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Seed Source Variation on Seed Traits of *Acacia catechu* Willd.

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ABSTRACT

Acacia catechu Willd. is a small or medium sized deciduous multipurpose trees yielding good quality timber and the heartwood is used for extraction of Katha, Cutch and Kheersal on a commercial scale. Estimate of seed source variation on seed traits of *Acacia catechu* Willd. was carried out by collecting seeds from plus trees selected at 32 seed sources from Himachal Pradesh during January-February. Significant differences were observed for all seed traits. Very low to heavy infestation of pods was observed among the seed sources. The pod colour varied between greyed orange to brown. Seed length showed maximum Variance, Coefficient of variability both at phenotypic and genotypic levels with Heritability - 95.30 %, Genetic advance - 2.71 and Genetic gain - 49.63 %. At genotypic level seed length showed positive and significant correlation with seed width (r=0.991), seed thickness (r=0.883), 100 seed weight (r=0.908) and pod length (r=0.822); seed width with seed thickness (r=0.777), 100 seed weight (r=0.856), and pod width (r=0.884), whereas being negatively related with seed length and number of seeds per pod (r=-0.771) and pod length (r=-0.816); and seed width with number of seeds per pod (r=-0.804) and pod length (r=-0.808). At phenotypic level also similar trends were observed but the values of correlation coefficients recorded were lower. The variation observed for seed traits did not follow any particular trend with regard to different populations. It is visualised that pod colour can be used as an effective tool for selecting genotypes for seed quality and high Katha-Cutch content.

Key words:

Acacia catechu Willd.; Variability; Plus Tree; Seed source

INTRODUCTION

Acacia catechu Willd. is a small or medium sized deciduous multipurpose tree attaining a height of 12-15 m, usually crooked and forked (Troup 1921). It is used for afforestation and reclamation due to its easy adaptability and rapid growth rate even under degraded and wasteland conditions (Anonymous 1985). The species yields good quality timber which is extremely strong and hard. The heartwood is used for extraction of Katha, Cutch and Kheersal. The species is considered to be an important lean summer season fodder tree with good palatability and nutritive value (Singh 1982).

Geographic variation exists in forest trees due to the genetic differentiation and environmental divergence in which they have developed through ages. Study of variation is the first step for any breeding programme. Forest tree improvement programmes start with the study of available variation in the entire range of species distribution and delimitation of seed sources capable of providing the best adapted trees (Suri 1984). Seed source studies are desirable to screen the natural available genetic variation to utilize the best material for maximum productivity and for further breeding work (Shiv Kumar and Banerjee 1986). At the nursery, crop variation begins with the sowing and germination of seed. The seed characters (i.e. seed length, seed width, seed thickness, 100 seed weight, number of seeds per pod, pod length, pod width, per cent pods infested and pod colour) effect the germination of seeds. Therefore, a study of the seed source variation in seed characters of *A. catechu* was undertaken.

MATERIALS AND METHODS

The present investigation was carried out at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). An ecogeographical survey of the populations of *Acacia catechu* was undertaken in the entire range of its distribution in Himachal Pradesh to identify the sites. A total of 32 seed sources were selected. The geographical location of the seed sources are distributed in the districts of Bilaspur, Hamirpur, Kangra, Sirmaur, Solan and Una ranging from 30^0 25' 40" to 33^0 32' 18" N latitude and 76^0 06' 11" to 77^0 52' 11" E longitude (Fig. 1; Table 1). The altitude of the entire range varies from 500 to 1250 m above mean sea level. The localities fall under tropical to subtropical (subtemperate) climate.

Plus trees were selected on the basis of different morphological traits viz. diameter, height, clean bole and crown spread following the standard procedure (Ledig 1974). Five plus trees from each site were selected and seeds form these plus trees were collected during January-February. Observations on seed length, seed width, seed thickness, 100 seed weight, number of seeds per pod, pod length, pod width, per cent pods infested and pod colour were taken for 25 randomly selected seeds/pods having four replications. Colour of the fresh pods was matched with the Royal Horticultural Society, standard colour chart and their code noted down.

