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Genetic Evaluation of African Collections of *Acacia senegal* in Western Rajasthan

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Abstract: *Acacia senegal*, a multipurpose tree, grows well on poor sandy soils of arid areas. Seeds of five accessions collected from the forests of Niger, Mali and Senegal were procured from CIFT France to identify suitable accessions for arid areas of India and plants for better survival and more biomass. The trial was established in 1988 with a spacing of 3 m x 3 m at Jodhpur. Average rainfall during the trial was 375.9 mm ranging between 50.6 mm (2002) and 844.0 mm (1990). Data were recorded in December of 2001 to 2005. Grand mean survival was 34.4% at 13-year age. EC 87/7493, an accession collected from ATE Nord Quest AOUROU Mali showed maximum survival, tree height, collar diameter, dbh and canopy diameter for all the growth stages. Heritability was more than 70% for tree height. Variation was maximum due to residual factors for all the traits.

Key words: *Acacia senegal*, exotic material, evaluation, genetic components.

Acacia senegal (L) Willd. locally known as *Kumat*, is the main source for gum Arabic. This tree grows well on poor, sandy soils, in natural stands and also in plantations, stabilizes soils and effectively provides a 'buffer' against desertification (Pearce, 1988). In India and Sudan it has proved useful for windbreaks. Its pods and foliage provide good fodder for livestock, seeds are consumed in the form of vegetable, the tough wood of its tap root and stem is used for tool handles and a strip fiber can be obtained from the long flexible surface root (Anonymous, 1979). Exotic seed material growing in the forests of Niger, Mali and Senegal was procured from CIFT France, to identify better accessions and plants for better survival and more biomass suitable for arid areas of India.

Materials and Methods

Seeds of five exotic collections, EC87/7490 (Foret De Korofane, Niger), EC87/7493 (ATE Nord Quest AOUROU Mali), EC87/7497 (Dialaka, Mali), EC87/7499 (Tendje: Sud Est NARA Mali) and EC87/7500 (Velingara-Louga Senegal), procured from Center Technique Forestier Tropical at Nogent-sur-Marne, Cedex (France), were sown in polythene bags containing a mixture of sand, clay and manure in ratio of 2:1:1 in last week of March, 1988. Four-month-old seedlings were transplanted to the field in the third week of July 1988 in a randomized complete block design with four blocks at Central Research Farm of Central Arid Zone Research Institute, Jodhpur (Latitude 26° 18'N, Longitude 73° 08'E, Altitude 241 m). The soil is sandy loam with a pH 8.1 and has low nutrient levels, with 0.23% organic carbon, 0.03% nitrogen and 0.02% phosphorus (Dhir, 1984). Each plot consisted of three rows of six plants each at 3 m x 3 m spacing. Data on all surviving plants for height, collar diameter, dbh and canopy diameter were recorded when the plants were 13-17 years old during December of 2001 to 2005 except of canopy diameter in 2001. Data were analyzed tree wise and various components were calculated as per expected mean squares given in Table 1. Since the number of living plants per plot was not uniform, 'C' value i.e. average number of living plants per plot was worked out. Heritability, genetic advance, percentage of variance due to different components were calculated using the formulae given below:

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% of contribution due to blocks =
$$(100 \times \sigma^2_b)/(\sigma^2_b + \sigma^2_p + \sigma^2_{bp} + \sigma^2_e)$$

% of contribution due to accessions =
$$(100 \times \sigma^2_p)/(\sigma^2_b + \sigma^2_p + \sigma^2_{bp} + \sigma^2_e)$$

% of contribution due to blocks x accessions =
$$100 \times \sigma^2_{bp}/(\sigma^2_b + \sigma^2_p + \sigma^2_{bp} + \sigma^2_e)$$

% of contribution due to residual factors =
$$100 \times \sigma^2_e/(\sigma^2_b + \sigma^2_p + \sigma^2_{bp} + \sigma^2_e)$$

CD = (t value at error d.f.) x ((2 x MS error)/(number of blocks x average number of surviving plants per plot))$^{-2}$

