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Influence of geographic variation on morphometric traits of seeds, pods and germination behavior of *Albizia procera*

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Abstract
In present study pattern of variation among seeds, pods and germination behavior of *Albizia procera* seeds, collected from different provenances of Himachal Pradesh, was evaluated. Various locations of Himachal Pradesh were visited to mark and select the trees of *Albizia procera* for collection of planting material. Morphometricl characters of collected pods and seeds as well as germination behavior of seeds were studied to select the best seed source for plantation and agroforestry programs. Various pod and seed parameters viz., pod length (cm), number of seeds per pod, pod weight of 100 pods (gm), pod width (cm), pod thickness (cm) and seeds viz., seed length (cm), seed weight of 100 seeds (gm), seed width (cm) and seed thickness (cm) were evaluated for selection of quality seeds. Further the seeds from best seed source were tested for the determination of viability. Best response for all pod and seed parameters were obtained with seeds from Baddi. So, on the basis of results obtained, it was concluded that seeds from Baddi can be used for plantation and agroforestry programs. It can be concluded that the observed patterns of variation will have implications for genetic resources conservation and tree improvement.

Keywords: *Albizia procera*, geographic variation, seed and pod characters, germination, seed viability

Introduction
Albizia species have enormous potential as multipurpose trees in forestry and agroforestry practices throughout the tropics. Among the fourteen Indian species of this genus, all of which are trees (Troup 1921), *Albizia falcataria* (L.) Fosberg (Syn. *Paraserianlhes falcataria* (L.) Nielson) *and Albizia procera* (Roxb.) Benth. (Syn. *Mimosa procera* Roxb., Vern. White Siris) are the most prominent. *Albizia procera* is one of the most important nitrogen fixing tree species belonging to family Fabaceae, sub-family Mimosoideae. *Albizia procera* is commonly known as 'Safed Siris' and its distributional range is throughout moist and dry deciduous forests of India. It has good adaptability for growing in moist as well as fairly drought conditions. It was introduced as an ornamental and fuel wood species into the U.S. Virgin Islands at least 100 years ago and into Puerto Rico in 1924 (Little and Wadsworth, 1964) [11]. Also, the timber of *Albizia procera* is very valuable due to its interlocking nature of wood grains and thus used in furniture manufacturing, pulp of *A. procera* used for production of high quality paper (Parrotta and Roshetko, 1997) [13], leaves and young branches are used as fodder and it is also used for fuel wood production due to high calorific value. This species is important for reforestation and agroforestry programs (Parrotta and Roshetko, 1997) [13]. Interest has been increased in recent years in producing quality seedlings by application of improved and modern nursery techniques (Gera and Ginwal, 2002) [6]. The success of plantation program depends largely on enhanced growth, germination and climatic conditions. Importance of varying seed source and provenance is well recognized in tree improvement (Callaham, 1964; Wright, 1976 and Suri, 1984) [1, 22, 17]. These studies are necessary for scanning the available genetic variation, to select and utilize the best planting material and seeds for obtaining maximum productivity for further breeding work (Shiv Kumar and Banerjee, 1986) [15]. Variation among the seeds from different provenances might be attributed to genetic differences caused by the adaptation of different provenances to diverse environmental conditions (Ginwal *et al*., 2005) [7] and soil types (Elmagboul *et al*., 2014) [5]. It is essential to screen out the best seed type for further development of tree improvement programs and breeding works. One of the most important and first step in tree improvement and afforestation program is to obtain information about the best provenance for given site.

Thus the objective of the study was to evaluate the variation based on morphological characters and germination response of seeds from different provenances so as to obtain the most excellent provenance for production of quality planting material for afforestation and agroforestry programs.

Materials and Methods

The present investigations were carried out in Microbiology Laboratory, Department of Basic Sciences at Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. A brief accounts of the materials used and methodologies adopted are presented under the following heads:

Site Characterization and Collection of planting material

Present study was conducted for evaluating variation in pod and seed characters of *Albizia procera* from varying geographic locations. A survey was done of different districts (Fig.1) of Himachal Pradesh and 20 to 30 years old trees (Fig.2) of *Albizia procera* were marked on the basis of plant height (m) and plant diameter (cm) (Table.1) for the collection of seeds and pods. In the month of June fully mature pods (with seeds) of *Albizia procera* from different provenance of Himachal Pradesh were collected. Mature pods (Fig. 3) were dried for 2-3 days before seeds extraction and extracted seeds (Fig.4) were also sun dried to reduce moisture. Discolored, stained and damaged seeds were removed

Morphological study of pods and seeds characters

Various morphological characters of pods viz., pod length (cm), number of seeds per pod, pod weight of 100 pods (gm), pod width (cm), pod thickness (cm) and seeds viz., seed length (cm), seed weight of 100 seeds (gm), seed width (cm) and seed thickness (cm) were determined. Seed density was determined by water displacement method (Pandey, 1991) [12] and expressed in cubic centimeters (cc) for each provenance. For measuring individual seed and pod length, width and thickness vernier caliper was used and for seed and pod weight electronic weighing balance.

