

## Seed Source Variation in Pod and Seed Characteristics of *Acacia nilotica* subsp. *Indica*

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**Abstract:** A study was conducted on seed source variation in pod and seed characters of *Acacia nilotica* ssp. *indica*. Germplasm was collected from 28 provenances of Central and North-western parts of India, lying between 75°39'E to 81°39'E longitude and 20°42'N to 25°27'N latitude, and under 18 seed zones of six states of the country. Findings revealed significant variation within and between provenances for pod length, pod width, number of seeds per pod, seed length, seed width, seed thickness, 100-seed weight and 100-seed volume. Significant positive correlations were found between tree height and clean bole and tree girth, pod length and seeds per pod, seed weight and seed length, width and thickness, seed weight and seed volume, seed volume and seed length, width and thickness. It indicated that improvement in pod length and seed weight will improve the other associated traits. Raipur, Kawardha and Mandla seeds sources had high seed weight with bold seeds and hence they would be best for raising the nursery. Selection of plus trees from these provenances can bring higher genetic gain and improvement in these traits.

**Key words:** *Acacia nilotica*, correlation, provenance, pod and seed size, variability.

Selection of right seed source of a species for a given site or region is necessary for maximum productivity both in plantation forestry, and agroforestry systems (Subramaniam *et al.*, 1992). Exploration of naturally occurring variability permits tree breeders to make rapid genetic advance. Forest species with large heterozygosity also exhibit considerable variation in traits like pod size, morphology of seed characters, hard seed coat, dormancy, pretreatment requirements, length of stratification period, germination rate and cardinal temperature for storage and optimum germination. The significance of source variation in seed and seedling traits has been reported in number of tree species, viz. *Acacia auriculiformis* (Huang, 1989), *Acacia catechu* (Ramachandra, 1996), *Acacia mangium*

(Salazar, 1989), *Acacia nilotica* (Shiv Kumar and Banarjee, 1986; Krishan and Toky, 1996; Bagchi and Dobriyal, 1990; Bagchi *et al.*, 1990), *Albizia lebbek* (Kumar and Toky, 1993), *Dalbergia sissoo* (Vakshasya *et al.*, 1992), *Eucalyptus tereticornis* (Ginwal *et al.*, 2004), *Prosopis cineraria* (Kackar *et al.*, 1986) and *Santalum album* (Bagchi and Sharma, 1989) etc. Morphological differences and their effect on seed germination of different provenances of *Acacia nilotica* and pretreatment requirement to hasten the germination have been reported by Mathur *et al.* (1984) and Shiv Kumar and Banarjee (1986). A basic knowledge about the nature and extent of seed source variation in seed parameters such as seed size and weight, seed vigor, germination, seedling

characteristics, frequency of abnormal seedlings and some primary metabolites, resistance to frost, drought, disease, etc., is essential for genetic improvement of the species especially for early selection (FAO, 1985; Ramachandra, 1996). Information on variations among seed zones will help to plan future breeding program (FAO, 1985; ISTA, 1993).

*Acacia nilotica* ssp. *indica* (Babul or Kikar) is a medium sized, multipurpose, fast growing, leguminous tree. It is extensively used for small timber, fodder, fuel, gum tannin, etc. Continuous exploitation of this species through dysgenic selection has eroded its genetic base. It needs immediate efforts for improvement and conservation. The present study aims at studying the magnitude of variation and nature of correlations in pod and seed parameters of *A. nilotica* ssp. *indica*.

## Materials and Methods

To study the nature and pattern of variations in pod and seed characteristics, its germplasm was collected during May-June, 2003 and June 2005 from 19 provenances of Central India and 9 provenances of North-western India, lying between 75°39'E to 81°39'E longitude and 20°42'N to 25°27'N latitude (Table 1). The seeds of local provenance, i.e. Jhansi were also collected to compare with those of other provenances. Explorations had covered 18 seed zones of six states i.e. 10 seed zones of Madhya Pradesh (MP), 4 seed zones of Maharashtra, 2 seed zones of Rajasthan and one seed zone of both Haryana and Uttar Pradesh. In each seed source (provenance), fresh mature pods (500-800 g pods/tree) were harvested from

