Gum Arabic Yield from Some Acacia Senegal (l.) Willd Provenances Grown in Clay Soil of the Blue Nile State, Sudan

Ammar Fadlalla Gessmalla*

Forestry Research Centre, Damazin Research Station, Agricultural Research Corporation (ARC), Sudan

*Corresponding Author: Ammar Fadlalla Gessmalla, Forestry Research Centre, Damazin Research Station, Agricultural Research Corporation (ARC), Sudan.

Abstract

Acacia senegal is an important multipurpose tree in the Blue Nile State, the tree produces gum arabic Hashab gum, which is collected from the natural exudation. The objectives of the study was to assess gum arabic yield per tree per picking for different *A.senegal* provenances and adaptive A. senegal growing in the Blue Nile State. *A randomized* complete block design was used at eight A.senegal provenances, Bout, Mazmoom, Gedaref, Domokeya, Nabag, Saata, Rahad and Semaih were collection from different geographical regions in the gum arabic belt of the Sudan, the first three were collection from the clay plain and the latter five from the sand plain, ranged in four replications any replication was consist eight blocks. Numbers of trees on one block were five trees, tapped starting at first day of September, axe was used for tapping. The results revealed that there were a significant differences among the means of gum yield (g/tree) for eight A.senegal provenances and their picking at the two seasons. Bout and Mazmoom, gave a higher gum yield from clay habitat1077-1046 and 1649- 1655g per tree at the two seasons respectively, while Nabag, Saata and Semaih gave a higher gum yield from sand habitat1029, 1142 and 1024g per tree to 2009, 1283 and1518 g per tree at the two seasons respectively . A higher gum yield per picking at two seasons recorded at first picking of Domokeya and Nabag provenance and gave 310 and 454g/tree respectively.

Keywords: Provenances; Acacia senegal; Natural exudates; Picking; Adaptation

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Introduction

Acacia senegal is a low branching, small, and spiny tree, which grows up to 7-15 m in height with a girth of about 1.3 m (Kew Gardens, 2016; Duke, 1983). It has a rounded, flat-topped crown (Orwa et al., 2009). The tree is deciduous, dropping its leaves during the dry season.

Acacia senegal is a leguminous tree species that is well adapted to Sudan and Sahalian agro ecology of Africa. There are over 300 species in this family. Notable among them is Acacia Senegal because it produces high quality of gum (FAO, 195).

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 arabic are 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). Gum arabic was reported to have antidotal effects as it can destroy many alkaloids (Duke, 1983). Acacia senegal seeds are traditionally used for human nutrition in Rajasthan (Ram et al., 2014). The wood is valued as firewood, and can be used to produce charcoal. The wood is also used to make utensils, poles and fence-posts. The bark and the roots provide fiber and make strong ropes and fishing nets (Orwa et al., 2009; Duke, 1983). Fodder for livestock.

Acacia senegal is native to Western Sudan, Nigeria and the Arabian Peninsula. It is commonly found in tropical areas of Western and Central Africa, and in Eastern Africa from Mozambique to South Africa (Kew Gardens, 2016). It was introduced into Egypt, Australia, Puerto Rico, the Virgin Islands, and South Asia. It is cultivated in India, Pakistan and Nigeria. Acacia senegal grow where annual rainfall is in the range of 380 to 2280 mm, and annual mean temperatures between 16.2°C and 27.8°C. It cannot survive frost but is particularly tolerant of drought. The Acacia senegal thrives in the drier parts of Sudan and in the Northern Sahara. It can survive in places where drought lasts for 11 months. It thrives on rocky slopes and sandy soils, but also on clay plains and cotton soils with a pH ranging from 5 to 8 (Kew Gardens, 2016).

In Sudan A. senegal fined in belt which is could gum arabic belt, where A. Senegal grows naturally, coincides with the area of central Sudan mainly between latitudes 10º and 14º N. The total gum belt area in Sudan amounts to 520,000 km^2, A field survey conducted in 1989 indicated that there existed scarcely any A. Senegal north of latitude 13º 45′ in Kordofan or Darfur (IIED and IES, 1990). A. Senegal is important species in agroforestry in semi-arid areas of Sudan, it has been managed as a part of a traditional shifting cultivation system with agriculture crops in order to maintain soil fertility (Barbier 1992, Ballal et al. 2005).

