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PROVENANCE VARIATION IN POD, SEED AND SEEDLING TRAITS OF *DALBERGIA SISSOO* ROXB., CENTRAL HIMALAYA, INDIA

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ABSTRACT

Seeds collected from 19 different altitudinal sources ranging from 120 to 1130m were evaluated for pod/ seed morphology, seed weight, seed germination and seedling growth in nursery and also in field trial. Considerable morphological and physiological variations between provenances for all the pod and seed traits including germination, plant height and collar diameter were found among the seed sources. Among various parameters, seed weight and plant height were most heritable traits, followed by genetic advance and genetic gain. Characters those showed greater genetic influence can be directly screened/ selected for the improvement of this potential tree species in Central Himalaya, India for raising quality plating material.

Key words: *Dalbergia sissoo*, morphological characters, seed source, heritability, genetic variation.

INTRODUCTION

Dalbergia sissoo, a large deciduous tree, is one of the most common, versatile, multipurpose, drought resistant, frost hardy and widely distributed indigenous tree species valued for its timber, fodder and nitrogen fixing quality (Tewari, 1994). It is distributed throughout the sub-Himalayan tract and Himalayan valleys up to 1000m. The tree is also excellent species for afforestation, reforestation and restoration of degraded lands. Due to its versatile nature, it has also been included in agroforestry system. However, problems are associated with quality planting material of *D. sissoo* in Central Himalaya as most of the stands produce forked/twisted trees, which reduce its acceptability as timber.

Screening and selection of suitable seed sources was emphasized to provide quality planting material to resource poor farmers of the region. Information on morphological and genetic variation in pod, seed size and weight among natural populations of *D. sissoo* will be useful to provide healthy (genetically and phenotypically superior) seed source for mass afforestation or tree breeding strategy. Several workers have already reported that information on seed characteristic may be useful for tree improvement (Uniyal, 1998; Kumar and Toky, 1993; Singh, 2004; Milberg *et al*., 1996). In this paper, we report the results of provenance variation in pod characters, seed morphology, germination and seedling growth of *D. sissoo* in order to help develop a strategy for the production of quality seedling for afforestation/reforestation of wastelands in Central Himalayan region.

MATERIAL AND METHODS

An extensive survey was conducted to screen natural populations of *D. sissoo* in the Central Himalaya and Siwalik foothills. Nineteen locations having abundant *D. sissoo* populations were selected for sampling and superior ideotypes were marked at each locality. Fresh ripen pods of *D. sissoo* were collected from marked parent trees from December 2000 to January 2001.Collected pods were sun dried and pod length, breadth and number of seeds/ pod were recorded. For each provenance, seeds were separately extracted from sun-dried pods and thereafter seed length, breadth, thickness (five replicates with 20 seed each) and seed weight was measured in seven replicates (each with 1000 seeds) as per ISTA (1998). For laboratory germination, five replicates (each consisting of 20 seeds) were placed in Petri dishes (9 cm diameter) at room temperature (25 ± 2^0C). After completion of germination, germinated seeds were shifted to soil media in polythene bags filled with sand, soil and farmyard manure (in 2:1:1 ratio) and arranged in randomized fashion in shade house. Manual watering and weeding was done at regular interval. After 6 months, 10 randomly selected seedlings were uprooted and shoot length and collar diameter was recorded. Six months old 30 seedlings were planted in experimental garden of forestry and after one year, growth, survival, seedling height and collar

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diameter were recorded. The results were statistically analyzed by computing coefficient of variation (CV) and correlation coefficient 'r'. Heritability values and genetic advance were worked out following the methodology of Johnson *et al.* (1955).

RESULTS

The geographical range of seed sources extended from 29^0 to 30^0N latitude, 77^0 to 79^0E longitude and 120 to 1130m altitude (Table 1). Significant ($P < 0.05$) variations were observed in pod length, breadth and number of seeds per pod among seed sources. However, average highest pod length was recorded in Rampurmandi and least in Langasu populations, respectively. The pod breadth varied from 0.59 to 1.12cm among provenances. Highest number of seeds per pod were also recorded highest in Rampurmandi and the lowest in Kalyani source (Table 1). Co-efficient of variation (CV %) which helps in comparing the variability for different characters exhibited that there was 75.8% difference between lowest and highest values for pod length; 92.6% in pod breadth; 81.5% number of seed per pod, irrespective of seed sources.

