Bakht Al-RudaUniversity Quarterly Refereed Scientific Journal, Issue (35) Volume (3) December 2022; [UBJSR: ISSN [1858-6139]: (Online)
http://www.juornal-bakhtalruda.bid/22/
Arab ImpactFactor(1.12)

Provenances Variation in Morphometric Traits of *Acacia senegal*(L.) Willd.,Grown in Clay Soil of the Blue Nile State, Sudan

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Acceptance Date: 1/10/2022 Publication Date:30/12/2022

Abstract

Acacia senegal is a multipurpose leguminous drought-tolerant tree or shrub. It is commonly used in agroforestry systems in Blue Nile State of the Sudan. The objective of the study was to determine variations between morphological and reproductive characters of *A.senegal* in the studied provenances. The morphological characters studied were; Tree Height (TH m), Basal Diameter (BDcm) and Bark Thickness (BATmm). Pods and seeds parameters were measured as reproductive characters including minimum pod length (MIPLcm), maximum pod length (MAXPLcm). Minimum Pod Width (MIPWcm), Maximum pod width (MAXPWcm), Seed Diameter (SDmm), Seed Thickness (STHmm) and 100 Seed Weight (100SWg). In addition to Gum yield (GY g). Analysis of variance revealed no significant differences between provenances in tree height. Furthermore, the study showed significant differences between the provenances in (BD) and (BAT) at ($p<0.04$). Semaih provenance recorded the highest mean basal diameter (16.875 cm), and Mazmoom provenance recorded the highest mean bark thickness (3.938 mm). The result revealed no significant differences between the provenances in all reproductive traits except seed diameter and 100 seed weight. Domokeya provenance recorded a significantly ($P<0.01$) higher mean seed diameter of (10.175mm), while Semaih provenance attained the highest mean 100 seed weight of (8.286g). On the other hand the result revealed a significant differences in average gum yield per tree among *A.senegal* provenances for the two seasons. Mazmoom reported (991.63g)the higher average gum yield per tree in the first season, while Nabag provenances reported (1273.33 g) the higher average gum yield per tree in the second season. In addition the result showed a positive correlation between TH and BAT($r = 0.131$), SD with STH and 100SW ($r = 0.501$and 0.857) respectively, STH with 100SW ($r = 0.571$),and SD and 100SW with gum yield ($r = 0.198$ and 0.147) respectively.

Keywords: Provenances; *Acacia senegal*; multipurpose; morphological traits, variations.

Introduction

Acacia senegal (L.) Willd, is a leguminous tree of the genus *Acacia* that belongs to the Family *Fabaceae*, sub-family *Mimosoideae*, consisting of more than 300 species that produce gum in commercial quantity (Ben,2005 and Omokhafe, *et al* 2007). It is reputed for its high quality gum production. It's naturally adapted to the hot, dry and barren region of Africa principally lying between 11^0 and 14^0 N latitudes, comprising of Chad, Niger, Nigeria and Sudan.

Acacia senegal is highly tolerant to rainfall and temperature variations. It grows mainly in sandy soils with annual rainfall mostly between 200-600 mm, and the best sites have a pH between 5 to 8 (Von Maydell, 1986). *Acacia senegal* is also common in clay soils along river beds, and marsh lands of the Sahelian Zone, where the annual rainfall ranges between 600 mm and 800mm. The mean annual temperature in its natural range is between 28 to 30 C^0 (Adamson and bell, 1974; Cossalter, 1991; Pearce *et al*, 1990). The species is an important source of fodder for herbivores especially during dry periods (Mallet *et al*., 2003; Fagg and Allison, 2004), improves soil fertility through nitrogen fixation, serves as a windbreak and contributes to dune fixation (Cossalter, 1991; Barbier 1992;Wickens*et al*., 1995). The tree also provides fuel wood, local construction materials and is highly suitable for use in agroforestry systems (Lott *et al*., 2003).