The data was subjected to statistical analysis using Randomized Block Design with three replications as per procedures laid down by Panse and Sukhatme (1967). Variance and coefficient of variability were worked out by the formula suggested by Burton and De vane (1953). The coefficient of variability between seed sources was found out by the formula given by Pillai and Sinha (1968). The expected genetic advance at 5% selection intensity and heritability in percentage was calculated as followed by Lewis et al. (2010). The phenotypic and genotypic correlation coefficients were computed by the method proposed by Al-Jibouri et al. (1958).

RESULTS AND DISCUSSION

The variation with respect to all the seed traits was significant among the different seed sources. The data pertaining to the variation in seed traits viz. seed length, seed width, seed thickness, 100 seed weight, number of seeds per pod, pod length, pod width, per cent pod infested and pod colour is presented in Table 2 the data envisages that the average seed length for all the seed sources was recorded to be 5.46 mm. The seeds collected from S_{15} (Nalagarh) recorded the maximum seed length (8.45 mm) at par with S_{16} (Ghrindan) with seed length of 8.04 mm while S_9 (Berthin) had minimum seed length (3.72 mm) which was at par with S_8 (Baljol) and S_{21} (Dharet) with mean values of 3.77 mm and 3.79 mm, respectively. Maximum seed width (6.46 mm) was observed in S_2 (Delgi) and S_8 (Baljol) exhibited minimum seed width (3.36 mm). Significant differences were observed in respect of seed thickness. Maximum (1.98 mm) and minimum (1.14 mm) seed thickness was observed for the seeds collected from S_{15} (Nalagarh) and S_{21} (Dharet C No. 2), respectively. Seed weight of 100 seeds differed significantly among different seed sources with a range of 2.23-4.48 g. Maximum seed weight (4.48 g) was obtained for S_{15} (Nalagarh) followed by S_{16} (Ghrindan) with a value of 4.39 g. Minimum seed weight (2.23 g) was recorded for S_7 (Baljol).

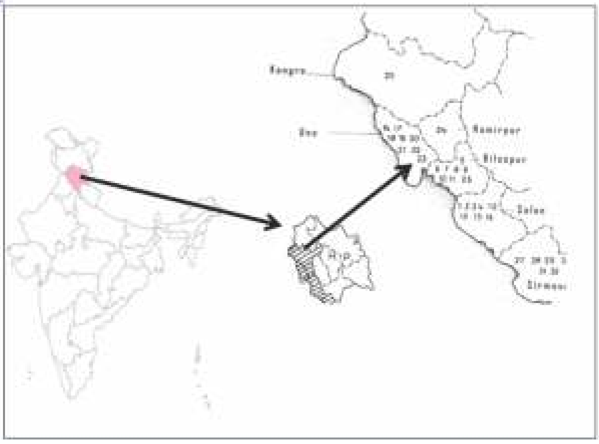

Fig 1. Location of seed sources from different parts of Himachal Pradesh.

The number of seeds per pod was in the range of 2.98 for S_{15} (Nalagarh) to 6.11 for S_{17} (Aulinda) seed source. The average pod length amongst the different seed sources was found to be 5.64 cm with a coefficient of variability of 3.36 percent. Maximum pod length (7.35 cm) was observed from S_{17} (Aulinda); and seed sources S_{15} (Nalagarh) and S_{16} (Ghrindan) had minimum pod length (4.29 cm). Maximum pod width (1.78 cm) was noticed for S_{15} (Nalagarh) whereas S_7 (Baljol) exhibited minimum pod width (1.05 cm).