The highest average seed length was recorded in the seeds collected from Badapur and the lowest in Gadolia and Mahandrath seed sources. Seed thickness was recorded highest in Chidiapur and lowest in Gadolia populations. Seed weight was

Table 1. Geographical description and morphological characteristics of *D. sissoo* provenances, Central Himalaya, India

Provenances	Altitude (m asl)	District	Latitude (N)	Longitude (E)	Pod length (cm)	Pod breadth (cm)	No. of seeds/ pod
Badapur	120	Bijnor	$29^0$40'	$78^0$15'	6.61 (3.41)	1.12 (4.46)	1.36 (13.36)
Najeebabad	200	Bijnor	$29^0$47'	$78^0$32'	5.83 (3.52)	0.92 (7.83)	1.30 (5.44)
Cheela	210	Pauri	$29^0$56'	$78^0$18'	5.94 (8.38)	1.06 (1.07)	1.86 (15.95)
Rishikesh	215	Tehri	29^0 7'	78^0 18'	6.05 (7.85)	1.05 (9.05)	1.35 (15.06)
Afjalgarh	220	Bijnor	$29^0$31'	$78^3$43'	5.52 (3.91)	0.97 (1.87)	1.42 (13.55)
Kalagarh	220	Pauri	$29^0$28'	$78^0$46'	6.05 (13.88)	0.94 (14.48)	1.36 (6.58)
Bhaguwala	225	Bijnor	$29^0$52'	$78^0$15'	6.27 (14.09)	0.91 (8.25)	1.58 (22.11)
Chidiapur	225	Haridwar	$29^0$45'	$78^0$34'	7.20 (7.56)	1.09 (6.37)	1.26 (9.05)
Lachhiwala	340	Dehradun	$30^0$14'	$78^0$12'	5.94 (6.38)	0.66 (7.07)	1.46 (11.46)
Rampurmandi	400	Dehradun	$30^0$42'	$77^0$56'	8.21 (9.30)	1.03 (4.97)	2.06 (14.40)
Satpuli	500	Pauri	$29^0$57'	$78^0$48'	5.71 (5.55)	0.59 (9.63)	1.32 (6.34)
Haripur	500	Dehradun	$30^0$46'	$77^0$31'	5.94 (5.25)	0.92 (3.95)	1.58 (10.40)
Fathepur	510	Dehradun	$30^0$12'	$78^0$10'	5.4 (5.89)	0.86 (6.73)	1.60 (17.12)
Srinagar	550	Pauri	$30^0$13'	$78^0$48'	5.77 (5.98)	0.92 (8.17)	1.52 (18.26)
Dogadda	670	Pauri	$29^0$48'	$78^0$36'	5.38 (5.03)	1.06 (3.05)	1.16 (13.07)
Langasu	815	Chamoli	$30^0$18'	$79^0$17'	4.88 (6.35)	0.94 (4.29)	1.34 (4.10)
Gadolia	840	Tehri	$30^0$23'	$78^0$35'	6.78 (4.52)	0.79 (8.65)	1.52 (15.71)
Kalyani	1040	Uttarkashi	$30^0$16'	$78^0$16'	6.07 (3.43)	0.98 (8.33)	1.14 (13.30)
Mahandrath	1130	Uttarkashi	$30^0$57'	$77^0$56'	6.17 (8.99)	0.96 (5.48)	1.46 (15.77)
F value					12.86**	23.41**	5.60**

* Value in parenthesis indicate coefficient of variation

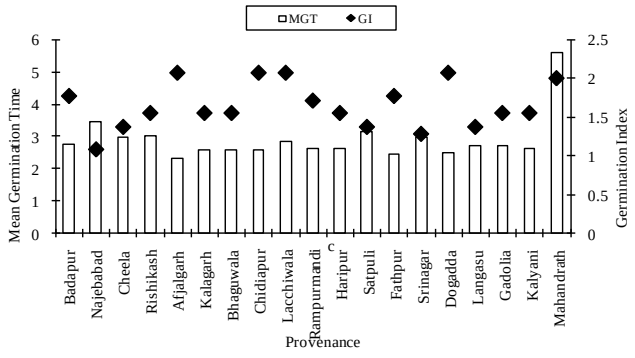

Figure 1. Median Germination Time (MGT) and Germination Index (GI) at room temperature (25±2^{0}C) of *D. sissoo* provenances, Central Himalaya, India

