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Relationship between Metal Ions in Gum Arabic (*Acacia senegal)* and the Mineral Contents in the Soil under Tree Stands in Different Rainfall Zones in Sudan

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***Abstract*: The aim of this study was to determine the relationship between metal ions in the gum polymer and those present in the soil under the tree stands. Samples of gum arabic and soils were collected from sites representing three main soil types viz (sand, clay and sandy clay or "gardud" under three rainfall (low, medium and high) conditions throughout the gum belt of North, South Kordofan and Blue Nile States. Gum and soil samples were analyzed to determine metal ions. Analysis of variance was used to determine the differences in metal ions of gums from different sites under different soils types and rainfall. The differences in rainfall isohyets in different soil types significantly affected calcium, potassium and magnesium contents and there was no significant effect on sodium content. From gum analysis the soil types were not significantly different in magnesium and sodium content. The difference exists only on calcium and potassium content in sandy soil, while clay soils contain higher potassium ions. Rainfall levels gave no significant difference on gum minerals in different soils except magnesium in sandy soil and calcium in sand and clay soils.**

***Keywords*: *Acacia senegal*, Gum Arabic, Rainfall, Soil type, Metal ions.**

I. INTRODUCTION

Gum Arabic is an exudate from certain *Acacia* trees that occur in a wide belt of semi-arid lands stretching across sub-saharan Africa (Islam et.al, 1997). *Acacia senegal* produces plant exudates known as acacia gum or gum Arabic, which is described as a plant exudate obtained from the stems and branches of natural strains of *Acacia senegal* or closely related species such as *Acacia seyal* (FAO1995). Gum, in general, is any water soluble or water-swellable polysaccharide that is extractable from marine and land plants, or from microorganisms that possess the ability to secrete viscous or gel-like gum (Abu Baker et.al 2007). Plant gums are biopolymeric products composed of complex heteropolysaccharides and proteinacous material, in addition to some mineral elements (Williams and Phillips 2000). The physicochemical properties of a compound are the measurable physical and chemical characteristics by which the compound may interact with other systems, and these characteristics collectively determine the quality, applicability or end-use of the compound. In plant gums, these properties are directly influenced by the botanical type, age, location, nature of the growing soils and climatic conditions around the resources gum tree (FAo 1995; Chikamai 1997; Idris et.al 1998; NGARA 2005; Elnour 2009). Previous studies from Elamin et.al (2013) proved that the presence of metal ions is directly related to gum viscosity where the monovalent ions increase viscosity and the revise for divalat ions. Therefore this study aim at knowing the relationship between metal ions in the gum polymer and theses present in the soil under the tree stands.

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II. MATRIALS AND METHODS:

Gum and soil samples were obtained from three different provenances in different ecological zones of the gum arabic belt within three rainfall isohyets (high, low and moderate). The experiment was carried out in three types of soils of the *A. senegal* belt (Clay, "gardud" or sandy clay and sandy soil). Zone one lies in the clay soil with low rainfall (350-450 mm) was represented by Karkog area. Zone two and three were represented by Eldaly and Bout, in moderate (500-600 mm) and high (700-900 mm) rainfall isohyets, respectively. Elodaya, Elfula and Elmoglad in west Kordofan represent the low (250- 350 mm), moderate (400-500 mm) and high (500-600 mm) rainfall isohyets in gardud soils, respectively. The sandy soil area was represented by Bara, El Himaira and Babanosa for low (150-200 mm), moderate (250-350 mm) and high (450-500 mm) rainfall isohyets, respectively.

Nine hashab trees were randomly selected from the different above areas, marked and then tapped for gum. The gum samples (81 samples) obtained from tapping the trees were dried at room temperature (32ºc), grinded in a blender to be ready for preparation of gum solutions.Soil samples were collected from forest in the same place where the trees were selected and the samples were taken from 0-30 and 30-60 cm soil depth. The gum and soil samples were kept in bags and were analysis for metal ions (K, Na, Ca, Mg) according to the standard atomic absorption conditions (Atomic Absorption Spectrometer, Model Buck scientific U S A, 2005).

The data were analysed using the statistical analysis system (SAS), JMP and EXCEL statistical programs. Analysis of variance and Duncan's Multiple Rage Tests at 0.05 probability level was used to study the significance of the differences between means of gum and soil composition from different locations of the gum belt. Correlation analysis between soil components was carried out.

III. RESULTS AND DISCUSSION

Table 1 shows the effect of type of soil on mineral content in the different rainfall isohytes. When the rainfall is high there were no significant differences in calcium content between gardud and clay soils but the differences were significant ($P<0.05$) between them and sandy soil. Sandy soils were significantly higher than clay and gardud in Ca content under low rainfall. However, there were no significant differences in its content between the different soil types under the different rainfall levels. Significant differences ($P<0.05$) existed in potassium content between clay and other soil types under medium rainfall and between gardud and other soil types under high rainfall. For magnesium content there were no significant differences between gardud and clay soils while its content decreased significantly ($P<0.05$) in sandy soil under high rainfall. With respect to sodium content, there were no significant differences between the different soil types under the different rainfall levels.