Gum arabic is a dried exudates obtained from the stems and branches of A senegal (L) willd or A seyal (FAO, 1999). The gum is found immediately under the bark where it is sometimes collected in regular cavities. It is formed within the plant by metamorphosis of the cells of the inner bark. The tissues involved are chiefly those of the sieve and the cambiform cells (Anderson, 1995). While to some extent it is a natural change, yet it is usually looked upon as being in part a pathological production, as gummosis develops more largely upon the wounding of the trees.

High gum Arabic production requires severe physiological stress from water depletion and heat Anderson, 1995). Gum Arabic formation has been regarded as a natural response of trees under dehydration stress to store a strongly hydrophilic form of reserve carbohydrate (Anderson, 1995). Gum Arabic is known to be formed at the time of leaf-fall and translocated to roots even before the tree has been tapped. Gum Arabic exudates from the cracks on bark of wild trees in the dry season, with little or none in the rainy season when flowers are out.

Study area

Blue Nile State is located in the south-eastern part of the Sudan, between Lat. 9º 30′ to 12º 30′ N, and Long. 33º 5′ to 35 3′ E. The total area is about 38500 square km. It is characterized by mountain series of which Ingassana is the main geographical feature which extends about 72 km. (BNSI, 2004)

The experiment site

The experimenter research site was located in the Blue Nile State near Ed Damazin town (34° 23′, 11°47′, 470m above sea level), 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 ºC, and the length of the growing season for main agricultural crops is 82 days. The soil consists of dark cracking clay (Vertisiol) which extends to at least 15 m in depth (Raddad. 2006). The natural vegetation is woodland savanna dominated by Acacia seyal, A. polyacantha Willd. A. senegal, Balanites aegyptiaca (L.) Del., Combretum spp., and Dichrostachys cinerea (L.) Wight & Arn. as characteristic tree species.(Elamin, 1990).

The aim of the study was to provide a new information needed for gum arabic yield improvement and to offer new management guidelines to using it for optimum and sustainable production of gum arabic for the benefit of local communities of the Blue Nile State in order to determine and analyze the gum arabic yield and its picking variations in relation to different provenances of A.senegal to facilitate gum yield improvement and to understand which adaptive A. senegal provenances growing in the Blue Nile State.

Materials and Methods

Experiment was conducted at two seasons (2013 to 2014) and (2014to 2015). Eight A. senegal provenance were grown in the experimenter research site since 1999, (Raddad. 2006), namely Bout, Mazmoom, Gedaref, Domokeya, Nabag, Saata, Rahad and Semaih were collection from different geographical regions in the gum arabic belt of the Sudan, the first three were collection from the clay plain and the latter five from the sand plain, these provenance were representative of wide natural ecological and geographical distribution with contrasting environmental conditions, corresponding to the elite production range of the species through the gum belt.

A randomized complete block design was used, four replications, any replication was consist eight blocks. Numbers of trees on one block were five trees, tapped starting at first day of September. The total trees for experiments were 160 trees (4 replication x8blocks x 5 trees). Collection of gum was started after 45 days and 10-15 days interval between pickings. The gum weighted after three days drying in room temperature. Data was analyzed using the MSTATC statistical program. The means were separated according to LSD

Results and Discussion

In the first season result showed a significant different among the average of gum yield per tree at the eight A. senegal provenances. The average gum yield per tree from Nabag, Mazmoom, Bout, Saata and Semaih gave a higher average of gum yield and gave 1029, 1046, 1077, 1142, and1024 respectively, comber to the other three provenances trees, Gadarief, Domokeya, and Rahad, which gave 696, 900, and 867 respectively.

The higher average of gum yield per picking (g/tree) recorded in the first picking at Domokeya provenances, and gave 310g/tree, while the lowest average of gum yield per picking (g/tree) recorded in the eight picking at Gadarief provenance and gave 31g/tree. Table 1.

Also showed a significant different between the clay A. senegal provenances, the higher average of gum yield per tree represented by Bout provenance and gave 1077g/tree and lowest average represented by Gadarief provenance and gave 696g/tree. Table 1.