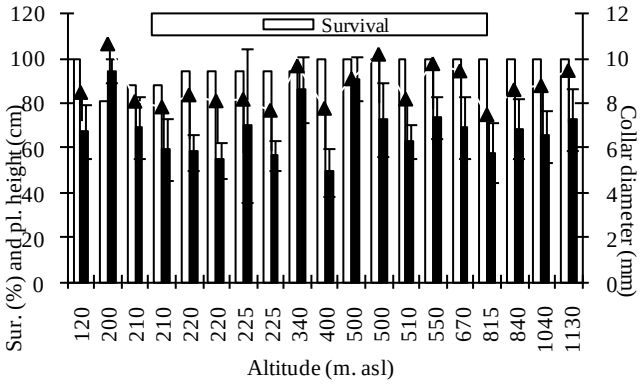

Figure 2. Provenance variation in survival, plant height and collar diameter in *Dalbergia sissoo* (after six months under nursery condition), Central Himalaya, India

recorded highest in Nagebabad and lowest in Afjalgarh populations. On average, there was 87.6% difference in lowest and highest CV in seed length; 85.3% in seed breadth, 74.1% in seed thickness and 88.3% in seed weight, irrespective of seed source, indicating that seed weight was the most variable trait while seed thickness the least variable character (Table 2).

On average, there was 98.9% germination, irrespective of seed populations at room temperature. Afjalgarh was the provenance, which had completed the germination quickly, while, Mahandrath took comparatively longer time for completing the process. It was also evidenced by their respective germination index values (Table 2 and Fig. 1).

Height growth varied significantly ($P < 0.05$) between provenances. On average, Fathepur population had highest shoot length. Lowest shoot length was, however, recorded in Haripur population. Collar diameter of seedlings varied from 2.01 to 4.32 mm among various populations (Fig. 2).

Survival, height and diameter growth of one-year-old *D. sissoo* seedlings in field trial has also been recorded. On average, 100.0% survival was recorded for Bhaguwala, Cheela, Rishikesh, Chiadiapur, Gadolia, Kalayni, Lachhiwala, Mahantrath, Najebabad, Rampurmandi and Srinagar popu-

Table 2. Morphological characteristics of seeds and germination per cent of *D. sissoo* provenances at room temperature (25±2^{0}C), Central Himalaya, India

Provenances	Seed length (cm)	Seed breadth (cm)	Seed thick-ness (mm)	Seed weight (g/1000 seed)	Seed germination
Badapur	0.97 (4.47)	0.50 (3.35)	0.58 (2.62)	15.50 (5.76)	100.0
Najebabad	0.90 (2.52)	0.49 (3.41)	0.58 (2.45)	22.33 (3.51)	96.66
Cheela	0.85 (8.36)	0.46 (3.22)	0.55 (1.99)	16.10 (3.98)	100.0
Rishikash	0.81 (16.05)	0.45 (17.78)	0.54 (12.75)	17.50 (1.74)	100.0
Afjalgarh	0.81 (2.97)	0.44 (4.13)	0.52 (2.51)	13.50 (2.91)	100.0
Kalagarh	0.82 (2.35)	0.45 (3.72)	0.48 (4.52)	19.81 (7.51)	100.0
Bhaguwala	0.87 (5.14)	0.51 (6.29)	0.54 (3.61)	20.10 (2.13)	100.0
Chidiapur	0.84 (3.10)	0.48 (10.21)	0.71 (2.23)	19.30 (4.11)	96.66
Lacchiwala	0.79 (3.42)	0.45 (1.98)	0.53 (5.72)	15.80 (2.89)	100.0
Rampurmandi	0.87 (3.53)	0.48 (4.52)	0.54 (6.06)	19.70 (2.67)	96.66
Haripur	0.77 (7.55)	0.41 (4.08)	0.53 (2.53)	13.52 (9.59)	100.0
Satpuli	0.86 (1.95)	0.47 (1.50)	0.61 (6.07)	17.90 (8.31)	93.33
Fathpur	0.85 (3.68)	0.48 (3.89)	0.57 (3.37)	19.00 (2.32)	100.0
Srinagar	0.80 (8.72)	0.46 (3.22)	0.47 (2.43)	15.41 (2.72)	10.0
Dogadda	0.84 (2.58)	0.45 (1.99)	0.55 (3.64)	16.90 (1.18)	100.0
Langasu	0.77 (5.92)	0.45 (7.03)	0.54 (7.69)	14.81 (3.68)	100.0
Gadolia	0.76 (4.34)	0.42 (4.45)	0.42 (4.82)	14.91 (2.94)	100.0
Kalyani	0.83 (1.08)	0.49 (4.92)	0.53 (5.40)	18.93 (4.64)	100.0
Mahandrath	0.76 (2.85)	0.53 (6.02)	0.45 (4.33)	13.64 (2.14)	96.66
"F"	11.86**	8.67**	44.03**	44.15**	4.15*

