SEED TRAIT VARIATION IN *ACACIA CATECHU* WILLD.

Mohit Gera, Neelu Gera* and Farooq Ahmad Dar

Abstract

Twenty genotypes of *Acacia catechu* Willd. scattered over the entire natural range of Jammu region were studied for variation in pod, seed, germination and nursery characteristics. Highly significant variations were observed among the genotypes for all the characters studied. The extent of variation observed for germination characters was large compared to other characters studied. Significant positive correlations were observed for seed weight and germination, pod size (length & width) and germination, number of seeds per pod and germination. The seed from families F7, F10, F13, F14 and F5 were found to be more vigorous on the basis of nursery performance and are recommended for establishment of seed orchards and for future improvement programs. Pod length, pod width, number of seeds per pod, seed weight and germination were observed to be important characters in evaluating the genotypes.

Introduction

The knowledge of genetic variation within a species is a pre-requisite for developing effective tree improvement programs. Forest tree improvement programs begin with the scanning of available variation in the entire range of the species distribution and then selection of suitable genotypes. Without sufficient information on variability in important traits, an attempt to use genetics to improve forest trees may not be successful. Variation in several seed and germination traits and its significance in seed sources' studies have been documented in a number of tree species viz., *Albizia lebbek* (Kumar and Toky, 1993), *Prosopis juliflora* (Sharma *et al.*1994), *Pinus sylvestris* (Reich *et al.* 1994), *Acacia nilotica* (Bagchi and Dobriyal, 1990; Ginwal *et al.*, 1995; Mathur *et al.*, 1984). Reports on effect of seed size on germination, early development and physiology of tree species are inconsistent. In some studies a positive correlation was observed between seed size and seedling size (Dunlap and Barnett, 1983) while in others it was unrelated (Szezygiel, 1981; Dormling and Jonhsen, 1992). Seed weight has been reported to be one of the most useful parameter for early selection of superior provenances (Khalil, 1986) while seed size and colour are important markers for identifying populations (Harper *et al.*, 1970).

* State Forest Research Institute, Janipur, Jammu – 180 007 (J&K), India

On account of its natural hardiness, fast rate of growth and value of wood, *Acacia catechu* Willd. is an ideal species and has been widely used in afforestation programs throughout the Indian sub-continent. The species is valued for nitrogen rich fodder, high quality fuelwood and charcoal, low cost structural timber and for variety of medicinal uses. The most important commercial use of this tree is Katha and Cutch, obtained when heartwood is boiled in water. The species is native to India, where it is widely distributed throughout the greater part of the Country barring the most humid and the driest regions. Three varieties of the species have been distinctly identified, viz., var. *catechu,* var. *catechuoides* and var. sund*ra*. Out of these, var. *catechu* is found in the State of J&K in dry deciduous forests of Jammu region. Khair is a classical example of Pioneer species in the riverine succession. It is amongst the principal tree species commonly recommended for plantation programs in the dry and frosty regions for soil and water conservation as well as for production of wood for manufacturing of "Katha" and "Cutch".

In this paper, variation in pod, seed, germination and nursery performance of twenty different genotypes of *Acacia catechu* from almost the entire natural range of Jammu region is reported. The candidate plus trees (CPT's) selected on the basis of this progeny test will be utilized for further improvement in the species and for establishment of seed orchards.

Materials and Methods

The study was conducted at Seed Development Division, Jammu situated at 32°17' N latitude and 73°26' E longitude. The area is situated at an altitude of 400m above msl and enjoys semi arid type of climate with mean annual rainfall 1050 mm. The seed collection area falls between 32° 25′ to 32° 68′ N latitude and 74° 89′ to 75° 90′ E longitude which covers almost the entire range of its geographical limit in Jammu region.

Pods of twenty candidate plus trees (Table 1) were collected from almost the entire natural range of the species in Jammu region during February, 2000. Approximately 500 grams fully ripened pods from each tree were collected and labeled separately. The pods were sun-dried and seeds were extracted manually. Four replicates were drawn manually from each seedlot. Fifty undamaged pods were randomly drawn from each replicate and measured for their maximum length, width and number of seeds per pod. A total of 400 randomly drawn seeds from each seedlot in four replications, each of 100 seeds were measured for their maximum length and width. Seed weight of eight randomly drawn samples each of 100 seeds, for each seedlot were obtained and 1000 seed weight was calculated.