Determination of Seed Viability

Before planting, viability test was performed in order to test the viability of seeds. Extracted seeds of *Alibizia procera* were subjected to 2,3,5-triphenyl tetrazolium chloride (TTC) test for evaluation of seed viability. Transversely cut seed halves were incubated for 24 hr and staining pattern was observed. Seeds with completely stained embryo were considered as viable seeds.

Germination behavior of seeds

A study was conducted to elucidate the pattern of variation in germination behaviour among different seed sources of *Albizia procera* to develop selection criteria for future tree improvement programmes. Germination response of seeds was studied in the laboratory of Department of Seed Science and Technology at Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. Daily germination counts were recorded and germination value (GV) was calculated according to Czabator (1962) [2]. The speed of germination was expressed in terms of germination value.

Germination percentage: It is the percent of germinated seeds at the completion of germination.

Peak Value of Germination (PV)

Peak value was calculated by the following formula.

PV = Highest seed germinated/ Number of days

Mean daily germination (MDG)

Mean daily germination can be calculated by the following formula.

MDG = Total number of germinated seeds/ Total number of days

Germination value: It is an index combining speed and completeness of seed germination. Germination value will be calculates according to Czabator (1962) [2].

G.V. = P.V. × M.D.G.

Where,
G.V. = Germination value
P.V. = Peak value of germination
M.D.G. = Mean daily germination

Germination energy index (GEI): Germination energy index was calculated using the formula Grouse and Zimmer (1958) [8].

Speed of Germination: Number of days taken to complete the germination was recorded for each replication.

Results and Discussion

A significant variation in the pod and seed characteristics and in germination behavior of *Albizia procera* were recorded for different provenances of Himachal Pradesh. The results obtained are represented hereunder with respective heads:

Morphological characters of pods and seeds

Fresh pods and seeds of *Albizia procera* were reddish brown in color. Pods were long with an average length of with elliptical lobes. Seeds were reddish brown in color having elliptical shape.

Significant results for variation in pod characters were recorded with different provenances of Himachal Pradesh. Pods from Baddi showed highest values for all the pod parameters viz., pod length, number of seeds per pod, pod weight, pod width, pod thickness followed by Jachh for pod length, number of seeds per pod, pod weight, pod thickness and Nauni for pod width (Table.2)

A significant variation in seed characters of *Albizia procera* was also recorded for different provenances of Himachal Pradesh (Table.2). Seeds from Baddi provenance showed a maximum seed weight and seed length followed by Jachh, in contrast the seeds from Dhaulakaun recorded the minimum value for seed weight. Highest and lowest value for seed length was found with seeds from Baddi and Gaggal. Seed width also obtained maximum values in Baddi whereas minimum was recorded in Dhaulakaun.

Seed Viability

Freshly harvested seeds of *Albizia procera* exhibited 95% viability; this status was maintained at least for 12 months of storage. Thereafter, the seed viability gradually declined; 25% decline as compared to freshly harvested seeds was evident after 24 months of storage (Fig.5).

Germination response of seeds from different provenance

Seeds of different provenances showed a significantly different germination behavior. Germination behavior of seeds was observed till 21 days for all the seeds collected from different provenances of Himachal Pradesh. Maximum germination was observed by the seeds from Baddi (81.11%) within 5 followed by Jachh (76% within 6 days). Maximum values for germination energy index (5.13), speed of germination (5days), peak value (3.22), mean daily germination (1.93) and germination value (6.25) were observed for the seeds of Baddi followed by Jachh (Table.2)