** Significant at $P < 0.01$. * Significant at $P < 0.05$, Value in parenthesis indicates co- efficient of variation (CV).

Table 3. Estimates of genetic parameters of pod and seed characters in *D. sissoo* provenances, Central Himalaya, India

Character	Heritability(%) (broad sense)	Genetic advance	Genetic gain (%)
Pod length	70.29	0.27	20.85
Pod breadth	81.82	0.250	26.91
No of seeds/pod	47.96	0.294	20.14
Seed length	67.57	0.084	10.24
Seed breadth	60.00	0.048	10.28
Seed thickness	88.63	0.121	22.57
Seed weight	94.36	0.634	36.02
Germination (%)	18.94	1.32	1.33
Plant height	22.90	7.60	11.10
Collar diameter	5.56	0.19	2.18

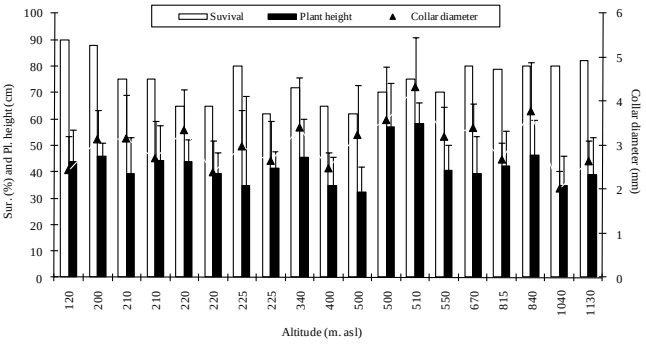

Figure 3. Provenance variation in survival, plant height and collar diameter in *D. sissoo* (after one year of field trial), Central Himalaya, India

lations. Although survival was only 81.0% to Kalagarh seed source, it showed highest plant height and collar diameter in seedlings. Among various populations, Srinagar seed source resulted into lowest collar diameter growth (Fig. 3).

Among various pod and seed traits, heritability values were noted highest for the seed weight, followed by seed thickness and pod breadth. Highest genetic advance was noticed for plant height while the least for seed breadth. Similarly, genetic gain was recorded highest for seed weight, followed by pod breadth. Germination, however, had least genetic gain (Table 3). Variations were random between the sources and these differences might have arisen due to the fact that genotypes grew under different environmental conditions in Central Himalaya, India.

Altitude of seed source showed significant ($P < 0.01$) inverse correlation with seed length, thickness and weight. Contrary to this, field survival was significantly positively ($P < 0.05$) correlated with altitude (Table 4a). Studies on correlation coefficient computed for pod, seed and seedling parameters showed that out of 55 coefficients, 29 were found

Table 4a. Correlation coefficient between geographical variable and seed and seedling traits of *D. sissoo* provenances, Central Himalaya, India

Variable	Morphological characters										
	1	2	3	4	5	6	7	8	9	10	11
Altitude	-0.155^{NS}	-0.115^{NS}	-0.129^{NS}	-0.521**	0.068^{NS}	-0.479**	-0.421**	-0.04^{NS}	0.19*	-0.01^{NS}	0.03^{NS}
Latitude	0.148^{NS}	-0.348**	0.173^{NS}	-0.425**	0.071^{NS}	-0.373**	-0.225*	-0.06^{NS}	0.23**	-0.05^{NS}	0.01^{NS}
Longitude	0.297**	0.341**	-0.140^{NS}	-0.220*	0.105^{NS}	-0.196*	-0.350*	-0.016^{NS}	-0.03^{NS}	0.21*	0.14^{NS}

Table 4b. Correlation coefficient among pod and seed parameters in *D. sissoo* provenances, Central Himalaya, India