Very low to heavy infestation of pods was observed among the different seed sources. Lowest pod infestation of 2.8 per cent was recorded for S_9 (Berthin) while being quite high for the pods from S_{26} (Bhakra) with 48.5 per cent infestation. The pod colour varied between 165A (Greyed Orange Group) to 200D (Brown group). The other colours noticed in between these groups were 165B, 199A, 199B (Grey Brown Group), 177A (Grey Orange Group), 200B and 200 D (Brown Group). The pod colour may be an effective trait for selection of genotypes for better seed. This can also be used to derive indirect genetic gain for selecting genotype with high katha and cutch content which forms the major use of this species.

The variation observed for seed traits did not follow any particular trend with regard to different populations. This could be probably because of environmental factors which might have played a significant role in changing the component of seed as also reported by Bagchi et al. (1990) on *Acacia*. Provenance variation exists for seed parameters and selection at a low key may be effective (Bagchi and Dobryal 1990). Bagchi (1992) from a preliminary study on *Acacia nilotica* also found significant differences for seed length, seed width and thickness among 42 provenances. The existence of significant genetic variation among seed sources for seed morphology was also recognized in *Dalbergia sissoo* by Vakshasya et al. (1992) and assigned it as to be geographical.

The splitting of cumulative variance showed maximum phenotypic (1.91) and genotypic (1.82) variance for seed length while recording minimum for pod width. Coefficient of variability was also maximum (Table 3) for seed length (25.33 % for phenotypic and 24.72 % for genotypic). Seed length also recorded the maximum heritability (95.30 %); genetic advance (2.71) and genetic gain (49.63 %), while being minimum for pod width (Table 4).

The variability estimates and genetic parameters for seed length showed a moderate genotypic coefficient of variability and genetic gain accompanied by a highest heritability of 95.30 per cent, while the other seed traits noticed a low genotypic coefficient of variability, moderate genetic gain and with high heritability (Table 3 and 4). Since, all the characters viz., seed length, seed width, 100 seed weight and number of seeds per

Table 1. Locations of seed sources from different parts of Himachal Pradesh.

Sr. No.	Seed Source	Code used	District	Altitude (m)	Latitude (N)	Longitude (E)
1	Kathani	S_{1}	Solan	1320	31°07′	76°55′
2	Delgi	S_{2}	Solan	1140	31°06′	76°54′
3	Haripur	S_{3}	Solan	1135	31°04′	76°53′
4	Kunihar	S_{4}	Solan	932	31°09′	76°58′
5	Nain Gugran	S_{5}	Bilaspur	584	31°10′	76°59′
6	Ghumarwin	S_{6}	Bilaspur	685	31°25′	76 °45′
7	Baljo l C. No. 1	S_{7}	Bilaspur	580	31 °19′	76 °48′
8	Baljol C. No. 3	S_{8}	Bilaspur	610	31 °19′	76 °48′
9	Berthin	S_{9}	Bilaspur	565	31 °17′	76 °47′
10	Amarpur	S_{10}	Bilaspur	672	31 °21′	76 °44′
11	Swarghat	S_{11}	Bilaspur	720	31 °14′	76 °42′
12	Berchha	S_{12}	Solan	915	31 °08′	76 °54′
13	Dolan	S_{13}	Solan	894	31 °06′	76 °52′
14	Bhatian	S_{14}	Una	430	31 °41′	76 °06′
15	Nalagarh	S_{15}	Solan	620	31 °11′	76 °52′
16	Ghrindan	S_{16}	Solan	678	31 °11′	76 °51′
17	Aulinda	S_{17}	Una	535	31 °41′	76 °04′
18	Mou C. No. 1	S_{18}	Una	550	31 °41′	76 °08′
19	Mou C. No. 2	S_{19}	Una	570	31°41′	76 °08′
20	Dharet C.No. 1	S_{20}	Una	535	31 °40′	76 °07′
21	Dharet C.No. 2	S_{21}	Una	520	31 °40′	76 °07′
22	Dehan	S_{22}	Una	520	31 °42′	76 °14′
23	Wahad	S_{23}	Una	500	31 °42′	76 °18′
24	Nagarera	S_{24}	Hamirpur	485	31°30′	76°27′
25	Gumbar	S_{25}	Kangra	500	31 °43′	75 °49′
26	Bhakra	S_{26}	Bilaspur	636	31 °24′	76 °43′
27	Gaura	S_{27}	Solan	1124	30 °48′	76 °13′
28	Nahan	S_{28}	Sirmaur	932	30 °07′	77 °01′
29	Tanda	S_{29}	Sirmaur	400	30 °04′	77 °45′
30	Sathaun	S_{30}	Sirmaur	1200	30 °05′	77 °40′
31	Gorkuwala	S_{31}	Sirmaur	450	30 °08′	77 °38′
32	Dilman	S_{32}	Sirmaur	1120	30 °49	77 °11