Table 1. Morphological observations of selected candidate plus trees of *Acacia catechu*.

Family	CPT No.	Location	Height (m)	Clear bole height (m)	Diameter at breast height (cm)	Crown diameter (m)
F1	1/1999	Hissar Khad	10.45	3.50	26.41	5.00
F2	9/1999	Hissar Khad	13.50	4.60	29.59	9.00
F3	12/1999	HISSAR KHAD	11.75	4.00	24.82	7.35
F4	18/1999	Sakta Chak	11.75	4.05	29.11	7.00
F5	19/1999	Sakta Chak	10.65	3.85	24.18	6.70
F6	20/1999	Sakta Chak	12.95	4.65	36.75	8.00
F7	21/1999	Sakta Chak	11.25	4.25	30.55	9.90
F8	29/2000	Mansar Morh	13.00	4.70	28.64	8.90
F9	30/2000	Mansar Morh	15.25	5.25	27.36	10.01
F10	31/2000	Mansar Morh	16.25	5.75	37.55	10.67
F11	32/2000	Mansar Morh	13.65	4.65	28.32	9.21
F12	33/2000	Mansar Morh	13.85	4.75	35.64	9.75
F13	35/2000	Baj Pur	10.35	3.40	22.27	5.00
F14	36/2000	Baj Pur	10.75	3.95	21.00	6.95
F15	37/2000	Baj Pur	11.75	4.15	27.05	7.50
F16	38/2000	Baj Pur	11.95	4.45	36.91	7.90
F17	39/2000	Dobu	11.45	4.29	20.68	6.96
F18	40/2000	Dobu	11.15	4.09	21.64	6.47
F19	42/2000	Dobu	10.75	3.92	20.09	5.94
F20	43/2000	Dobu	10.81	3.96	22.27	6.00

A total of 400 randomly drawn seeds of each seedlot, in 4 replications of 100 each, were used for standard germination test (ISTA, 1993). A uniform pretreatment was given to the seeds by soaking the seeds in warm water at 45°C for two hours, allowed to cool and kept soaked for 24 hours. Seeds of each replicate were kept on moist, non-toxic germination paper in germination boxes and incubated at 30± 1°C in a seed germinator. Care was taken to keep the seeds moist and observations were recorded daily at 10:00 a.m. till the end of the experiment, i.e., 28 days, when the final germination was recorded.

To study the progress of germination in the different seedlots, total cumulative germination percent was calculated at the end of each week up to the final count after four weeks. Germination rate was then calculated following Mathur *et al.* (1984). Time taken to reach 25% and 50% germination was also recorded. Germination value (GV) was calculated by multiplying peak value of germination (PV) with mean daily germination (MDG), i.e., GV=PV x MDG

(Czabator, 1962). Median radicle emergence time (T_{50}) was calculated using the formula:

$$T_{50} = t_i + \left(\frac{\frac{N+1}{2} - n_i}{n_j - n_i} \right) X \; [t_j - t_i]$$

where,

n_i and n_j are cumulative germination counts at successive times t_i and t_j when $n_i < (N+1)/2 > n_j$ and N= total number of seeds germinated.

200 seedlings each from the twenty selected seedlots were pricked into polybags of size 15 x 23 cm and arranged in a randomized block design in four replications. The polybags were kept over a polythene sheet in nursery and maintained by regular weeding, hoeing and irrigation. Seedlings were assessed for height, collar diameter and biomass (dry weight) during August 2000. Twenty-five seedlings from each replication were utilized for recording of these observations.

The data thus obtained was subjected to analyses of variance and least significant differences (LSD). The seed sources were ranked for the variables studied using software program 'SX'.

Results

Mean values of pod and seed characters of selected CPTs of *Acacia catechu* are presented in Table 2. Among the pod characteristics, mean pod length was found to vary between 4.49 cm (F1) and 8.00 cm (F9), mean pod width between 1.11 cm (F6) and 1.59 cm (F16) and the number of seeds per pod between 2.68 (F6) and 5.70 (F15). The coefficients of variation (CV%) for these traits were found to be 15.36, 11.05 and 19.09% respectively. Analysis of variance (ANOVA) for data obtained on the pod characteristics showed that differences between seed sources were statistically significant ($P<0.001$).