Parameters	1	2	3	4	5	6	7	8	9	10
2	0.241*	-								
3	0.422**	0.042^{NS}	-							
4	0.237*	0.415**	0.043^{NS}	-						
5	0.178^{NS}	0.401**	0.054^{NS}	0.461**	-					
6	0.165^{NS}	0.256*	-0.072^{NS}	0.526**	0.181^{NS}	-				
7	0.368**	0.248*	-0.062^{NS}	0.624**	0.223*	0.386**	-			
8	-0.08^{NS}	-0.16^{NS}	-0.13^{NS}	0.15^{NS}	0.09^{NS}	0.16^{NS}	0.01^{NS}			
9	0.23*	0.12^{NS}	-0.31**	-0.01^{NS}	0.14^{NS}	-0.14^{NS}	0.42**	-0.15^{NS}		
10	-0.06^{NS}	0.09^{NS}	0.25*	-0.49**	-0.29*	-0.27*	-0.37**	0.33**	-0.28*	
11	0.04^{NS}	0.01^{Ns}	0.22*	-0.31**	-0.25**	-0.29**	-0.20*	-0.03^{NS}	-0.12^{NS}	0.80**

** Significant at P = 0.01, *Significant P=0.05, NS- Non-Significant

1. Pod length, 2. Pod breath, 3. No of seeds/pod, 4. Seed length, 5. Seed breadth, 6. Seed thickness, 7. Seed weight, 8. Germination % in room, 9. Field survival, 10. Plant height, 11. Collar diameter

significant at P < 0.01 and P < 0.05 level of probabilities. These relationships were expected because of inter dependence of all the combinations (Table 4b).

DISCUSSION

The results revealed that *D. sissoo* populations, collected from 19 sources showed large variations in pod and seed morphology, including seed weight. A basic knowledge about the nature and extent of seed variation in relation to seed parameters will be very useful for the production of quality seedlings. Various workers have proved that, seeds of a single species when collected from different sources or from different altitudes differ in viability, germination, growth and biomass performance (Isik, 1986; Singh *et al*., 2006). Variation in seed and seedling traits among and within sources suggest that selection among sources might result in rapid genetic gain for the traits (Dhillon and Khajuria 1995). Variation in seed morphology characters of *D. sissoo* may probably be due to resource availability, which varies over season and therefore, may influence seed size (Murali 1997). Similarly differences in seed weight between populations could have been a result of differences in the environmental conditions e.g. nutrients, light or water to which the mother plants were subjected during growing season (Gutterman 1992).

Although heritability in broad sense may give useful indication about the relative value of selection in the material at hand to arrive at a more reliable conclusion, heritability and expected genetic gain should be considered jointly. Volker *et al*. (1990) has shown that heritability estimates along with genetic gain is more useful than the heritability alone in predicting the resultant effect for selecting the best genotypes for given trait. Higher heritability values accompanied by high genetic gain have earlier been reported for seed weight in *Grewia optiva* (Uniyal, 1998) and *Celtis australis* (Singh, 2004). The critical evaluations of various genotypes revealed significant inter genotypic variation, reflecting wide range of genetic difference in accordance with the reports of Bagchi and Dobriyal (1990). Moderately high heritability estimates associated with moderate genetic advance have earlier been reported for plant height in *Terminalia species* (Chauhan, 1998) and for plant height and stem diameter in *Grewia optiva* (Uniyal, 1998), which supports to present findings.

The pod length and breadth of *D. sissoo* showed significant (P < 0.01) positive correlation, while seed length, thickness and seed weight showed significant (P< 0.05) inverse correlation with longitude. Among two growth traits, plant height had significant positive (P< 0.05) relation with longitude of the seed source. These correlations revealed that pod size and plant height increased towards eastern location, whereas, seed size and weight was found decreasing. In an earlier study, Vakshayas *et al*. (1992) observed negative correlation of seed size of *D. sissoo* with latitude but Kumar and Toky (1993) reported that pod, seed size and seed weight in *Albizia lebbek* increased with increase in latitude, which supports to the present findings.

Among various provenances of *D. sissoo*, Rampurmandi, Badapur, Nagebabad and Kalagarh, has greater pod size, more seeds/pod, larger and heavier seeds with higher per cent germination and taller seedlings compared to those of other populations. These populations may be selected to raise quality planting material of this promising species of Central Himalaya, India.

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