10 to 20 selected disease free trees, 100 to 500 m apart, having straight clean bole. It is reported to be cross-pollinated species and chances of inbreeding are less (Tybric, 1989). The provenances were delineated, based on geographical barriers (rivers, hills, forests, etc.), long distances, varying soil and vegetation types, as recommended by Turnbull (1975) and FAO (1975). Morphological parameters of each tree i.e., height, clean bole, girth at breast height and edaphic conditions of the site were recorded during exploration. Random samples of 15 pods/tree and 20 seeds/tree were used for recording data on size of pod and seed. Hundred seeds were used to record seed weight and volume. Data were analyzed statistically adopting standard methods of mean, standard error, coefficient of variation and correlations as per Panse and Sukhatme (1985).

## Results and Discussion

There were large variations in plant height, girth and the coefficient of variation was quite high in tree height (25.85%), clean bole (39.54%) and tree girth (37.72%), indicating a large variation in size of trees (Table 2). Age difference and growing conditions might be major cause of these variations. Data also revealed a large variation in geographic location, latitude, longitude, altitude and soil type of the provenances (Table 1). Analysis of soil samples revealed variation in soil types from clay to sandy, fine to gravely, acidic to saline, red, gray and black, irrigated, partially irrigated, rainfed etc. The extent of variations in all these factors account for the genotypic variability in adaptability, growth, productivity, morphology and

Table 1. Geographical and edaphic characteristics of different provenances of *Acacia nilotica* subsp. *indica*

Source/Location		Longitude	Latitude	Altitude	Seed zone	Soil type and colour
District	State	(m)				
Jhansi	UP	78°32'E	25°30'N	271	UP-X	Red sandy
Sagar	MP	78°43'E	23°51'N	532	MP-II	Clay loam and black
Damoh	MP	79°26'E	23°50'N	371	MP-II	Clay loam, light black
Jabalpur	MP	79°56'E	23°10'N	394	MP-II	Loam, clay, loam black
Mandla	MP	80°22'E	22°35'N	441	MP-X	Black clay and sandy
Kawardha	CG	81°14'E	22°00'N	341	MP-X	Black clay loam,
Raipur	CG	81°37'E	21°15'N	325	MP-VIII	Clay loam, black, sandy and red sandy
Rajnandgaon	CG	81°05'E	21°05'N	302	MP-IX	Clay loam, brown and black
Nagpur	MR	79°05'E	21°09'N	304	MR-VI, V	Sandy brown and black clay
Wardha	MR	78°11'E	21°05'N	307	MR-IV	Clay loam, black and red sandy
Akola	MR	76°58'E	20°42'N	297	MR-III	Sandy brown and black clay
Malkapur	MR	76°12'E	20°53'N	240	MR-III	Sandy brown and black clay
Khandwa	MP	76°22'E	21°48'N	303	MP-XII	Grayish and black clay
Indore	MP	75°50'E	22°44'N	551	MP-XIII	Sandy brown and black clay
Ujjain	MP	75°46'E	23°11'N	478	MP-XIV	Black clay loam
Shajapur	MP	76°17'E	23°26'N	448	MP-XIV	Sandy brown and black clay
Rajgarh	MP	76°52'E	23°55'N	422	MP-XV	Clay loam, black and brown
Bhopal	MP	77°24'E	23°15'N	545	MP-XV	Clay loam, black and brown
Guna	MP	77°18'E	24°38'N	487	MP-I	Clay loam and red sandy
Gwalior	MP	78°11'E	26°08'N	242	MP-III	Black Clay and red sandy
Dholpur	RJ	77°52'E	26°41'N	180	RJ-I	Sandy soil
Bharatpur	RJ	77°29'E	27°13'N	175	RJ-II	Sandy loam and fine loam
Dausa	RJ	76°20'E	26°53'N	344	RJ-II	Sandy loam and fine loam
Jaipur	RJ	75°47'E	27°07'N	432	RJ-II	Sandy loam and fine loam
Alwar	RJ	76°36'E	27°33'N	151	RJ-II	Sandy loam
Rewari	HR	76°34'E	28°11'N	246	HR-II	Sandy loam
Jhajjar	HR	76°34'E	28°53'N	224	HR-II	Sandy loam
Karnal	HR	77°02'E	29°42'N	232	HR-II	Clay loam, saline