Mean seed length was found to vary between 0.63 cm (F6, F7 & F20) and 0.78 cm (F5 & F12), mean seed width between 0.49 cm (F6) and 0.64 cm (F10) and 1000 seed weight between 27.43 g (F6) and 51.19 g (F16). The coefficients of variation (CV%) for these traits were found to be 6.79, 6.28 and 15.58% respectively. The ANOVA for the data obtained on seed characteristics

showed that differences between seedlots were significant (P<0.001). Not surprisingly, heavier seeds were also longer and wider and there were significant correlations between these three characters.

Table 2. Mean values of Pod and Seed characters for selected candidate plus trees of *Acacia catechu.*

Family	Pod Length (cm)	Pod Width (cm)	No. of Seeds per Pod	Seed Length (cm)	Seed Width (cm)	Mean Seed Weight (g)
F1	4.49	1.33	3.18	0.67	0.56	31.47
F2	5.30	1.13	3.30	0.73	0.60	37.86
F3	5.66	1.23	4.40	0.66	0.58	39.30
F4	5.81	1.22	3.95	0.66	0.57	36.92
F5	6.41	1.33	4.95	0.78	0.60	42.70
F6	5.01	1.11	2.68	0.63	0.49	27.43
F7	5.61	1.14	3.85	0.63	0.52	32.11
F8	5.88	1.14	4.43	0.67	0.62	38.32
F9	8.00	1.57	5.15	0.72	0.58	38.58
F10	7.56	1.38	4.55	0.70	0.64	48.02
F11	5.49	1.45	3.10	0.73	0.58	35.89
F12	5.99	1.52	4.35	0.78	0.61	41.42
F13	6.75	1.51	5.00	0.67	0.59	41.21
F14	7.09	1.40	5.40	0.66	0.56	35.15
F15	7.17	1.40	5.70	0.69	0.57	40.71
F16	7.90	1.59	5.23	0.76	0.62	51.19
F17	6.04	1.34	4.45	0.68	0.54	39.41
F18	5.07	1..52	4.53	0.74	0.60	48.60
F19	6.22	1.47	4.58	0.74	0.62	48.56
F20	6.48	1.26	5.65	0.63	0.54	32.45
F.Test	***	***	***	***	***	***
CV(%)	15.36	11.05	19.09	6.79	6.28	15.58
SE ±	0.30	0.01	0.36	0.02	0.01	1.43
CD(5%)	0.59	0.02	0.73	0.03	0.02	2.86

Significance level: *** P<0.001

Mean values for characters of germination and nursery performance for the seedlots are presented in Table 3. The median radical emergence time was observed to vary between 91 hrs (F 14) and 400 hrs (F19). Germination percent was found to vary between 66.00 (F2) and 96.50 (F16), germination value between 10.42 (F20) and 177.4 (F14) and germination energy between 22.00 (F2) and 82.00 (F14), with coefficients of variation 10.55, 48.53 & 28.80%

respectively. Germination started after 1-2 days and by end of third week, all viable seed had germinated. Final germination was >50% for all the seedlots. Maximum germination was recorded in F16 (96.50) which was statistically at par with families F14 (95.50), F4 (94.50) and F15 (92.00). The seedlots F14 showed maximum germination value (177.40) and germination energy (82.00) whereas the minimum values were recorded for these parameters in F20 (10.42) and F2 (22.00) respectively.

Highly significant variations were observed among seedlots for all the characters of seedling performance. Family F7 recorded maximum height (87.43 cm), which was statistically at par with families F10 (81.54 cm), F13 (80.56 cm), F14 (77.44 cm) and F5 (77.62 cm). Families F10 & F19 recorded maximum collar diameter (0.39 cm), which was statistically at par with families F2, F7, F8 and F11. Maximum seedling biomass was recorded in families F8 (24.17 g) followed by F7 (20.87 g).

Statistically significant positive correlations (Table 4) were observed between pod length, times, number of seeds per pod, mean seed weight and germination. Similar correlations were also observed between pod width, time, number of seeds per pod, seed length, seed width, seed weight and germination; number of seeds per pod, times, seed weight and germination; seed length, time seed width and weight; seed width, time, seed weight, times and germination.