Results and Discussion

Analysis of variance of 13 to 17-year-old trees for tree height, collar diameter, dbh and canopy diameter is presented in Table 2. There were significant differences among the accessions for tree height for all the five growth years. Differences

Table 1. Expectation of mean squares

Source	Degrees of freedom	Expectations
Block	b-1	$\sigma^2_e + C\sigma^2_{bp} + CP\sigma^2_b$
Provenance	p-1	$\sigma^2_e + C\sigma^2_{bp} + CB\sigma^2_p$
Block x provenance	(b-1)(p-1)	$\sigma^2_e + C\sigma^2_{bp}$
Residual	bp(c-1)	σ^2_e

C = average number of surviving plants per plot which was not constant over the years.

for other characters were significant when the trees were 13, 14 and 15-year-old for collar diameter, 13-year-old for dbh, and 15-year-old for canopy diameter. Though blocking was non-significant for all the traits, but its interactions with accessions were significant for collar diameter, dbh and canopy diameter for all the growth stages except dbh in 2002. In case of tree height, interaction was significant in 2001 only. Number of trees per plot decreased from 6.2 (out of 18) in 2001 to 4.7 in 2005.

Survival of the population was 34.4% and about 2% of the plants died every year (Table 3). Within 17 years after establishment, about $3/4^{th}$ of the plants died and only 26.1% of the population (of 360 plants) could survive. Maximum survival (45.8%), was recorded by EC 87/7493 and this accession maintained the highest value for all the growth years. Grand mean height of 13-year-old plantation was 5.68 m and it increased by about 5% to 5.98 m in the next year. Evaluation of genetic material of *A. senegal* collected from Sahelian phytographical zone (Burkina Faso, Niger, Mali and Sudan) had a faster height growth than material from Sudanian zone at Djibo in Burkina Faso (Raebild *et al.*, 2003).

The year 2002 experienced a very severe drought with rainfall of only 50.6 mm with 7 rainy days.

Table 2. ANOVA of 13, 14, 15, 16 and 17 year old trees for tree height, collar diameter, dbh and canopy diameter in A. senegal

Source of variation	d.f.	Mean square in different years				
		2001 (13)	2002 (14)	2003 (15)	2004 (16)	2005 (17)+
Tree height						
Blocks	3	1.77	0.28	0.15	0.68	0.43
Accessions	4	9.32**	13.17**	10.95**	12.52**	9.35**
B x A	12	2.67*	1.83	2.23	1.33	2.07
Residual		1.31	1.53	1.25	1.42	1.18
Residual d.f.		104	96	88	81	74
C		6.2	5.8	5.4	5.1	4.7
Collar diameter						
Blocks	3	30.0*	26.3	16.8	4.7	8.0
Accessions	4	28.5*	36.4*	33.2*	25.3	26.3
B x A	12	33.0**	28.2**	27.6*	30.6*	25.5*
Residual		11.1	11.9	11.9	13.0	11.6
dbh						
Blocks	3	15.0	42.0	4.76	2.57	6.23
Accessions	4	19.2*	19.1	24.48	16.78	13.11
B x A	12	16.3**	10.3	15.28**	20.32*	16.64*
Residual		6.8	29.6	7.64	8.88	7.67
Canopy diameter						
Blocks	3	–	2.55	0.90	0.51	0.59
Accessions	4	–	2.60	9.63**	3.15	1.77
B x A	12	–	6.23**	3.79*	5.19*	5.88**
Residual		–	1.57	1.85	1.92	1.65

** P<0.01, * P<0.05, data was not recorded during 2001, C-Average number of surviving plants per plot, + age of trees in year.