MP: Madhya Pradesh, MR: Maharashtra, RJ: Rajasthan, HR: Haryana, UP: Uttar Pradesh, CG: Chhattisgarh.

physiological process of the intermating population of seed source growing in a particular region. Seed zones based on patterns of geographical variations help in certification and distribution of seed and planting stock to assure good growth,

adaptability to site and survival. This information on variations among seed zones will help to plan future breeding program (FAO, 1985; ISTA, 1993). Difference in initiation of flowering and pod maturity were observed in different states during

Table 2. Mean and variation in tree size, pod and seed characters of different provenances of *Acacia nilotica* subsp. *indica*

Character	Mean±SE	Range	CV (%)	F-ratio
Tree height (m)	11.38±0.200	5.6-20.0	25.85	—
Clean bole (m)	2.68±0.072	0.95-5.1	39.54	—
Tree girth (cm)	111.23±2.85	45.0-350.0	37.72	—
Pod length (cm)	15.14±0.098	8.0-24.5	17.14	8.275**
Pod width (mm)	14.40±0.042	10.0-20.0	13.38	12.214**
Seeds per pod	11.79±0.071	6.0-15.0	17.84	5.383**
Seed length (mm)	7.67±0.026	5.5-9.8	8.43	7.096**
Seed width (mm)	6.38±0.023	3.0-8.2	9.55	6.512**
Seed thickness (mm)	3.78±0.017	2.0-7.8	12.42	5.874**
Seed weight (g)	13.29±0.17	9.1-19.3	12.96	3.432**
Seed volume (cc)	10.20±0.12	7.0-14.5	12.25	2.613**

\*\* significant at 0.01 P level.

germplasm collection. Flowering and pod maturity were about 15 to 20 days earlier in Chhattisgarh and Maharashtra in comparison of Haryana. A general belief that crops perform poorly beneath this tree was contradicted by some of the farmers in Rajasthan and Chhattisgarh.

#### Variation in pod and seed characteristics

Significant variation was observed between and within the provenances for pod length, pod width, seeds per pod, seed length, seed width, seed thickness, 100-seed weight and 100-seed volume ( $P < 1\%$  level, Table 2). Variation among provenances in pod and seed characters has been reported and used for improvement in many other tree species like *Acacia auriculiformis*, *A. mangium*, *A. catechu*, *Prosopis cineraria* and *Acacia nilotica* (Huang, 1989; Salazar, 1989; Ramachandra, 1996; Kackar *et al.*, 1986; Shiv Kumar and Banarjee, 1986; Krishan and Toky, 1996; Bagchi and Dobriyal, 1990; Bagchi *et al.*, 1990). Pod length, pod width, seeds per pod and seed

weight had high variability with coefficient of variation (CV) of 17.14%, 13.38%, 17.84% and 12.96%, respectively, indicating selection can be effectively employed to improve these traits. Seed length, width and thickness had comparatively less variation than other traits. The mean pod length was 15.14 cm and it varied from 8.0 to 24.5 cm (Table 2, Fig. 1). Mandla provenance had longest pod followed by Jabalpur and Raipur. Sagar provenance had the shortest pod. Pod width of Gwalior provenance was minimum and maximum was in Mandla provenance. Average number of seeds per pod was 11.7 and varied from 6 to 15 seeds per pod in the surveyed population. One pod of *A. nilotica* can have a maximum of 16 seeds due to 16 ovules in pistil. Shajapur provenance had maximum seeds per pod followed by Raipur and Bhopal provenances. Alwar provenance had the lowest seeds per pod. Seed length of Rewari provenance was minimum and it was maximum in Rajnandgaon provenance. Seed width of Guna was found minimum

