Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

Research Article

Genetic variability in *Acacia nilotica* provenance selections of central India

S. Vimala Devi*, Vishal Singh and A. Datta
ICAR- Central Agroforestry Research Institute, Jhansi (UP), India
***E-mail** *:* vimals123@gmail.com

(Received: 27 Jan 2017; Revised: 10 Oct 2017; Accepted: 24 Oct 2017)

Abstract
In the context of climate change and sustainable agriculture, agroforestry systems play an important role by providing scope for maximizing land use system. In arid and semi-arid regions of the country, where there is moisture and soil quality content, the choice of species which are well adopted to these regions are essential. *Acacia nilotica*, because of its diverse utility has an important status in the rural farming under different agroforestry systems. Elite planting material is the basic requirement for promoting agroforestry species. Assessing the variation within and among the provenance selections for different traits will help selection of genotypes for different use in agroforestry system. The growth traits which are important for fuel, timber and fodder production viz., tree height and the canopy diameter, had significant difference among the provenance selections. The mean tree height was 5.72 m with a range of 4.98m (MP-Prov-7) - 6.75m (MP-Prov-8) and the mean canopy diameter was 5.44m with a minimum of 4.58m (MP-Prov-7) and a maximum of 7.41(TN-Prov-1) and showed medium to high heritability indicating that selection for genotypes based on these traits will lead to improved genotypes

Key words
Acacia nilotica, fodder and fuel, genetic variation, diversity, germplasm

Introduction

The realization of the effects of climate change redirected the increased focus in recent years on agroforestry, which deals with the management of land use system for increased sustainability. Enhancement of fodder production per unit area per unit time is also essential to meet the demand from livestock sector for which different land use systems are being developed. *Acacia nilotica* is one of the important agroforestry species, especially in the arid and semi-arid regions of the country. It is commonly known as babool, kikkar, Indian gum Arabic, thorn tree or wattle, belonging to the subfamily *Mimosoideae* of the family *Fabaceae***.** The main advantage of this genus is its fast biological nitrogen fixation, ability to establish on nitrogen- deficient and drought prone soils, tolerant to waterlogged or poor drainage conditions and thus can be used in rehabilitation of dry and degraded lands. It has the ability to improve the nitrogen content of soil through its interaction with symbiotic bacteria augments soil stabilization. It is an important source of fodder, the leaves and pods together will supplement the protein component in the livestock feed. When everything is dry; *Acacias* serve as the only green fodder source of the country during peak summer season. It is a good source of timber, fuel wood, industrial source for the raw material tannin and a good protective hedge because of its thorns and hence plays an important role in rural farming. In efforts for wasteland development and conservation studies, babool registered highest survivability among fodder trees in comparison to Ailanthus and neem and also *Acacia nilotica* registered high net worth in agroforestry system of bundhelkhand region by producing fodder and fuel requirement in comparison to Sisham, Ailanthus and Neem (Prasad *et.al*.,2008). The study on maximization of forage production has reported that babool has higher dry fodder and also shows variation in dry fodder production/tree/year (Beniwal et.al., 1995). Tree growth and canopy diameter contributes to the production of green as well as dry fodder biomass. Genetic diversity analysis reveals genetic backgrounds and relationships of germplasm resources. Assessing the variation within and among the provenance selections for different traits will help selection of genotypes for different use in agroforestry system. In view of this, the present study was undertaken to study the genetic variability present in the provenance selections collected from central India and identify provenance/genotypes of potential value for fodder and fuel.

Materials and Methods

An exploration was conducted in 2003, by Central Agroforestry Research Institute, Jhansi in the Central part of the India, which falls under semi-arid regions in three major states viz., Chhattisgarh, Madhya Pradesh, and Maharashtra lying between 20^o 42'N to 25^o 27'North latitude and 75^o 39'E to 81^o39'East longitude. The selections based on their morphology and growth includes 11 provenance from Madhya Pradesh (Sagar, Damoh, Jabalpur, Mandla, Khandwa, Indore, Ujjain, Shahjanpur, Rajgarh, Bhopal and Guna), 3 provenances of Chattisgarh (Kawardha, Raipur and Rajandgaon) and 4 provenances of Maharashtra (Nagpur, Wardha, Akola and Malkapur). The seeds of local provenance i.e. Jhansi were also collected for use