Table 3. Survival percentage, tree height, collar diameter, dbh and canopy diameter of five accessions of A. senegal

S.No.	Acc. No.	Age of the plants (years)				
		13	14	15	16	17
Survival percentage						
1	EC 87/7490	43.1	38.9	33.3	31.9	30.6
2	EC 87/7493	45.8	43.1	40.3	40.3	37.5
3	EC 87/7497	18.1	18.1	18.1	12.5	12.5
4	EC 87/7499	26.4	23.6	23.6	22.2	19.4
5	EC 87/7500	38.9	37.5	34.7	33.3	30.6
	Grand mean	34.4	32.2	30.0	28.1	26.1
Tree height (m)						
1	EC 87/7490	5.26	5.36	5.28	5.32	5.39
2	EC 87/7493	6.50	6.98	6.67	6.93	6.84
3	EC 87/7497	4.86	5.24	5.02	5.08	5.31
4	EC 87/7499	5.45	5.55	5.15	5.36	5.38
5	EC 87/7500	5.74	6.11	5.95	6.08	6.18
	Grand mean	5.68	5.98	5.75	5.95	5.98
	CD 5%	0.64	0.71	0.67	0.74	0.70
	CD 1%	0.84	0.93	0.88	0.97	0.91
Collar diameter						
1	EC 87/7490	10.1	10.2	10.4	10.2	10.8
2	EC 87/7493	11.9	12.5	12.2	12.3	12.8
3	EC 87/7497	8.6	8.9	8.6	9.2	9.2
4	EC 87/7499	10.8	10.9	10.5	10.3	11.6
5	EC 87/7500	10.8	11.6	11.4	10.9	11.7
	Grand mean	10.7	11.1	10.9	11.6	11.6
	CD 5%	1.85	1.98	2.05	2.22	2.12
	CD 1%	2.43	2.60	2.70	2.92	2.86
dbh (cm)						
1	EC 87/7490	7.76	9.80	8.19	8.43	8.86
2	EC 87/7493	9.12	9.37	9.96	9.75	10.43
3	EC 87/7497	6.52	7.03	6.96	7.13	8.04
4	EC 87/7499	8.34	8.51	8.41	7.93	9.41
5	EC 87/7500	8.70	8.96	9.16	8.98	9.70
	Grand mean	8.29	8.99	8.78	8.74	9.51
	CD 5%	1.44	3.13	1.65	1.83	1.77
	CD 1%	1.90	4.11	2.17	2.41	2.32
Canopy diameter (m)						
1	EC 87/7490	–	4.81	4.77	4.92	5.03
2	EC 87/7493	–	5.45	5.84	5.58	5.41
3	EC 87/7497	–	4.50	3.88	4.51	4.44
4	EC 87/7499	–	5.06	5.11	5.05	5.21
5	EC 87/7500	–	4.99	4.91	4.81	4.98
	Grand mean		5.02	5.04	5.07	5.10
	CD 5%		0.72	0.81	0.86	0.82
	CD 1%		0.96	1.07	1.12	1.08

During 1988-2005, the average annual rainfall was 375.9±43.5 mm, maximum being 844 mm in 1990, with 20.8±1.6 number of rainy days. This drought affected the plants in 2003 in reducing their height due to shrinkage of plants and/or burning of the tips.

Per cent of variation due to blocks was almost zero and it was maximum for residual factors i.e. uncontrollable genetic and environmental variation, and experimental error. As *A. senegal* is highly cross-pollinated tree species (Tandon *et al.*, 2001), so every tree is a different genotype resulting in more uncontrollable genetic variation. Under arid conditions such reports of maximum contribution of variance due to residual factors have been reported earlier in *A. tortilis* (Solanki *et al.*, 1992), *Prosopis cineraria* (Jindal, 1998; Jindal and Singh, 2006), *Tecomella undulata* (Jindal *et al.*, 1992) and *Salvadora oleoides* (Jindal *et al.*, 2009). EC 87/7493, an accession collected from ATE Nord Quest AOUROU, Mali had the maximum values for survival (37.5%), height (6.84 m), collar diameter (12.8 cm), dbh (10.43 cm) and canopy diameter (5.41 m).

EC 87/7497 from Mali, but from different zone, was the poorest performer for these traits. So care should be taken while introducing the material, which can be done only after evaluating at the site for which it is to be planted.

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