The most important use of the *Acacia senegal* is the harvest of gum arabic, an exudates from the bark that is tapped for this purpose during the dry season (Orwa*et al*., 2009). Several thousand tons of gum arabicare internationally traded every year, mainly in Europe and the USA (Kew Gardens, 2016). Gum arabic has many commercial uses: food (flavor fixative, emulsifier, stabilizer of dairy products), pharmaceutics (these two sectors representing 60-75% of the use of gum arabic), and industrial products (inks, pigments, polishes) (Kew Gardens, 2016).

In Sudan *A.senegal* is found a long a belt known as gum arabic belt. The total gum belt area in Sudan amounts to 520,000 km^2.

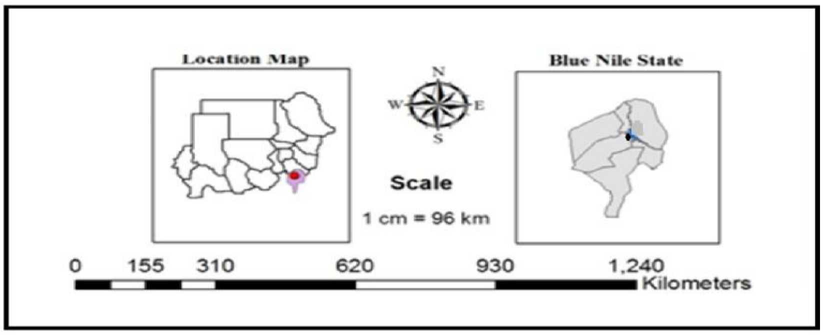
A. senegal is an important species in agroforestry in semi-arid areas of Sudan, it has been managed as a part of a traditional shifting cultivation system with agricultural crops in order to maintain soil fertility (Barbier,1992;Ballal *et al*. 2005).

The main objective of the study was to determine morphological and reproductive characteristic variations of the selected provenances of *A.senegal* grown in the Blue Nile State, which may further lead to gum yield improvement and underpin the most adaptive *A. senegal* provenances.

The experiment site

The previous experiment was carried out on an already existing research site and plots established by (Raddad) since 1999. It is located in the Blue Nile State near Ed Damazin town (34° 23′, 11°47′) at about 470 m asl. The climate at the trial site is semi-arid with a mean annual rainfall (May-October) of 736 mm. The mean annual temperature is 28.1 C^o. The soil consists of dark cracking clay (Vertisiol) which extends to at least 15 m in depth (Raddad. 2006).

Fig. 1. Location of study area and experiment site



Plant materials and experimental design

Eight *A.senegal* provenances were collected from different geographical regions of the gum belt of the Sudan, namely Bout, Mazmoom, Gedaref, Domokeya, Nabag, Saata, Rahad, and Semaih. The first three were collected from the clay plain and the latter five from the sand plain, grown since 1999. A complete randomized block designed was used, four replications from each provenance, number of trees on one replication were 40 trees; the total trees for experiment were 160 trees (4 replications x 8 plots x 5 trees). Tree height and basal diameter were measured using tape 50 m and caliper respectively, while bark thickness, seed diameter, and seed thickness were measured by vernier caliper. A ruler of 30 cm was used to measure pod length and pod width. One hundred seeds was weighted using sensitive balance. Collection of gum yield was started after 45 days from tapping with interval periods of 10 to 12 days between the pickings for the two seasons. Gum dried at room temperature and was weighted after three days using sensitive balance.

Data were analyzed using the MSTATC statistical program. Means were separated using LSD.

