm), number of branches (8.96) and height of first branch above ground level (13.27cm) were recorded maximum in PB-16. Highest number of leaves (20.08) was recorded in PB -9 closely followed by PB-13, PB-17 and PB-16. The differences among pod and seed morphological traits may be genetic in nature as a result of adaptation to diverse environmental conditions (Mathur *et al.,* 1984). Similar trend in seed sources variation in seed and seedling traits has been reported in *Pongamia pinnata* (Kaushik *et al.,* 2007; Kaushik *et al*., 2011).

Among all the characters, the highest phenotypic coefficient of variation (PCV) (43.70) and genotypic coefficient of variation (GCV) (43.40) was recorded for germination percent (Table 2). The PCV and GCV were moderately high for 100-pod weight, 100- seed weight, number of leaves, plant height and number of branches. Little differences between PCV and GCV and high estimates of heritability for most of the characters revealed the heritable nature of variability. The GCV were in the vicinity and less than the PCV for all the characters which suggested the influence of non-additive kind of gene action. GCV alone is no indication of the magnitude of heritable variation.

Heritability has an important place in tree improvement programmes as it provides index of the relative strength of heredity versus environment (Dorman, 1976). In the present study, the heritability estimates were recorded higher than 86.00% for 100 pod weight, 100-seed weight, pod length, pod breadth, pod thickness, seed thickness, germination percent, seed length and seed breadth with highest estimates for 100-pod weight (99.70%) which envisaged that environment had comparatively low influence for these characters. Maximum genetic advance (88.77%) was achieved in germination percent. 100 pod length (47.21%) and 100 seed weight (45.65%) also exhibited high genetic advance. Among the different seed sources, wide range in values was observed for most of the characters particularly 100 pod weight, 100-seed weight and seed germination percent.

High heritability coupled with high genetic advance for germination percent, 100-seed and 100-pod weight suggested the potentiality of source material for improvement through selection for these traits. High heritability accompanied by high genetic advance for several growth parameters have earlier been reported in *Eucalyptus tereticornis* (Kumar, 2007) and *Dalbergia sissoo* (Devagiri *et al.,* 2004).

Table 1. Geographical details of various seed sources collected from Punjab, India

Seed source	Place of collection	Longitude	Latitude
PB-1	Raja Combine, Mullanpur, Ludhiana	75º70´E	30 º89´N
PB-2	Traffic signal, Mullanpur, Ludhiana	75º68´E	30 º85´N
PB-3	Jagraon, Ludhiana	75º48´E	30 º81´N
PB-4	Jagraon, Ludhiana	75º48´E	30 º81´N
PB-5	26 km Stone of Talwandi Sabo, Moga	75º17´E	30 º82´N
PB-6	Talwandi Sabo, Moga	75º17´E	30 º82´N
PB-7	Basti Bhag Singh Wala, Ferozepur	74º69´E	30 º90´N
PB-8	Dashmesh School, Faridkot, Faridkot	74º77´E	30 º68´N
PB-9	Village Kothe Ber, Near Kot Kapura, Faridkot	74º81´E	30 º58´N
PB-10	28 km stone of Muktasar, Kot Kapura, Faridkot	74º81´E	30 º58´N
PB-11	Govt. Girls School, Jhabelwali, Muktasar	74º60´E	30 º51´N
PB-12	Near Water Tank, Vill. Sukhwan, Muktasar	74º63´E	30 º39´N
PB-13	Vill. Butter Sirin, Block Gidherbaha, Muktasar	74º66´E	30 º20´N
PB-14	Opposite tubewell, Vill. Butter Sirin, Muktsar	74º66´E	30 º20´N
PB-15	Village Kot Fatta, Bathinda	74º08´E	30 º11´N
PB-16	Village Pakho Kalan, Sangrur	74º42´E	30 º22´N
PB-17	IBP Petrol Pump, Maholi Kalan, Barnala	75º76´E	30 º62´N

Table 2. Estimates of genetic variability for pod, seed and seedling characters

Character	Coefficient of variation (%)		Heritability (%)	Genetic advance as % of mean	Range
	Phenotypic	Genotypic			
100- pod weight (g)	22.99	22.95	99.70	47.21	197.0-464.0
100 -seed weight (g)	24.01	23.07	92.30	45.65	87.5-230.0
Pod length (cm)	13.06	12.92	97.94	26.35	3.33-5.77
Pod breadth (cm)	8.13	7.90	94.37	15.81	1.90-2.55
Pod thickness (cm)	16.22	15.83	95.18	31.81	0.64-1.22
Seed length (cm)	8.65	8.14	88.64	15.79	1.73-2.20
Seed breadth (cm)	8.18	7.60	86.43	14.57	1.30-1.74
Seed thickness (cm)	18.89	18.48	95.77	37.26	0.33-0.84
Germination percent	43.70	43.40	98.61	88.77	15.48-100.00
Number of leaves	21.20	16.85	63.13	27.58	11.22-20.08
Plant height (cm)	24.26	16.76	47.73	23.85	18.08-38.14
Number of branches	23.92	15.87	43.99	21.68	4.40-8.96
Height of first branch (cm)	23.26	15.81	46.20	22.14	6.50-13.27
Internodal length (cm)	13.72	7.72	31.63	8.94	2.08-2.96
Collar diameter (mm)	18.47	12.02	42.36	16.11	3.88-6.03

Table 3. Path coefficients showing direct and indirect effects of selected characters on 100 seed weight