Discussion

The purpose for provenances testing is to measure the pattern of genetic variation and to aid in selection of well adapted and highly productive provenances. Phenotypic variation is determined by the genotypic and environmental interaction and is assumed to be expression of genotypic variation when the environmental conditions are controlled (Westoby *et al*., 2002) [21]. Therefore, the screening of provenances is essential to determine the most promising provenances for specific geographic area. Geographic collection and planting zones can be delineated if provenance testing is conducted during the early stages of a tree breeding programe. In this present study of provenance variation of *Albizia procera*, the overall data confirm a significant variation in the seed, pod and germination. Ginwal and Gera (2002) [6] have confirmed the variation in seed and germination of 12 *Acacia nilotica* provenances of India. *Albizia procera* has a wide geoclimatic distribution in India. Thus, it can be one of the reasons for its wide morphological and genetic variation. Tewari (1992) [18] have also reported a wide variation in seed length and seed weight for different provenances of *Azadiractha indica*. Seed weight is one of the useful criteria for early selection of superior provenances (Khalil, 1986) [10]. Across different provenances of *Albizia procera* in Himachal Pradesha significant variation in seed germination, germination value, germination speed etc. was recorded. Shu (*et al*., 2012) [16] have also observed a considerable variation in germination of *Magnolia officinalis* seeds collected from different provenances. The variations in germination traits among provenances are also in conformity with those found in *Pinus roxburghii* (Todaria *et al*., 2003), *Picea smithiana* (Rawat and Uniyal, 2011) [14], *Albizia chinensis* (Dhanai *et al*., 2003) [4], *Tectona grandis* (Gupta *et al*., 1976) [9] and *Grewia oppositifolia* (Uniyal *et al*., 2003) [20]. The present study identifies that Baddi is the best provenances for *Albizzia procera* in Himachal Pradesh based on seed, pod and germination attributes for all the five provenances which were sampled.

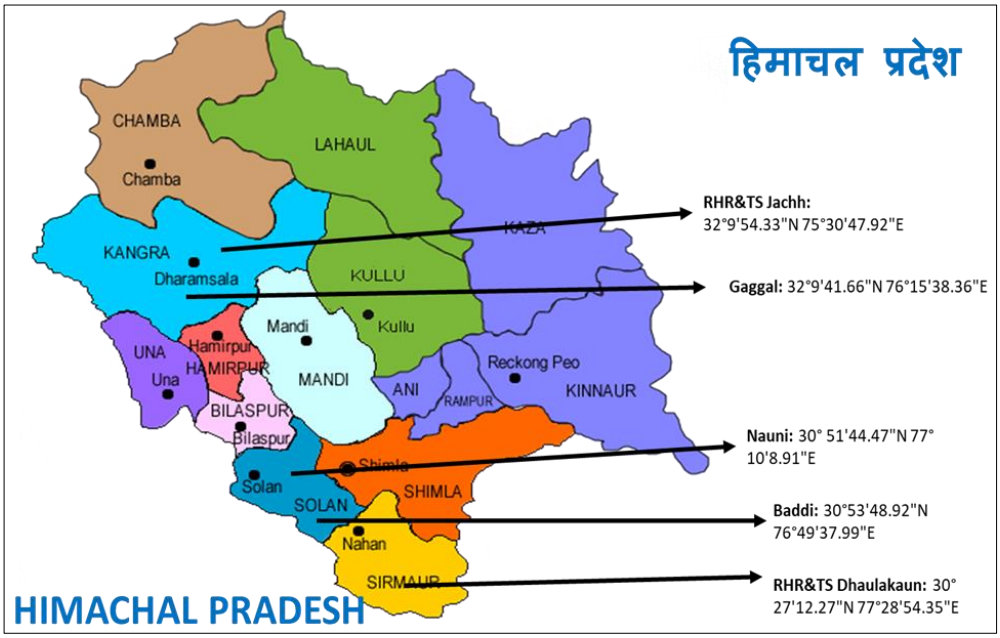

Fig 1: Map of Himachal Pradesh representing different geographic location of sampling

Fig 2: Marked trees of *Albizia procera* in different districts of Himachal Pradesh