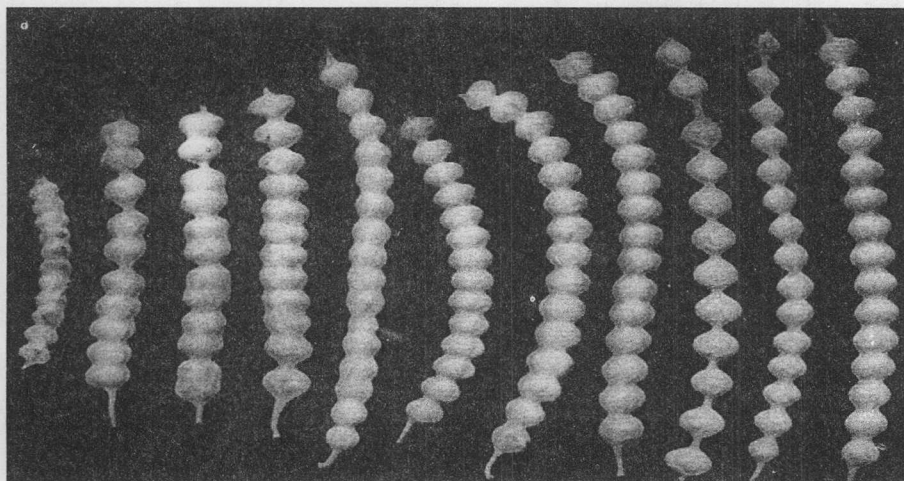


Fig. 1. Variation in pods of *Acacia nilotica* spp. *indica*.

and was maximum in Kawardha provenance. Seed thickness was lowest in Dholpur and highest in Raipur provenance. Average 100-seed weight was 13.29 g and it ranged from 11.09 to 15.12 g (Table 3). Raipur provenance had maximum seed weight followed by Kawardha and Malkapur. Minimum seed weight was recorded in Jhansi provenance. Average volume of 100-seeds was 10.2 cc and it was found minimum in Jhansi and maximum in Kawardha provenance.

Comparing the length of pod and number of seeds per pod of different provenances, the Rajgarh provenance had short pod (14.11 cm) with high number of seeds (12.07). Their pods had uniform width through out the length and were completely filled with seeds. While, the Mandla and Jabalpur provenances had longest pod (mean 17.5 cm) with nearly 12 seeds per pod. In fact, the pods of both provenances were like necklace having beads on string (Fig. 1). Collections from Raipur, Kawardha, Mandla and Wardha had high seed weight with

bold seeds (Table 3). This area of Chhattishgarh state is known as rice bowl of the country and has highest intensity of *Acacia* trees mainly on field bunds, under agroforestry system. The inputs in the form of manure, fertilizer, irrigation, etc., applied to the field crops, contributed to better growth, productivity, pod and seed quality of *Acacia* trees growing under the system. The system is traditionally followed over generations, in which selection pressure of retaining best trees and culling of inferior types are generally practiced. Further, selection of plus trees from said area may bring higher genetic gain and improvement.

#### *Correlations between tree size, pod and seed characters*

Tree height had significantly high and positive correlation with clean bole and tree girth (Table 4). However, tree size (height, clean bole and girth) had very little and non-significant correlations with pod and seed size and with seed weight. Significant positive correlations were found

Table 3. Mean values of pod and seed characters of different provenances of *Acacia nilotica* subsp. *indica*