Discussion

The occurrence of *Acacia catechu* over a wide geographical range, encompassing a great diversity of edapho-climatic conditions of its habitat, is expected to be reflected in the genetic constitution of its diverse population. Ramachandra (1996), reported considerable variability to exist in this species indicating a good potential for selection and improvement. The species, therefore, offers opportunity for studying variation and to select superior sources/individuals for adaptability, growth and further improvement.

Morphological variation in pod and seed characters of the species could be attributed to different genetic constitution of the CPT's located in comparatively similar edapho-climatic conditions. Comparatively wider variations were observed in case of pod length, number of seeds per pod and seed weight. Such genetic variations have been reported in *Acacia catechu* (Ramachandra, 1996), *Acacia nilotica* (Bagchi and Dobriyal, 1990), *Dalbergia sissoo* (Gera *et.al.*, 2000). Genotype x environment interactions are of key importance in studying variation because they lead to a change in performance ranking of a given

Table 3. Mean values of germination and nursery parameters of selected candidate plus trees of *Acacia catechu*.

Family	Day on which a specific portion of seed had germinated		Median radicle emergence time (T50) hrs.	Final germination percent	Germination value	Germination energy	Seedling height (cm)	Seedling collar dia (cm)	Seedling biomass (g)
	25%	50%							
F1	7	10	261	78.50(62.37)	23.43	40.00	67.77	0.32	15.62
F2	8	12	290	66.00(54.33)	20.50	22.00	71.41	0.38	16.87
F3	6	7	214	67.00(60.67)	20.50	51.00	61.28	0.26	16.95
F4	5	7	204	94.50(76.44)	38.56	46.50	62.93	0.35	17.19
F5	6	6	160	90.00(71.56	104.50	73.00	77.62	0.34	15.97
F6	3	6	156	69.50(56.48)	43.31	45.00	68.14	0.31	12.46
F7	7	10	327	77.00(61.34)	15.11	46.00	87.43	0.37	20.87
F8	3	4	160	82.00(64.90)	63.36	48.00	73.62	0.36	24.17
F9	6	7	200	72.00(58.05)	42.74	40.00	71.39	0.31	13.34
F10	6	7	251	81.50(64.52)	58.49	58.50	81.54	0.39	16.90
F11	6	7	262	87.00(68.87)	32.12	45.00	67.19	0.36	16.59
F12	6	7	170	85.50(67.62)	51.35	58.50	66.67	0.32	14.13
F13	3	5	113	84.00(66.42)	107.50	62.00	80.56	0.34	18.29
F14	3	4	91	95.50(77.75)	177.40	82.00	77.44	0.31	17.66
F15	5	6	195	92.00(73.57)	33.55	45.00	68.30	0.30	14.16
F16	4	5	150	96.50(79.22)	87.32	68.50	75.20	0.33	15.74
F17	14	18	346	91.00(72.54)	10.99	70.50	75.92	0.35	19.12
F18	12	16	386	90.00(71.56)	12.40	44.00	70.11	0.34	16.03
F19	11	16	400	87.00(68.87)	12.39	33.50	75.04	0.39	17.26
F20	9	13	370	81.50(64.52)	10.42	33.50	73.49	0.35	18.97
F.Test			***	***	***	***	***	***	***
CV(%)			11.46	10.55	84.53	28.80	8.69	3.35	15.23
SE ±			3.47	2.51	1.71	2.31	5.34	0.01	1.77
CD(5%)			6.93	5.02	3.41	4.62	10.70	0.03	3.55

Significance level: *** P<0.001. Arc sine values in parenthesis

Table 4. Simple correlation (r) between pod, seed, germination and seedling characters of selected candidate plus trees of *Acacia catechu*.