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	**0.4643**	-0.0053	-0.1336	0.2401	-0.0072	0.0577	-0.2878	0.4427	0.0058	0.1496
X2	0.0506	**-0.0484**	-0.0213	-0.1097	-0.0004	-0.0308	0.1213	0.0004	-0.0724	-0.4617
X3	0.3583	-0.0060	**-0.1718**	0.2382	-0.0034	0.0575	-0.2188	0.1338	0.0182	0.0508
X4	0.2340	0.0111	-0.0859	**0.4765**	-0.0045	0.0256	-0.2964	0.0730	0.0370	0.1988
X5	0.2880	-0.0017	-0.0504	0.1869	**-0.0116**	0.0394	-0.3156	0.6337	0.0127	0.0528
X6	0.2925	0.0162	-0.1078	0.1333	-0.0050	**0.0917**	-0.2125	0.2082	0.0264	0.1597
X7	0.3482	0.0153	-0.0980	0.3681	-0.0095	0.0508	**-0.3837**	0.4901	0.0405	0.2263
X8	0.2812	0.0000	-0.0314	0.0476	-0.0101	0.0261	-0.2573	**0.7309**	0.0053	0.0959
X9	0.0307	0.0397	-0.0354	0.1999	-0.0017	0.0275	-0.1761	0.0441	**0.0883**	0.3301
X10	-0.1404	-0.0452	0.0177	-0.1916	0.0012	-0.0296	0.1756	-0.1417	-0.0589	**-0.4945**
X11	0.1429	-0.0311	-0.0751	0.0678	-0.0001	0.0232	0.0089	-0.0555	-0.0158	-0.2069
X12	-0.1331	-0.0347	0.0085	-0.2140	0.0015	-0.0203	0.1649	-0.1908	-0.0530	-0.4517
X13	0.1377	-0.0152	-0.0540	0.2195	-0.0003	0.0022	-0.0816	0.0124	0.0162	0.0470
X14	0.2929	-0.0260	-0.1426	0.0763	-0.0033	0.0833	-0.0578	0.1008	-0.0032	-0.1311

X1=100 –pod weight,X2 = Collar diameter, X3= Pod length, X4= Pod breadth, X5= Pod thickness, X6= Seed length, X7= Seed breadth, X8= Seed thickness, X9= Germination percent, X10=No. of leaves, X11= Plant height, X12= No. of branches, X13= Height of first branch, X14= Internodal distance, Values in diagonals represent direct effect

	X11	X12	X13	X14
X1	-0.3296	-0.2906	0.1357	0.3517
X2	-0.6873	0.7261	0.1438	0.2995
X3	-0.4681	-0.0504	0.1438	0.4628
X4	-0.1525	-0.4553	0.2107	0.0893
X5	-0.0750	-0.1344	0.0115	0.1604
X6	-0.2710	-0.2247	0.0109	0.5068
X7	0.0249	-0.4356	0.0973	0.0840
X8	0.0813	-0.2645	0.0078	0.0769
X9	0.1912	-0.6083	0.0840	-0.0200
X10	-0.4481	0.9259	-0.043	0.1479
X11	**-1.0710**	0.5355	0.3962	0.3962
X12	-0.5658	**1.0136**	0.1170	0.1421
X13	-0.9277	0.2593	**0.4573**	0.0421
X14	-0.7610	0.3128	0.0345	**0.5575**

In the present study, correlation matrix exhibited significant positive as well as negative associations of varying magnitude among pod, seed and seedling traits. 100-seed weight showed positive and highly significant correlations with 100-pod weight, pod length, pod thickness, seed length, seed breadth and seed thickness. 100-pod weight depicted positive and highly significant correlation with collar diameter, pod length, pod breadth, pod thickness, seed length, seed breadth and seed thickness. The results are conformity with those of Devagiri *et al.* (2004), who recorded positive and significant correlations among seed traits. Path coefficient analysis was used in the present study for understanding the effect of its components on 100-seed weight (Table 3). Number of branches had the highest direct effect on 100-seed weight (1.0136) followed by seed thickness (0.7309), internodal distance (0.5575) and pod breadth (0.4765). The minimum positive direct effect on 100-seed weight was observed in germination percent. Number of leaves had the maximum negative direct effect (-0.4945). Number of branches had positive direct indirect effect on 100-seed weight *via* seed breadth (0.1649), internodal distance (0.1421) and height of first branch from ground level (0.1170).

Seed thickness recorded the maximum positive indirect effect *via* 100-pod weight (0.2812). The effect of pod breadth was due to indirect effect of 100-pod weight, height of first branch and number of leaves. The study revealed that number of branches, seed thickness, internodal distance and pod breadth can be collectively used as selection criteria for improving 100-seed weight in this species. Similar results on inter trait correlations in *Dalbergia sissoo* have been reported by Gera *et al.* (1999).

From the present investigation, it is clear that considerable differences existed among seed sources for pod, seed and seedling characters in *Pongamia pinnata*. Seed sources PB-7, PB-2 and PB-16 were found to be best on the basis of 100-seed weight and other characters. These seed source showed promise in their further exploitation for plantation and selection for improvement. High genotypic correlation coefficients between various pod, seed and seedling characters indicated that traits under study were genetically controlled and selection can be very effective tool in improvement of this economically and ecologically important tree species. Numbers of branches, seed thickness, inter nodal distance and pod breadth can be collectively used as selection criteria for improving 100-seed weight in this species.

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