Also a significant different were found between the sand A. senegal provenances , the higher average of gum yield per tree represented at Saata provenance and gave 1142g/tree, and lowest average represented at Rahad provenance trees and gave 867g/tree. Table 1.

Provenance	Habitat	Pickings								Total/g/tree
		1	2	3	4	5	6	7	8	
Bout	Clay	240ab	200a	173a	135ab	96a	107abc	73a	53a	1077
Mazmoom	Clay	210b	200a	174a	161a	94ab	119ab	49bc	39abc	1046
Gadarief	Clay	249ab	90c	96d	95c	50d	46d	39c	31c	696
Domokeya	Sand	310a	109bc	138bc	111bc	69cd	79c	48bc	36bc	900
Nabag	Sand	256ab	199a	158ab	131abc	71c	113ab	62ab	39abc	1029
Saata	Sand	282ab	179a	186a	151a	98a	133a	66ab	47ab	1142
Rahad	Sand	232ab	147ab	110cd	96bc	75bc	122ab	49bc	36bc	867
Semaih	Sand	300a	185a	163ab	111bc	75bc	96bc	58abc	36bc	1024
CV%		20.9	22.7	13.5	21.7	17.3	20.4	28.8	26.6	

SE ±	27.1	18.6	10	13.5	6.8	10.4	8	5.3	
Sign	Ns	**	***	*	***	***	Ns	Ns	

Ns: no Significant different s: *significant difference,**high significant difference,***very high significant difference.

Table 1: *Gum arabic yield per tree per picking for A. senegal provenances at first season.*

Also in the second season result showed a significant different among the eight A. senegal provenances. The average gum yield per tree from Nabag, Mazmoom, Bout, and Semaih gave a higher average of gum yield and gave 2009, 1655, 1649, and1518g/tree respectively, comber to the other four provenances, Gadarief, Domokeya, |Saata, and Rahad gave 1232, 926, 1283and 1339g/tree respectively.

A higher average of gum yield per picking (g/tree) recorded in the first picking at Nabag provenance, and gave 454g/tree, while the lowest average of gum yield per picking (g/tree) recorded in the eight picking at Domokeya provenance and gave 86g/tree. Table 2

Also showed a significant different between the A. senegal clay provenances resources, the higher average of gum yield per tree represented by Mazmoom and Bout provenances and gave 1655 and 1649 g/tree respectively, lowest average represented by Gadarief provenance and gave 1232g/tree. Table 2

Also a significant different were founded between the sand A. senegal provenances, the higher average of gum yield per tree represented by Nabag and gave 2009g/tree, and lowest average represented by Domokeya provenances and gave 926g/tree. Table 2

In this study, gum yield process in A. senegal seems to be highly affected by the provenances, and also affected by rainfall, because in the first season total of rainfall was 765.6 mm and average of gum yield ranged between 696 g per tree from Gadarief provenance and 1142 g per tree from Saata provenance. While in the second season total of rainfall was 896.9 mm more than first season and average of gum yield ranged between 926 g per tree from Domokeya provenances and 2009 g per tree from Nabag provenance. Figures 1 and 2

Provenances	Habitat	Picking								Total/g/ tree
		1	2	3	4	5	6	7	8	
Bout	Clay	258b	193ab	260a	266ab	137bc	260a	187abc	88a	1649
Mazmoom	Clay	209bcd	191ab	274a	271ab	180ab	204abc	217ab	109a	1655
Gadarief	Clay	165cd	119cd	154b	234bc	139bc	150cd	177abc	94a	1232
Domokeya	Sand	135d	91d	113b	137d	114c	128d	122c	86a	926
Nabag	Sand	454a	199a	333a	291a	191a	232a	194ab	115a	2009
Saata	Sand	220bc	140bcd	182b	193c	136bc	163bcd	153bc	96a	1283
Rahad	Sand	167cd	134cd	183b	210c	144c	209abc	196ab	96a	1339
Semaih	Sand	231bc	153abc	174b	242abc	159abc	221ab	240a	98a	1518
CV%		24.41	24.43	24.33	15.03	23.02	22.62	25.14	24.42	
SE ±		28	19	25	17.3	17.4	22.1	23.3	12	
Sign		***	***	***	***	*	**	*	ns	

Ns: no Significant different s: *significant difference,**high significant difference,
***very high significant difference.