 DOI: 10.5958/0975-928X.2017.00159.4

as control in the provenance trial, besides the seeds of Coimbatore provenance were also obtained from Institute of Forest Genetics and Tree Breeding, Coimbatore (Tamil nadu). They are maintained as germplasm source at CAFRI Research Farm in a randomized block design with 3 replications in single row plot having 5 plants of each provenance spaced 5x5 m between and within rows(table.1). An evaluation of this provenance selection was made at an age of ten years by recording its growth parameters. The raw data was compiled by taking the means of three plants taken for each line and replication for different traits in this experiment. The means of the individual replication were subjected to further statistical and biometrical analysis. Mean, standard error, variance and coefficient of variation were analyzed statistically using systat for windows (Wilkinson et al. 1996). The variability, genetic advance as per cent of mean, phenotypic and genotypic variance, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were worked out for growth traits as suggested by various workers (Yoshida et al. 2007; Pliura et al. 2007; Baenziger et al. 2004). Broad sense heritability in all the accessions was estimated by partitioning the variance in measurements into between accessions and within-accessions components and applying these in the following function (Falconer and MacKay 1996). Correlation analysis was done based on the Diversity analysis was carried out among the provenance selections using SAS statistical software.

Result and Discussion

Acacia nilotica (Babool) is a well-known multipurpose tree commonly found in the dry areas of Asia, Africa, and Australia. Various parts of the tree such as leaves, bark, roots, and fruits are used for fodder, fuel, timber and various medicinal and other industrial uses. The provenance selection genotypes in the germplasm of CAFRI, Jhansi was studied for all the morphological characters *viz.*, Tree height (TH), Clean bole height (CBH), Basal Diameter(BD), Diameter at Breast Height (DBH), Diameter at Clean Bole Height (DCBH), Canopy diameter(CD). Significant differences for TH, DBH and CD ($P< 0.05$) and DCBH ($P<0.01$) were observed between progenies of most of the provenances whereas differences among the provenance progenies for CBH, BD and number of branches/tree were non-significant statistically (table 2). The growth traits, which are important for fuel, timber and fodder production, are the tree height and the canopy diameter, which contributes for the good timber and fodder biomass, had significant difference among the provenance selections. The mean tree height was 5.72 m with a range of 4.98m (MP-Prov-7) - 6.75m (MP-Prov-8) and the mean canopy diameter was 5.44m with a minimum of 4.58m (MP-Prov-7) and a maximum of 7.41 (UP-Prov-1). The diameter at the breast height and at clean bole height also had significant difference. Clean bole height influences the timber value, which did not have significant differences among the provenance selections. As the timber of Acacia is mainly used for agricultural implements, selection based on tree height and canopy diameter will help the improvement of Acacia for timber and fodder.

The genetic variability parameters for all the growth traits showed high phenotypic variance than the genotypic variance indicating that the environmental influence is high for these traits. This is expectable in tree species as the between and among the provenance variations is observed for various reasons. However, the traits viz., Tree height, Diameter at breast height, Diameter at clean bole height and the Canopy diameter showed medium to high heritability indicating that selection for genotypes based on these traits will lead to improved genotypes. The genetic advance and the genetic advance as percent of mean was high for DBH, Canopy diameter and tree height respectively.

Measure of correlation co-efficient computed to examine inter character relationships among the morphological traits, revealed that clean bole height, DBH, diameter at clean bole height and canopy diameter is positively correlated with tree height. Though clean bole height had non-significant variation among the genotype, because of its positive correlation, it influences the tree height, and hence selection of elite trees with good tree height will led to *Acacia nilotica* genotypes for good quality timber. Canopy diameter is positively correlated with tree height, DBH and diameter at clean bole height indicating that direct selection for tree height and canopy diameter is sufficient for identifying genotypes which is good both for timber and fodder. However, these traits show moderate heritability and hence selection in these germplasm will yield moderate gain. While considering the selection in arid regions, other traits like fodder biomass would also have to be considered for improving fodder value.

Using the Euclidean distance between the provenance selections as the measure of similarity the hierarchical cluster analysis with unweighted pair-group method using arithmetic averages method (UPGMA) method was done for the morphological characters. The study on genetic diversity among 20 provenance selections of *Acacia nilotica* divided genotypes into four different major groups (Fig.1). The cluster distance among the progenies varied form 0.2-1.5. In general the provenance genotypes from different state were grouped into same clusters, indicating that distance within is less than between the geographical boundaries, except for the provenance selections from Madhya Pradesh. Wide variation is observed between the provenance progenies from Madhya Pradesh which fall across the three clusters, indicating the variation with the region (table.5). The single provenance selection TN-Prov-1 from Coimbatore stood alone as indicated in Fig.1, suggesting the variation with respect to geographical regions. enance trials of *A. nilotca* has been taken up at different institutes in the country such as Forest Research Institute, Dehradun; Arid Forest Research Institute, Jodhpur; JNKVV, Jabalpur; TFRI, Jabalpur; IFGTB, Coimbatore, HAU, Hisar, State Forest Departments and other institutions in the country (Anonymous, 1994; Tewari (1994); Ginwal et al. 1995) but the present evaluation consists of study of provenance after field planting from arid & semi-arid regions. A provenance study of seed parameters among 35 seed sources of *A. nilotica* revealed significant variation and Udaipur provenance had bigger seed (Bagchi and Dobriyal, 1990).