Provenances	Pod length (cm)	Pod width (mm)	Seeds per pod	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100-seed weight (g)	Seed volume (cc)
Jhansi	15.90	14.26	12.11	7.38	6.07	3.37	11.09	9.07
Sagar	12.88	13.51	10.03	7.52	6.36	3.58	11.91	9.46
Damoh	14.14	14.30	10.73	7.44	6.36	3.75	12.45	9.83
Jabalpur	17.49	14.90	11.96	7.73	6.32	3.74	13.40	10.20
Mandla	17.52	16.65	11.75	8.03	6.59	3.74	14.39	10.94
Kawardha	12.89	15.00	10.70	8.02	6.80	3.90	14.93	11.72
Raipur	17.10	16.10	12.40	7.86	6.70	3.92	15.12	11.37
Rajnandgaon	15.87	15.40	12.00	8.19	6.65	3.73	14.48	10.87
Nagpur	15.65	15.06	12.03	8.06	6.44	3.71	14.38	10.71
Wardha	14.60	14.68	10.68	7.92	6.66	4.13	14.63	11.20
Akola	14.58	14.67	12.13	7.78	6.63	3.92	14.40	11.12
Malkapur	14.69	14.92	11.20	8.09	6.63	3.88	14.79	11.12
Khandwa	15.40	14.44	11.58	7.54	6.56	3.81	13.63	10.25
Indore	15.11	14.06	11.90	7.65	6.45	3.78	13.52	10.32
Sajapur	16.18	14.07	12.47	7.90	6.46	3.81	13.66	10.25
Ujjain	15.19	13.77	12.31	7.35	6.31	3.81	13.39	10.35
Rajgarh	14.11	13.82	12.07	7.32	6.12	3.74	12.40	9.53
Bhopal	14.94	13.62	12.40	7.32	6.12	3.83	11.88	9.18
Guna	14.26	14.07	12.17	7.51	5.86	3.78	12.17	9.65
Gwalior	14.94	10.28	10.86	7.65	6.26	3.69	13.23	9.64
Dholpur	13.89	10.36	10.29	7.42	6.24	3.32	12.74	9.56
Bharatpur	13.89	10.36	10.29	7.42	6.24	3.32	12.74	9.56
Dausa	14.72	13.76	10.82	7.32	6.27	3.45	12.74	10.13
Jaipur	14.62	14.51	9.97	7.62	6.70	3.59	13.64	10.64
Alwar	14.42	14.10	9.40	7.41	6.38	3.77	13.20	10.80
Rewari	13.99	13.64	9.80	7.21	6.25	3.73	13.00	10.36
Jhajjar	13.07	13.06	9.78	7.35	6.23	3.60	12.26	9.33
Karnal	14.73	13.35	10.77	7.40	6.58	3.48	12.20	9.33

and seeds per pod, seed weight and seed length, width and thickness. Seed weight and seed volume had high and positive correlation (0.94). Seed volume also had high and significantly positive correlation with seed length, width and thickness. Hence, pod length, seed weight and volume

can be directly used for selection of provenances and plus trees to produce quality seeds, and improvement in one character will improve all other associated traits. Reports of similar results in *Acacia nilotica*, *Dalbergia sissoo* and *Santalum album* corroborate present findings. Bagchi

Table 4. Correlations between tree size, pod and seed parameters of *Acacia nilotica* subsp. *indica*

Characters	Tree height	Clean bole	Tree girth	Pod length	Pod width	Seeds/pod	Seed length	Seed width	Seed thickness	Seed weight
Tree height	1									
Clean bole	0.453**	1								
Tree girth	0.561**	0.048	1							
Pod length	0.078	0.121	0.132	1						
Pod width	-0.245	-0.500	0.088	0.488*	1					
Seeds/pod	0.073	0.287	-0.026	0.639**	0.409*	1				
Seed length	0.158	0.093	0.005	0.410*	0.532*	0.325	1			
Seed width	0.011	0.001	0.097	0.186	0.488*	-0.054	0.685**	1		
Seed thickness	0.161	0.264	0.115	0.183	0.581*	0.336	0.487*	0.424*	1	
Seed weight	0.162	0.093	0.165	0.335	0.495*	0.177	0.822**	0.803**	0.626**	1
Seed volume	0.099	0.081	0.086	0.242	0.616**	0.076	0.725**	0.784**	0.653**	0.938**

\*, \*\* significant at p level of 5 and 0.01%, respectively.

also reported that the correlations among the length, width and weight of *Santalum album* seeds were positively significant. In *Acacia nilotica* also, similar and positively significant correlations between seed length and width have been reported. Though, it was positive, but non-significant between seed thickness and seed length and width (Bagchi and Dobriyal, 1990). Seeds per pod had very low and non-significant correlation with seed size, volume and weight, indicating that these characters have negligible effect on quality of seeds and cannot be relied for selection and improvement (Table 4).

It is known that bold seeds impart seedling vigor. The provenances of *Acacia nilotica* with heavier seeds yielded plants with the best height and diameter and seeds of smaller size take longer to germinate (Shiv Kumar and Banarjee, 1986; Bagchi *et al.*, 1990). The protracted time requires longer nursery care and inhibits raising uniform seedlings for large-scale plantations. The present finding on selection of seed source having bold seeds with high seed weight will be expected to produce vigorous seedlings and reduce cost of raising nursery and subsequent management of plantations.

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