Results and discussion

Morphological and reproductive characters

Morphological and reproductive characters of *A. senegal* provenances assessed are given in tables 1 and 2 respectively. The result in table 1, revealed no significant differences in means of tree height among *A.senegal* provenances, and its ranged between (6.12 to 6.60m) from Domokeya and Gedaref provenances respectively. In comparison, (Ibrahim *et al*. 2014) found slightly lower figure (5.640m) for mean of tree height in a similar trial. On the other hand results showed significant differences ($p<0.04$) among *A. senegal* provenances in basal diameter and bark thickness, Semaih and Gedaref provenances recorded significantly higher mean of basal diameter (16.875 and 16.575cm) respectively, compared to the other remaining provenances. However, the Saata provenance recorded the lowest mean of basal diameter (13.725cm), Mazmoom provenance recorded a significantly higher mean of bark thickness (3.938 mm) compared to the remaining provenances, however, it is significantly less than (Ibrahim *et al*. 2014) who recorded bark thickness of (5.330mm) for the same provenance from other trial. Bout and Gedaref provenances showed no significant differences between them which recorded (3.875mm), significantly greater than Domokeya (3.313mm) and Saata (3.488mm). These results indicate that *A.senegal* provenances obtained from clay soils were significantly different from the ones obtained from the sandy soils in this trial because they seem to be adapted to the environmental conditions of the clay plains of the region.

Results shown in Table (2) reflect no significant differences in all pod characteristics evaluated in addition to seed thickness among reproductive characters of *A.senegal* provenances. Mean pod length ranged between (8.39 to 10.84cm) recorded by Bout and Saata provenances respectively, however (Ibrahim *et al*. 2014) recorded (9.35cm) as the longest pod length.

Mean pod width ranged between (1.96 to 2.28cm) recorded by Nabag and Domokeya provenances respectively, compared to (2.903cm) recorded by (Ibrahim *et al*. 2014) for relevant trait. The means of seed thickness ranged between (1.525 cm to 1.837cm) attained by Saata and Semaih provenances respectively, compared to (3.87cm) reported by (Ibrahim *et al*. 2014). However, provenances studied showed highly significant differences between them ($p< 0.01$) in means of seed diameter which were ranging between (8.70 to 10.325mm) recorded by Bout and Semaih provenances respectively. They also showed highly significant differences between them in mean of the 100 seed weight trait ($p< 0.0024$). However the higher weight was (8.286g) recorded by Semaih provenance, while the lowest weight was (6.441g) which had been recorded by Bout provenance. The results of the present study showed some significant differences in both seed diameter and 100 seed weight traits between the sand and clay seed sources of *A. senegal* grown in the Blue Nile State. The sand seed sources were superior in these two traits over the provenances of the clay. This can be interpreted as these two traits were strongly genetically controlled and the environment had little interaction on them albeit these sandy seed sources were obtained from a different geographical location. Figures obtained in the study agree with those found by (Ibrahim *et al*. 2014) for seed diameter but not for 100 seed weight were recorded a higher weight of (24.10g).

Average gum yield per tree significantly varied among *A.senegal* provenances at the two seasons. Mazmoom and Nabag provenances produced the highest average gum yield per tree (991.63) and (1273.33g) in the first and second seasons respectively, while Gedaref produced the lowest average gum yield per tree in first and second seasons (788.33 g) and (676.67g) respectively.

Correlation

Results of correlation analysis within morphological characters and between these traits and gum yield of *A. senegal* provenances were shown in Table.3. Generally, almost all morphometric traits analyzed showed either significant positive or negative correlations between them. However, gum yield have been negatively correlated with tree height, bark thickness, minimum pod length and minimum pod weight (r = -0.117), (-0.022), (-0.099) and (-0.013) respectively), but was positively correlated with seed diameter and 100SW (r = 0.198) and (0.147) respectively.

Table 1. Variation in the means of morphological characters for Acacia senegal provenances studied.

	Morphological character		
Provenances	**TH/m**	**BD/cm**	**DAT/mm**
Bout	6.285	14.975	3.875
Mazmoom	6.173	14.250	3.938
Gedaref	6.595	16.575	3.875
Domokeya	6.108	14.925	3.313
Nabag	6.345	15.275	3.688
Saata	6.385	13.725	3.488
Rahad	6.208	14.600	3.625
Semaih	6.357	16.875	3.688
Means	6.307	15.150	3.686
SE ±	0.127	0.678	0.261
CV%	4.04	8.94	14.16
Sign	NS	*	*

TH = Tree height, BD = Basal diameter, BAT = Bark thickness,
NS = No significant difference, * = Significant difference (p< 0.04)

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Table.2. Variation in the means of reproductive characters for *Acacia senegal* provenances.