Traits	Pod length	Pod width	No. of seeds per pod	Seed length	Seed width	Seed weight	Germi-nation percent	Germi-nation value	Germi-nation energy	Seedling height	Seedling collar dia	Seedling biomass
Pod length	1.0000	0.3831	0.7366***	0.1583	0.3916	0.5304*	0.5319*	0.4692*	0.4055	0.3400	0.0789	0.0816
Pod width		1.0000	0.4818*	0.6105**	0.4697*	0.6355**	0.4861*	0.2396	0.3102	0.2643	- 0.1124	- 0.3916
No. of seeds per pod			1.0000	0.1315	0.2958	0.4585*	0.4712*	0.3741	0.3762	0.1942	- 0.1810	0.9050***
Seed length				1.0000	0.6969**	0.7249***	0.2870	0.0881	0.1330	0.0437	0.1482	- 0.3550
Seed width					1.0000	0.8203***	0.2293	0.1797	0.0796	0.0680	0.3023	0.0948
Seed weight						1.0000	0.4560*	0.0848	0.2152	0.1533	0.2285	- 0.0503
Germination percent							1.0000	0.3720	0.5650**	0.1782	0.1236	0.0954
Germination value								1.0000	0.7473***	0.2542	- 0.2206	0.0099
Germination energy									1.0000	0.2995	- 0.2486	0.0536
Seedling height										1.0000	0.5290*	0.4213
Seedling collar dia											1.0000	0.4499*
Seedling biomass												1.0000

Significance level : * P<0.05, ** P<0.01, *** P<0.001.

genotype when grown in different environments. When the environmental variations are minimised, observed phenotypic value will almost be equivalent to genotypic value, if seed quality is similar. Therefore, differences observed for germination percent, germination value and germination energy could be genetic in nature because environmental deviations are negligible for experimental conditions and seeds were stored in similar conditions. This is supported by the reports of Arya *et al.* (1995) for *Prosopis cineraria,* Vakshasya *et al.* (1992) and Gera *et al.* (2000) for *Dalbergia sissoo.*

Significant variation was observed in morphological characters among the genotypes at nursery stage evaluation. Since the seedlings were raised under similar condition, variations among the seed sources may be attributed to genetic differences. Such variations in nursery performance have been reported in *Acacia albida* (Sneizko and Stewart, 1989), *Acer rubrum* (Townsend *et al.*, 1977) and *Prosopis cineraria* (Hooda and Bahadur, 1996). Seedling height may be considered to be a useful character for early selection of superior populations, as it is known to be strongly inherited (Shivkumar and Banerjee, 1986).

The correlations among the characters studied show that in *Acacia catechu,* pod size, seed weight and germination percent may prove to be important indicators for selection of genotypes to meet the immediate requirement of bulk seed. All the above mentioned characters are positively correlated with seedling height. The importance of seed length, seed weight and germination percent as a criterion for seed source selection has been reported in *Dalbergia sissoo* by Gera *et al.* (2000). The consideration of seed weight in describing the geographic variation has been advocated because of low plasticity in this character (Harper *et al.*, 1970). In the present study highly significant differences have been observed in this character.

The selection of genotypes on the basis of one criterion only, may sometimes prove dysgenic as the family F7 showed the maximum seedling height and the seedling biomass statistically at par with the maximum value but had comparatively poor germination. This shows that in screening of genotypes multi-trait selection is essential.

The genotype F14 performed better in germination and nursery stage evaluation. Owing to greater germination value and germination energy, this can be considered as more vigorous than others. Germination energy is a measure of speed of germination and is assumed to given an idea of the vigour of seed and seedlings which it produces (Willan, 1985). In the present study also, positive correlation has been obtained between germination percent, time,

seedling height and seedling biomass. Aldhous (1972) opined that only those seeds which germinate rapidly and vigorously under favourable conditions, are likely to be capable of producing vigorous seedlings in field conditions which is of immediate interest, whereas, week or delayed germination is often fatal. Germination value, being further expression of germination energy is used as an integrated measure of seed quality. This is in accordance with the results of Isik (1986) which stated that populations with high germination rate are more vigorous in terminal and root growth. Khalil (1986) also recommended the detection of fast growing provenances based on germination traits.

The genotypes F7, F10, F13, F14 and F5, which recorded the maximum seedling height in nursery stage evaluation, can be considered as more vigorous than others. These can be utilized in establishment of first generation seed orchards, which can subsequently be upgraded after the results of progeny testing is available, say after half rotation, i.e., after 12-15 years.

Acknowledgement

The authors are grateful to Director and Conservator of Forests (Research Circle), State forest Research Institute, Jammu and Kashmir, for providing necessary facilities and guidance.

References

Aldous, J. R. 1972. *Nursery Practice*.Forestry Commision Bulletin No. 45 London.