Table 2: *Gum arabic yield per tree per picking A.senegal provenances at second season.*
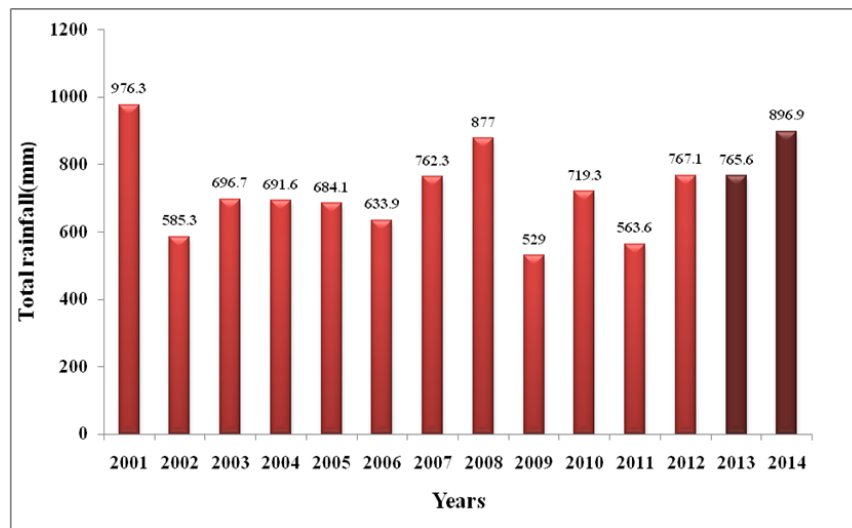
Figure 1: Total rainfall at the experimental site in the Blue Nile State at period 2001-2014.
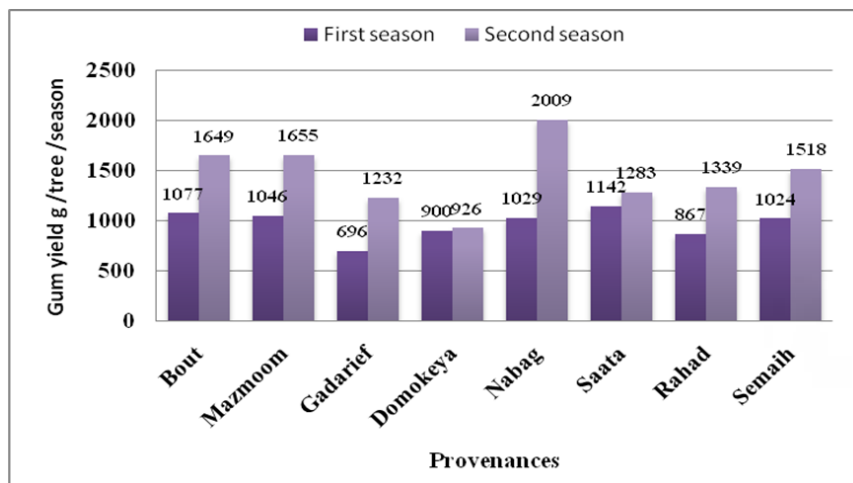

Figure 2: Total of gum yield g per tree at the two seasons.

Conclusion

- There is a significant difference among the A. senegal provenances and also between the gum yield (g/tree) in the pickings over the two seasons.
- In this study all A.senegal provenances produced high gum yield over the two seasons but A.senegal provenances from Clay habitat (Bout and Mazmoom), and A.senegal provenances from sand habitat (Nabag, Saata and Semaih) gave a higher average of gum yield comber with Gadarief from clay habitat, Rahad and Domokeya from sand habitat
- The data obtained in the study conclude that the first three gum pickings appears to be an important factor in gum arabic yield and could be used as an indicator for the prediction of the total gum yield in the subsequent years, because first three gum pickings yielded more gum than the other pickings.
- The study recommends and encroach local communities to be aware of the valuable services and benefits of A.senegal.
- Extra silvicultural and management efforts should be directed towards protection of the tree for sustainable production of gum in the future.

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