	Reproductive characters										
Provenances	**MIPL**	**MAXPL**	**Means**	**MIPW**	**MAXPW**	**Means**	**SD**	**STH**	**100SW**	**G.y season1**	**G.y season2**
Bout	4.950	11.825	8.39	1.650	2.550	2.10	08.700	1.537	6.441	979.97	1123.32
Mazmoom	5.450	13.075	9.26	1.725	2.400	2.06	08.862	1.700	6.867	991.63	870.00
Gedaref	5.150	13.025	9.09	1.725	2.250	1.99	09.537	1.800	7.689	788.33	676.67
Domokeya	4.800	13.925	9.36	1.975	2.575	2.28	10.175	1.700	8.280	808.20	848.34
Nabag	4.375	13.200	8.79	1.600	2.325	1.96	10.138	1.812	8.239	959.28	1273.33
Saata	6.175	15.500	10.84	1.900	2.625	2.26	09.712	1.525	7.597	979.97	968.33
Rahad	4.875	14.575	9.73	1.952	2.400	2.18	09.700	1.637	7.865	830.59	1220.0
Semaih	5.850	14.150	10	1.925	2.600	2.26	10.325	1.837	8.286	918.60	1251.67
Mean	5.203	13.659	9.43	1.806	2.466	2.22	09.644	1.694	7.658	907.07	1028.96
SE ±	0.38	0.9912		0.1079	0.1351		0.3165	0.0783	0.3128		
CV%	14.71	14.51		11.95	10.96		6.56	9.25	8.17		
Sign	Ns	Ns		Ns	Ns		*p=0.01	Ns	**p=0.0024		

MIPL=minimum pod length, MAXPL=maximum pod length, MIPW=Minimum pod width, MAXPW=Maximum pod width, SD=Seed diameter, STH= Seed thickness, 100SW= 100 seeds weight, G.y= gum yeild

Table.3. Correlation coefficients between means of morphological traits and gum yield of *A. senegal*provenances

Data	TH	BD	BAT	MIPL	MAXPL	MIPW	MAXPW	SD	STH	100SW	G.y
TH	1										
BD	0.206	1									
BAT	0.131*	103	1								
MIPL	0.028	-.121	-.052	1							
MAXPL	-.054	-.060	-.367*	.344	1						
MIPW	-.241	-.062	.201	.210	.271	1					
MAXPW	-.288	-.210	-.123	.261	.0290	.473**	1				
SD	.121	.082	.098	.074	.069	.491**	.125	1			
STH	.275	.315	.166	.066	-.180	.133	-.270	.501**	1		
100SW	.155	.129	,144	.082	.150	.462**	-.024	.857***	.571**	1	
G.y	-.117	.024	-.022	-099	.049	-.013	.114	.198	.020	.147	1

G.y= gum yield, *Significant difference.** high significant difference, ***very high significant difference

Conclusion

The study confirmed the presence of significant differences in some morphological traits between the provenances studied. It showed two distinct groups of the provenances (clay and sandy soil). However provenances showed no significant differences in tree height, but two provenances from the clay soil group namely Gedaref and Mazmom provenances showed significant differences in basal diameter and bark thickness as compared to the sandy soil group except the Semaih provenance. Although they showed no significant differences in pod dimension characteristic but the sandy soil group (Domokeya, Nabag and Semaih) in turn showed significant differences between them and the clay soil group in seed diameter, 100 seeds weight, and gum yield. However, Nabag provenance from sandy group almost produced the higher average of gum yield over the two seasons. The information rendered by the present work and the distinct variations depicted provide some useful and new information that help provenance researchers to decide on selection of the appropriate provenances of *A. senegal* with potential to be used in the clay soils of the Blue Nile State from other geographic locations of the Sudan. More research work on provenances variation is indispensable and is strongly recommended as this will augment this present information and will facilitate further selection of provenances and genotypes of *A. senegal* to increase gum yield in the Blue Nile State.

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