The number of seeds per pod was in the range of 2.98 for S_{15} (Nalagarh) to 6.11 for S_{17} (Aulinda) seed source. The average pod length amongst the different seed sources was found to be 5.64 cm with a coefficient of variability of 3.36 percent. Maximum pod length (7.35 cm) was observed from S_{17} (Aulinda); and seed sources S_{15} (Nalagarh) and S_{16} (Ghrindan) had minimum pod length (4.29 cm). Maximum pod width (1.78 cm) was noticed for S_{15} (Nalagarh) whereas S_{7} (Baljol) exhibited minimum pod width (1.05 cm).

Very low to heavy infestation of pods was observed among the different seed sources. Lowest

Table 2. Variation with respect to seed traits among the seed sources of *Acacia catechu*.

Seed source	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100 seed weight (g)	No. of seeds per pod	Pod length (cm)	Pod width (cm)	Per cent pods infested	Pod Colour
S_1	4.70	4.63	1.25	2.29	5.40	6.13	1.22	21.4	165B
S_2	7.92	6.46	1.81	4.28	3.42	4.45	1.58	29.6	165A
S_3	5.80	4.82	1.35	3.59	4.45	5.59	1.36	9.3	165A
S_4	5.29	4.74	1.26	3.27	4.10	5.36	1.36	15.0	165A
S_5	6.98	5.93	1.67	4.27	3.98	5.05	1.65	11.7	199A
S_6	6.13	5.04	1.47	3.77	4.32	5.62	1.29	7.2	199B
S_7	3.81	3.43	1.23	2.23	4.98	6.16	1.05	16.0	199A
S_8	3.77	3.36	1.34	2.83	5.39	6.48	1.24	6.3	199A
S_9	3.72	3.43	1.18	2.43	4.35	5.48	1.24	2.8	200D
S_{10}	5.47	5.12	1.43	3.51	3.44	4.71	1.49	6.7	200D
S_{11}	7.74	6.28	1.51	4.23	4.34	5.37	1.64	27.3	165A
S_{12}	5.60	4.25	1.43	3.90	4.29	5.74	1.30	16.3	200B
S_{13}	5.76	4.79	1.44	4.07	5.13	6.21	1.32	21.0	177A
S_{14}	5.19	4.67	1.60	3.37	5.19	6.24	1.60	25.0	199B
S_{15}	8.45	6.42	1.98	4.48	2.98	4.29	1.78	11.7	165B
S_{16}	8.04	6.14	1.76	4.39	3.04	4.29	1.64	13.2	165A
S_{17}	3.81	3.54	1.20	2.38	6.11	7.35	1.24	20.4	200B
S_{18}	5.39	4.81	1.35	3.34	4.21	5.33	1.28	12.8	200D
S_{19}	5.18	4.71	1.56	3.73	4.32	5.44	1.36	13.4	200D
S_{20}	4.04	3.59	1.24	3.39	5.17	6.24	1.15	14.9	165A
S_{21}	3.79	3.46	1.14	2.25	5.48	6.52	1.15	15.1	165A
S_{22}	5.66	4.64	1.35	3.72	4.16	5.61	1.41	12.5	200B
S_{23}	3.89	3.57	1.22	2.90	5.69	6.86	1.21	17.4	200D
S_{24}	5.75	4.71	1.67	3.49	4.31	5.59	1.26	4.2	200D
S_{25}	4.20	3.75	1.47	2.74	5.13	6.31	1.17	15.6	200D
S_{26}	7.70	5.50	1.87	4.24	3.46	4.92	1.17	48.5	199A
S_{27}	5.78	4.60	1.45	3.72	4.27	5.45	1.27	8.4	200D
S_{28}	4.53	4.11	1.59	3.35	4.79	5.97	1.23	24.6	165A
S_{29}	4.99	4.09	1.64	3.34	4.21	5.42	1.27	21.8	200D
S_{30}	5.61	4.78	1.69	3.53	4.21	5.57	1.26	13.4	200D
S_{31}	4.99	4.09	1.59	3.39	4.11	5.34	1.22	22.2	200B
S_{32}	5.09	4.27	1.50	3.52	4.16	5.51	1.29	6.2	200D
Mean	5.46	4.62	1.48	3.44	4.46	5.64	1.33	15.99	-
SE(m)±	0.18	0.19	0.06	0.12	0.12	0.11	0.07	1.57	-
$CD_{0.05}$	0.49	0.52	0.17	0.32	0.33	0.31	0.19	0.43	-
CV(%)	5.51	6.81	7.05	5.67	4.51	3.36	8.42	55.53	-