Arya, S., Toky, O. P., Bisht, R. P., Tomar, R. and Harris, P. J. C. 1995. Provenance variation in seed germination and seedling growth of *Prosopis cineraria* (L.)Druce in arid India. *Silvae Genetica*, 44 (1), 55.

Bagchi, S. K. and Dobrial, N. D. 1990. Provenance variation in seed parameters of *Acacia nilotica*. *Indian Forester*, 116, 958-961.

Czabator, F. J. 1962. Germination values- an index combining speed and completeness of pine seed germination. *Forest Science*. 8(4), 386-396.

Dormling, I. and Johnsen, 1992. Effect of the parental environment on full sib families of *Pinus sylvestris*. *Canadian Journal of Forestry Research*, 22, 88-100.

Dunlap, J. R. and Barnett, J. P. 1983. Influence of seed size on germination and early development of Loblolly pine (*Pinus taeda* L.) germinants. *Canadian Journal of Forestry Research*, 13, 40-44.

Gera, Mohit, Gera, Neelu and Gupta, B. N. 2000. Perliminary observations on genetic variability and character association in *Dalbergia sissoo* Roxb. *Indian Forester* 126 (6), 608-615.

Harper, J. L., Lovell, P. H. and Moore, K. G 1970. The shapes and sizes of seeds. *Annual Review of Ecology & Systematics.* 1, 327-340.

Hooda, M. S. and Bahadur Raj, 1996. Genetic variability in half – sib progenies of *Prosopis cineraria* (L.) Druce. Proc. of QFRI-IUFRO conference on *"Trees Improvement for sustainable tropical forestry"*, Queensland, Australia 27 Oct- 1 Nov.

International Seed Testing Association, 1993. International rules for seed testing and annexes International Seed Testing Association, *Seed Science and Technology,* 24.

Isik, K. 1986. Altitudinal variation in *Pinus brutia* Ten: Seed and seedling characteristics. *Silvae Genetica,* 35, 2-3.

Khalil, M. A. K. 1986. Variation in seed quality and some juvenile characters of white spruce (*Picea glauca). Silvae Genetica*, 35, 78-86.

Kumar, N. and Toky, O. P. 1993. Variation in Pod and seed size among *Albizia lebbek* provenances. *Nitrogen Fixing Tree Research Reports,* 2, 64-67.

Mathur, R. S., Sharma, K. K. and Rawat, M. M. S. 1984. Germination behaviour of various provenances of *Acacia nilotica* ssp. *indica. Indian Forester*, 110, 435-449.

Ramachandra, N. G. 1996. Provenance variation in seed and seedling parameters in *Acacia catechu.* Willd. Ph.D. Thesis, FRI Deemed University, Dehradun, India, 224.

Reich, P. B., Oleksyn, J. and Tjoelker, M. G. 1994. Seed mass effect on germination and growth of diverse European Scot Pine populations. *Canadian Journal of Forestry Research,*. 24, 306-320.

Sharma, N. K., Burman, V., Tewari, J. C., Bohra, M. D. and Harsh, L. N. 1994. Variability studies in pod and seed characteristics of *Prosopis juliflora* (SW)DC. *Indian Journal of Forestry*, 17(7), 161-165.

Shivkumar, Padmini and Banerjee, A. C. 1986. Provenance trials of *Acacia nilotica*. *Journal of Tree Science,* 5(1), 53-56.

Sniezko, R. A. and Stewart, H. T. L. 1989. Rangewide provenance variation in growth and nutrition of *Acacia albida* seedlings propagated in Zimbabwe. *Forest Ecology & Management,* 27, 179-197.

Szezygiel, K. 1981. Effects of seed weight on height growth of Norway Spruce seedlings under optimal conditions]. *Sylwon*, 125 (1), 33-39 (In Polish with English summary.

Townsend, A. M. 1977. Characterstics of red maple progenies from different geographic areas. *Journal of American Society of Horticulture Science,* 28(1), 33-36.

Vakshasya, R. K., Rajora, O. P. and Rawat, M. S. 1992. Seed and seedling traits of *Dalbergia sissoo* Roxb.: seed source variation studies among ten sources in India. *Forest Ecology and Management,* 48. 265-275.

Willan, R. I. 1985. A guide to forest seed handling with particular reference to the tropics. FAO forestry paper, 20/2., 217-218