Fig 3: Pods of *Albizia procera* with seeds collected from Himachal Pradesh

Fig 4: Seeds extracted from pods of *Albizia procera* of Himachal Pradesh

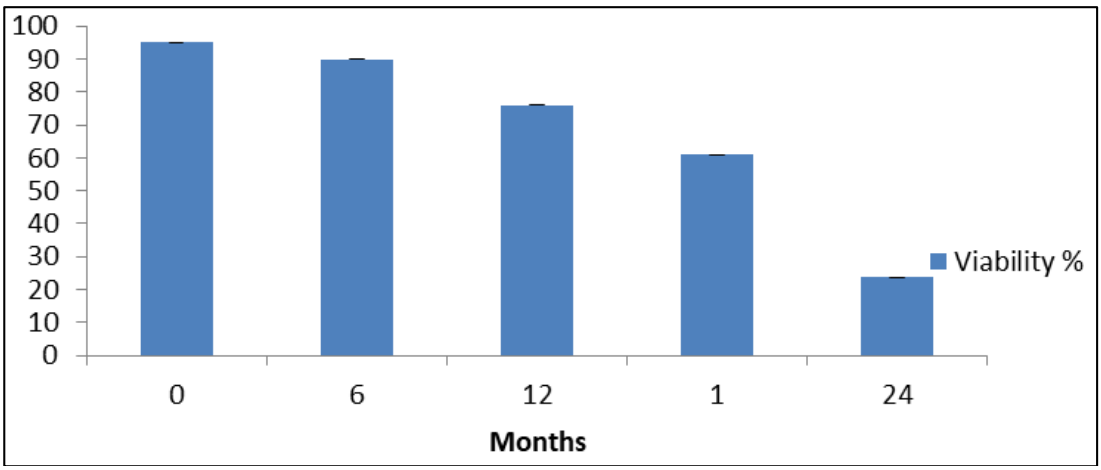

Fig 5: Viability percentage of seeds upto 24 months.

Table 1: Different geographic locations of *Albizia Procera* in Himachal Pradesh for sample collection.

Name of location	District	Altitude (msl)	Latitude	Longitude	Rain fall (mm/year-2016)	Plant height (m)	Plant diameter (cm)
UHF Nauni	Solan	1265.1	30° 51'45.47"N	77° 10'9.91"E	1612	20	24
Baddi	Solan	433	30°53'58.46"N	76°49'31.81"E	1035	26	30
RHR&TS Jachh	Kangra	407.3	32°9'54.31"N	75°30' 47.89"E	1196	22	27
Gaggal	Kangra	752.2	32° 9'36.75"N	76°15' 42.67"E	1831	22	26
RHR&TS Dhaulakaun	Sirmour	534	30°27'12.27"N	77°28'44.46"E	1742	23	28

Table 2: Phenotypic characters of pod/seed and germination response of *Albizia procera* seeds collected from varying geographic range of Himachal Pradesh

Traits	Himachal Pradesh					C.D.
	Nauni	Baddi	RHR&TS Jachh	Gaggal	RHR&TS Dhaulakaun	
Pod length (cm)	11.06^{a}	14.13^{a}	12.95^{a}	8.44^{a}	10.75^{a}	3.42
Seed per pod	8.0^{a}	10.00^{a}	9.00^{a}	7.00^{c}	7.00^{c}	2.73
Pod weight (100 pods) in gm	47.00^{c}	53.90^{a}	48.23^{b}	45.72^{d}	45.77^{d}	0.18
Pod Width (cm)	1.90^{b}	2.20^{a}	1.70^{d}	1.80^{c}	1.67^{d}	0.09
Pod Thickness (cm)	0.23^{b}	0.30^{a}	0.28^{a}	0.19^{c}	0.25^{b}	0.04
seed length (cm)	0.55^{c}	0.73^{a}	0.61^{b}	0.49^{d}	0.52^{c}	0.04
seed weight(100 seeds)in gm	3.77^{c}	5.13^{a}	4.22^{b}	3.57^{d}	3.27^{e}	0.04
seed Width(cm)	0.42^{c}	0.51^{a}	0.47^{b}	0.40	0.39^{c}	0.03
seed Thickness(cm)	0.16^{a}	0.20^{a}	0.18^{a}	0.14^{b}	0.12^{b}	0.04
Seed density (gm/cm3)	1.18^{d}	1.52^{a}	1.24^{c}	1.07^{e}	1.34^{b}	0.04
germination %	68.67^{c}	81.33^{a}	76.00^{b}	60.67^{e}	64.67^{d}	0.08
Germination Value	2.78^{d}	6.25^{a}	3.41^{b}	2.84^{c}	2.65^{e}	0.03
Germination energy Index	4.15^{b}	5.13^{a}	4.16^{b}	3.82^{d}	4.05^{c}	0.03
Speed of germination	5.13^{c}	5.60^{a}	5.48^{b}	5.17^{c}	5.02^{d}	0.05
Peak Value	1.72^{d}	3.22^{a}	1.89^{c}	1.99^{b}	1.74^{d}	0.04
Mean daily germination	1.63^{c}	1.93^{a}	1.80^{b}	1.44^{e}	1.53^{d}	0.03