pod infestation of 2.8 per cent was recorded for S_9 (Berthin) while being quite high for the pods from S_{26} (Bhakra) with 48.5 per cent infestation. The pod colour varied between 165A (Greyed Orange Group) to 200D (Brown group). The other colours noticed in between these groups were 165B, 199A, 199B (Grey Brown Group), 177A (Grey Orange Group), 200B and 200 D (Brown Group). The pod colour may be an effective trait for selection of genotypes for better seed. This can also be used to derive indirect genetic gain for selecting genotype with high katha and cutch content which forms the major use of this species.

The variation observed for seed traits did not follow any particular trend with regard to different populations. This could be probably because of environmental factors which might have played a significant role in changing the component of seed as also reported by Bagchi et al. (1990) on *Acacia*. Provenance variation exists for seed parameters and selection at a low key may be

Table 3. Variability estimates for seed traits among the seeds sources of *Acacia catechu.*

Character	Variance		Coefficient of variability (%)	
	Phenotypi c	Genotypic	Phenotypic	Genotypic
Seed length (mm)	1.19	1.82	25.33	24.72
Seed width (mm)	0.90	0.80	20.50	19.34
Seed thickness (mm)	0.05	0.04	15.63	13.95
100 seed weight (g)	0.45	0.41	19.55	18.71
No. of seeds per pod	0.60	0.56	17.35	16.76
Pod length (cm)	0.52	0.48	12.78	12.33
Pod width (cm)	0.04	0.03	14.86	12.25

Table 4. Estimates of genetic parameters for seed traits among the seeds sources of *Acacia catechu*.

Character	Heritability (%)	Genetic advance	Genetic gain (%)
Seed length	95.30	2.71	49.63
Seed width	89.00	1.73	37.45
Seed thickness	79.60	0.38	25.68
100 seed weight	91.60	1.27	36.92
No. of seeds per pod	93.20	1.49	33.41
Pod length	93.10	1.38	24.47
Pod width	67.90	0.28	21.05

Table 5. Phenotypic (P) and genotypic (G) correlation coefficients for seed traits among the seed sources of *Acacia catechu*.