Conclusion

The genetic variability studies in *Acacia nilotica* from five states shows significant differences among the provenance selections for the important traits contributing to the fodder yield i.e., tree height and canopy diameter. The diversity analysis indicates that the provenance selections from Madhya Pradesh have large variation with the geographical boundaries indicating the scope for selection. Hence tree improvement of *Acacia nilotica* can be made based on these traits for obtaining better genotypes suitable for agroforestry system and maximize the fodder biomass.

References

Anonymous. 1994. Annual Report of Indian Council of Forestry Research and Education, Dehradun.

Baenziger, P.S., McMaster, G.S., Wilhelm, W.W., Weiss, A. and Hays, C.J. 2004. Putting genes into genetic coefficients. *Field Crops Res*. 90:133-144.

Bagchi, S.K. and Dobriyal, N.D. 1990. Provenance variation in seed parameters of Acacia *nilotica*. *Indian Forester*, 116 (12): 958-961.

Beniwal, R.S., Toky,O.P. and Sharma, P.K.1995. Genetic variability in symbiotic nitrogen fixation between provenances of *Acacia nilotica* (L.) Willd ex.Del. *Gen. resour. and crop evol*.,42(1):7-13.

Falconer, D. S., and Mackay, T. F. C. 1996. .Introduction to Quantitative Genetics, Ed 4. Longmans Green, Harlow, Essex, UK.

Ginwal, H.S., Gera, M. and Srivastava, R.L. 1995. Provenance variation in growth and biomass production of *Acacia nilotica* Wild. Ex. Del, seedlings under nursery conditions. *Annals of Forestry*, 3(1): 35-44

Pliura,A., Zhang,S.Y., Mackay,J., and Bousquest, J.2007. Genotypic variation in wood density and growth traits of poplar hybrids at four clonal traits. *For. Ecol.Manage*. 238(1-3):92-106.

Prasad, J.V.N.S., Gill,A.S., Baig,M.J., Burman, D. and Gupta, S.K. 2008 Fodder and fuel-wood production through agroforestry in semi-arid Central India. *Indian Journal of Agronomy* 53(2): 152-156

Tewari, D.N. 1994. Provenance Trial Case studies, Biodiversity and Forest Genetic Resources in India.

Wilkinson, L., Blank, G. and Gruber, C. 1996. Desktop analysis with SYSTAT. Prentice Hall, Upper Saddle River, New Jersey

Yoshida, T., Ellner, S.P., Jones, L.E., Bohannan, B.J.M., Lenski, R.E. and Hairston, N.G. Jr. 2007. Cryptic population dynamics: rapid evolution masks trophic interactions. *PLoS Biol*., 5, 1868–1879.

Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

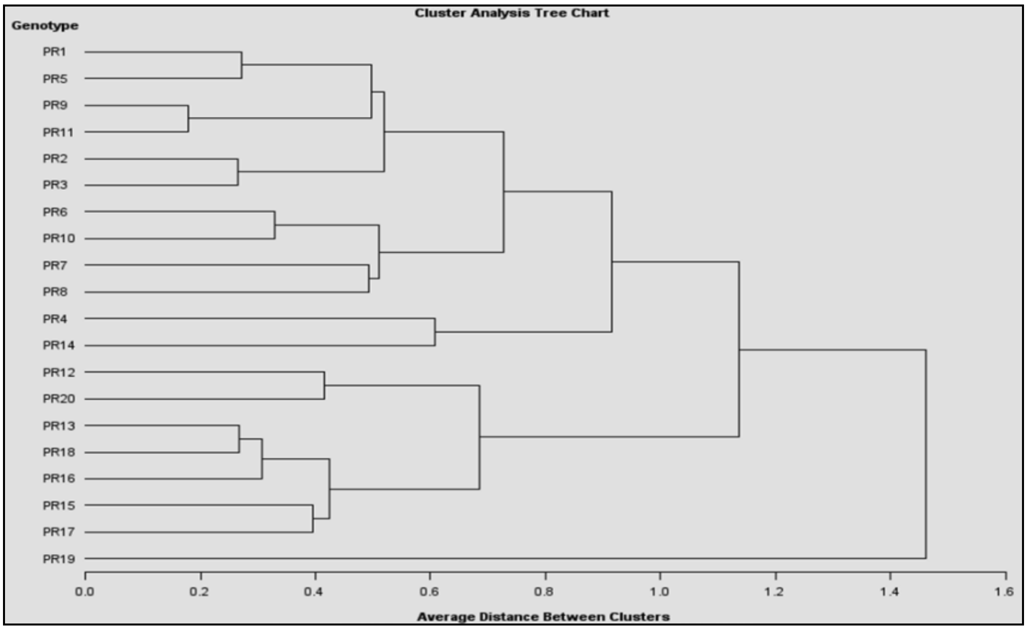

Fig.1: The cluster composition of difference provenance accessions based on morphological traits

Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

Table. 1: Geographic location of the 20 provenances of *Acacia nilotica*

Sl. No.	Prov. code	District	State	Longitude	Latitude	Altitude (m)	Soil type & colour
1	PR1	Sagar	Madhya Pradesh	79^0 28' E	22^0 30' N	532	Clay loam and black
2	PR 2	Damoh	Madhya Pradesh	79^0 29' E	23^0 50' N	371	Clay loam light black
3	PR 3	Jabalpur	Madhya Pradesh	79^0 59' E	$23^0$12' N	394	Loam, clay loam black
4	PR 4	Mandla	Madhya Pradesh	80^0 25' E	$22^0$15' N	441	Clay loam,black & sandy
5	PR 5	Kawardha	Chattisgarh	81^0 13' E	22^0 03' N	341	Clay loam, black
6	PR 6	Raipur	Chattisgarh	81^0 35' E	21^0 15' N	325	Clay loam,black & sandy
7	PR 7	Rajnandgaon	Chattisgarh	81^0 05' E	21^0 10' N	302	Clay loam, black, brown
8	PR 8	Nagpur	Maharashtra	79^0 20' E	21^0 10' N	304	Sandy brown & clay black
9	PR 9	Wardha	Maharashtra	79^0 20' E	21^0 10' N	307	Clay loam, red & black
10	PR 10	Akola	Maharashtra	78^0 15' E	20^0 55' N	297	Sandy brown & black clay
11	PR 11	Malkapur	Maharashtra	76^0 11' E	20^0 32' N	240	Sandy brown & black clay
12	PR 12	Khandwa	Madhya Pradesh	76^0 22' E	21^0 51' N	303	Grayish & black clay
13	PR 13	Indore	Madhya Pradesh	75^0 55' E	22^0 50' N	551	Sandy brown & black clay
14	PR 14	Ujjain	Madhya Pradesh	75^0 43' E	23^0 09' N	478	Black clay loam
15	PR 15	Shajapur	Madhya Pradesh	$76^0$10' E	23^0 20' N	448	Sandy brown & black clay
16	PR 16	Rajgarh	Madhya Pradesh	76^0 50' E	23^0 55' N	422	Clay loam, red & black
17	PR 17	Bhopal	Madhya Pradesh	77^0 26' E	$23^0$25' N	545	Clay loam, red & black
18	PR 18	Guna	Madhya Pradesh	$77^0$15' E	24^0 45' N	487	Clay loam & red sandy
19	PR 19	Coimbatore	Tamil Nadu	77^0 56' E	11^0 45' N	271	Black & Red sandy
20	PR 20	Jhansi	Uttar Pradesh	78^0 37' E	25^0 27' N	650	Sandy loam

Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

Table 2 Growth traits in *Acacia nilotica* germplasm at 10 years

Sl.No	Prov. code	IC No.	TH (m)	CBH (m)	BD (cm)	DBH (cm)	DCBH (cm)	CD(m)	# Branch
1	PR 1	IC 556942	6.27	1.53	19.91	16.41	15.64	6.36	6.21
2	PR 2	IC 556943	5.63	1.32	16.12	13.94	13.13	5.20	5.86
3	PR 3	IC 556944	5.08	1.32	14.89	12.20	11.65	4.77	6.75
4	PR 4	IC 556945	5.65	1.29	28.99	15.09	14.33	5.70	6.69
5	PR 5	IC 556946	5.27	1.22	15.61	13.58	12.80	5.30	6.55
6	PR 6	IC 556947	5.29	1.39	14.91	12.77	12.31	5.18	6.00
7	PR 7	IC 556948	5.21	1.35	18.02	14.53	14.32	5.00	6.11
8	PR 8	IC 556949	5.55	1.37	14.94	12.61	12.09	4.90	6.13
9	PR 9	IC 556950	6.35	1.83	17.64	14.92	14.64	5.79	7.50
10	PR 10	IC 556951	5.30	1.39	16.50	14.40	13.01	5.22	5.82
11	PR 11	IC 556952	6.42	1.89	15.74	12.83	11.88	5.49	6.57
12	PR 12	IC 556953	5.93	1.55	17.49	14.59	13.79	5.70	7.57
13	PR 13	IC 556954	5.50	1.41	15.85	13.44	12.81	5.24	5.17
14	PR 14	IC 556955	4.99	1.46	13.54	10.77	10.17	4.59	5.25
15	PR 15	IC 556956	6.75	1.53	17.63	21.31	14.96	5.84	7.44
16	PR 16	IC 556957	5.61	1.37	17.18	14.41	13.68	5.54	6.88
17	PR 17	IC 556958	5.93	1.48	16.02	13.71	12.57	5.46	9.88
18	PR 18	IC 556959	5.73	1.58	17.47	13.85	13.22	5.24	10.02
19	PR 19	IC 556961	5.87	1.57	24.74	13.82	13.04	5.00	5.57
20	PR 20	IC 556960	6.28	1.48	19.83	17.00	16.93	7.41	7.46
Mean			5.73	1.46	17.65	14.31	13.34	5.44	6.77
Significance at 1% and 5% CD			*	NS	NS	*	**	*	NS
% CV			12.04	22.26	40.20	20.51	13.59	11.53	37.39

Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

Table.3: Estimation of genetic variables for growth traits in *Acacia nilotica* germplasm

Traits	**Range**	**Variance**		**Co-efficient of variation**		**Heritability**	**Genetic Advance**	**GA as % of mean**
		Genotypic	Phenotypic	Genotypic	Phenotypic			
Tree Height	4.98-6.75	0.12	0.60	6.04	13.48	20.07	0.32	5.57
Clean Bole Height	1.21-1.89	0.00	0.10	4.59	22.11	4.31	0.03	1.96
Basal Diameter	13.53-28.99	0.36	50.68	3.39	40.34	0.71	0.10	0.59
Diameter at Breast Height	10.77-21.31	2.51	11.12	11.07	23.30	22.55	1.55	10.82
Diameter at Clean Bole Height	10.17-16.93	1.48	4.77	9.13	16.36	31.14	1.40	10.50
Canopy Diameter	4.58-7.41	0.28	0.68	9.79	15.12	41.97	0.71	13.07
No of Branch	5.16-10.02	0.10	6.50	4.62	37.66	1.50	0.08	1.17

Table.4: Correlation coefficients for the morphological traits in *Acacia nilotica*

Traits	**Tree height**	**Clean bole height**	**Basal diameter**	**Diameter at breast height**	**Diameter at Clean bole height**	**Canopy Diameter**	**No.of primary branches/ tree**
Tree height	1.000	0.684*	0.277^{NS}	0.714*	0.610*	0.687*	0.379^{NS}
Clean bole height		1.000	-0.015^{NS}	0.119^{NS}	0.099^{NS}	0.242^{NS}	0.268^{NS}
Basal diameter			1.000	0.356^{NS}	0.510*	0.346^{NS}	0.012^{NS}
Diameter at breast height				1.000	0.803*	0.660*	0.240^{NS}
Diameter at Cleanbole height					1.000	0.863*	0.231^{NS}
Canopy Diameter						1.000	0.286^{NS}
No.of primary branches/ tree							1.000

Electronic Journal of Plant Breeding, 8(4): 1077-1084 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00159.4

Table.5: Provenance selections under different cluster groups

Cluster No	No. of Accessions	Accession identity
I	1	TN-Prov-1
II	7	MP-Prov-2, UP-Prov-1, MP-Prov-6, MP-Prov-11, MP-Prov-9, MP-Prov-8 & MP-Prov-10
III	2	MP-Prov-4& MP-Prov-7
IV	10	MP-Prov-1, CH-Prov-1, MH-Prov-2, MH-Prov-4, MP-Prov-2, MP-Prov-3, CH-Prov-2, MH-Prov-3, CH-Prov-3 & MH-Prov-1