Table 3: Correlation coefficient (r) among pod, seed and germination traits of *A. procera*

	V 1	V 2	V 3	V 4	V 5	V 6	V 7	V 8	V 9	V 10	V 11	V 12	V 13	V 14	V 15	V 16
Pod Length (cm)	1															
Seed Per Pod	0.980**	1														
Pod Weight (gm)	0.968**	0.929*	1													
Pod Width (cm)	0.724	0.697	0.861	1												
Pod Thickness (cm)	0.893*	0.847	0.787	0.408	1											
Seed Length (cm)	0.997**	0.970**	0.980**	0.763	0.882*	1										
Seed Weight (gm)	0.967**	0.966**	0.974**	0.815	0.751	0.967**	1									
Seed Width (cm)	0.979**	0.991**	0.937*	0.694	0.826	0.967**	0.981**	1								
Seed Thickness	0.914*	0.970**	0.876	0.711	0.698	0.900*	0.955*	0.967**	1							
Seed Density (gm/cm^3)	0.797	0.674	0.803	0.583	0.865	0.820	0.671	0.662	0.491	1						
Germination Percentage	0.979**	0.984**	0.902*	0.617	0.924*	0.968**	0.920*	0.966**	0.917*	0.745	1					
Germination Value	0.924*	0.864	0.985**	0.868	0.723	0.941*	0.947*	0.890*	0.810	0.799	0.828	1				
Germination Energy Index	0.933*	0.870	0.979**	0.868	0.797	0.957*	0.910*	0.863	0.784	0.883*	0.865	0.964**	1			
Speed Of Germination	0.917*	0.938*	0.869	0.600	0.743	0.895*	0.946*	0.973**	0.940*	0.541	0.897*	0.842	0.758	1		
Peak Value	0.833	0.758	0.936*	0.883*	0.590	0.857	0.888*	0.801	0.719	0.739	0.704	0.981**	0.915*	0.770	1	
Mean Daily Germination	0.980**	0.986**	0.905*	0.625	0.920*	0.969**	0.924*	0.968**	0.921*	0.743	1.000**	0.831	0.867	0.898*	0.709	1

V- Variable, ** Significant at P < 0.01, * Significant at P < 0.05

Table 4: Simple correlation (r) between characters studies and geographical factors of *Albizia procera*

Characters	Altitude	Lattitude	Longitude	Rain fall
Pod Length (cm)	-0.475	-0.233	-0.435	-0.947*
Seed Per Pod	-0.373	-0.140	-0.504	-0.970**
Pod Weight (100 pods) in gm	-0.404	-0.309	-0.316	-0.858
Pod width (cm)	0.021	-0.445	0.022	-0.595
Pod Thickness (cm)	-0.599	-0.318	-0.347	-0.903*
Seed length (cm)	-0.449	-0.289	-0.378	-0.935*
Seed weight (gm)	-0.387	-0.122	-0.484	-0.882*
Seed width (cm)	-0.455	-0.054	-0.577	-0.934*
Seed thickness (cm)	-0.244	-0.000	-0.567	-0.910*
Seed density **(gm/cm^3)**	-0.540	-0.615	0.018	-0.700
Germination percentage	-0.429	-0.210	-0.460	-0.989**
Germination value	-0.463	-0.277	-0.308	-0.764
Germination energy index	-0.353	-0.492	-0.132	-0.829
Speed of germination	-0.545	0.166	-0.737	-0.846
Peak value	-0.444	-0.250	-0.257	-0.625
Mean daily germination	-0.422	-0.211	-0.459	-0.990**

Conclusions

In order to produce quality seeds with minimum cost and labor it is essential to determine variation in seed and effect of locations. For a successful crop production, the use of good quality seed is very essential which increases the yield by 15-20%. The extant of this increase is directly proportional to the quality of seed that is being sown. On short term basis some specific breeding zones must be set up in the environmentally homogenous areas, which can increase the chances of better seedling establishment of *Albizzia procera*, where the tree is day by day declining in number. One of the reasons can be its adaptability and establishment in the early growth periods. In this study we have identified the provenances which can help to overcome this problem. Hence, Baddi seed source of *Albizzia procera* provides a great opportunity to the tree breeder to screen and capture natural variation for success of afforestation, besides providing information on the raw material for breeding and evolving improved planting stock within a seed source.

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Conflict of interest

Authors declare that no animal, human and other living being was harmed during this work.

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