Character		Seed length	Seed width	Seed thickness	100 seed weight	No. of seeds per pod	Pod length
Seed width	P	0.917*					
	G	0.991*					
Seed thickness	P	0.712*	0.640*				
	G	0.833*	0.777*				
100 seed weight	P	0.852*	0.794*	0.705*			
	G	0.908*	0.856*	0.801*			
No. of seeds per pod	P	-0.765*	-0.703*	-0.654*	-0.703*		
	G	-0.804*	-0.771*	-0.749*	-0.761*		
Pod length	P	-0.774*	-0.744*	-0.624*	-0.684*	0.945*	
	G	-0.818*	-0.816*	-0.746*	-0.743*	1.000*	
Pod width	P	0.651*	0.731*	0.463*	0.598*	-0.487*	-0.549*
	G	0.822*	0.884*	0.626*	0.750*	-0.630*	-0.670*

* Significant at 5% level of significance

effective (Bagchi and Dobryal 1990). Bagchi (1992) from a preliminary study on *Acacia nilotica* also found significant differences for seed length, seed width and thickness among 42 provenances. The existence of significant genetic variation among seed sources for seed morphology was also recognized in *Dalbergia sissoo* by Vakshasya et al. (1992) and assigned it as to be geographical.

The splitting of cumulative variance showed maximum phenotypic (1.91) and genotypic (1.82) variance for seed length while recording minimum for pod width. Coefficient of variability was also maximum (Table 3) for seed length (25.33 % for phenotypic and 24.72 % for genotypic). Seed length also recorded the maximum heritability (95.30 %); genetic advance (2.71) and genetic gain (49.63 %), while being minimum for pod width (Table 4).

The variability estimates and genetic parameters for seed length showed a moderate genotypic coefficient of variability and genetic gain accompanied by a highest heritability of 95.30 per cent, while the other seed traits noticed a low genotypic coefficient of variability, moderate genetic gain and with high heritability (Table 3 and 4). Since, all the characters viz., seed length, seed width, 100 seed weight and number of seeds per pod are under strong additive genetic control, so they will have a significant influence through selection. The other traits like seed thickness, pod length and pod width will also be effective following selection for these characters but at a lower level to that of the former mentioned traits. This was in line with the variability study of Bagchi et al. (1990) in which they noticed that environmental factors seems to play a little part in changing any component of seed size and all the characters under study seems to be highly heritable.

The correlation coefficients represented in Table 5 showed that at genotypic level seed length showed a highly significant and positive correlation with seed width (r = 0.991), 100 seed weight (r = 0.908), seed thickness (r = 0.883) and pod width (r = 0.822); Seed width with seed thickness (r= 0.777), pod width (r= 0.884) and 100 seed weight (r= 0.856); seed thickness and 100 seed weight (r= 0.801); between seed thickness and pod width (r= 0.626) and between 100 seed weight and pod width (r= 0.750); while having a highly significant and negative correlation with pod length (r = -0.818) and number of seeds per pod (r= - 0.804); number of seed per pod (r = - 0.771) and pod length (r = - 0.816); seed thickness and number of seeds per pod (r= - 0.749); 100 seed weight and pod length (r= - 0.743); number of seeds per pod and pod width (r= -0.630) and between pod length and pod width (r= -0.670). At the phenotypic level a lower value of correlation coefficients was observed for all the pair of characters studied, while showing a similar negative / positive and significant correlation as noted at the genotypic level similar to that observed by Kaushik et al. (2007).

Substantial differences between phenotypic and corresponding genotypic correlations in all pairs of characters were observed due to environmental effects. Further, the magnitude of genotypic correlations was higher than their corresponding phenotypic correlations barring the association of number of seeds per pod with pod length which exceeded the upper limit. These relationships indicate that seed length, seed width, seed thickness, 100 seed weight and pod width which had significant positive correlations with each other should be considered as effective parameters for selection of better seeds. It also suggests that selection for any one of these traits will be reliable for others also. Such findings are in support of the work done by Arora et al. (1989) in *Trigonella foenum-graecum* and Gupta (1993) in G*rewia optiva*.

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