Table 1 Effect of soil type on soil mineral content in three rainfall areas of the gum belt.

Soil type	Ca			K			Mg			Na		
	L	M	H	L	M	H	L	M	H	L	M	H
Sand	4.03 a	2.53 a	0.15 b	0.98 a b	2.85 a	0.62 b	9.32 a	8.65 a	0.83 b	1.52 a	3.19 a	1.67 a
Gadrud	0.41 b	4.08 a	3.27 a	1.31 a	1.87 a	1.82 a	5.06 a	13.93 a	12.8 a	1.55 a	1.79 a	2.04 a
Clay	1.10 b	3.69 a	2.11 a	0.44 b	0.31 b	0.15 b	5.25 a	14.77 a	10.4 a	1.59 a	1.51 a	1.76 a
Pro<	0.0003	0.59	0.006	0.06	0.003	0.005	0.17	0.13	0.0001	0.82	0.48	0.31
SE±	0.5	1.09	0.59	0.24	0.44	0.31	1.71	2.2	1.02	0.07	1.02	0.17

Means with the same litter in the same column were not significantly different

Note: L, M, H denote low, medium and high, respectively.

From gum analysis the soil types were not significantly different in Mg and Na content. The difference exists only on Ca and K content in sandy soil, while clay soils contain higher K ions. There was no significant difference in Ca content between sandy and gardud soils but the differences were significant ($P<0.05$) between sand and clay content.

In case of K, the results were not the same as the case in Ca content. Sandy soils contain the lowest K content while clay soil have the highest ones with no significant differences with gardud soil and that differences are significant with sandy soil and no significant differences between sand and gardud soil (table 2).

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Table (2) Effect of soil type on gum arabic mineral content

Soil type	Ca	K	Mg	Na
Sand	20.13 a	20.04 b	16.41 a	0.39 a
Gardud	15.94 ab	20.98 ab	16.69 a	0.40 a
Clay	11.93 b	21.69 a	16.26 a	0.32 a
P<	0.009	0.005	0.15	0.26
SE±	1.72	0.32	0.15	0.03

Means with the same litter in the same column were not significantly different

In sandy soils, the rainfall gave no significant effect on K and Na contents, while there were significant differences (P<0.05) on Ca and Mg contents. Mg amount decreases with increasing rainfall, but Ca highest in medium rainfall and lowest in low rainfall (table 3)

Table (3) Relationship between rainfall and gum arabic mineral contents in sandy soil

Rainfall	Ca	K	Mg	Na
High (400-450mm)	20.46 ab	20.29 a	16.31 b	0.39 a
Medium(250-350mm)	24.71 a	19.92 a	16.38 ab	0.37 a
Low(150-200mm)	15.21 b	19.92 a	16.54a	0.41 a
P<	0.07	0.62	0.061	0.84
SE±	2.34	0.29	0.05	0.04

Means with the same litter in the same column were not significantly different

In gardud and clay soil different rainfall levels has no significant effect on all minerals content, except Ca amount in clay soil, there were no significant differences between high and medium rainfall but there was significant difference under low rainfall (table 4, 5).

Table (4) Relationship between rainfall and gum arabic mineral contents in gardud soil

Rainfall	Ca	K	Mg	Na
High(500-600mm)	11.84a	21.1 a	16.46 a	0.39a
Medium(400-500mm)	18.37 a	20.36 a	17.14 a	0.47 a
Low(250-350mm)	17.6 a	21.47 a	16.46 a	0.34 a
P<	0.11	0.32	0.34	0.62
SE±	2.01	0.48	0.34	0.09

Means with the same litter in the same column were not significantly different

Table (5) Relationship between rainfall and gum arabic mineral contents in clay soil

Rainfall	Ca	K	Mg	Na
High(700-900mm)	13.97 a	22.51 a	16.52 a	0.23 a
Medium(500-600mm)	15.87 a	21.76 a	16.03 a	0.36 a
Low(350-450mm)	5.96 b	20.8 a	16.22 a	0.36 a
P<	0.04	0.34	0.51	0.31
SE±	2.26	0.75	0.28	0.06

Means with the same litter in the same column were not significantly different

The relationship between metal ions in gum arabic and the soil under trees is presented in figure 1. It is clear that the tree takes a small amount of sodium from the soil and much more magnesium, despite the abundance in the soil. However the tree needs large amounts of potassium, calcium, which is evident in the amount of minerals in gum as related to the amount present in the soil. This may indicate that the tree consumed larger quantities of elements during the period preceding gum formation which is the period of active tree growth in autumn.

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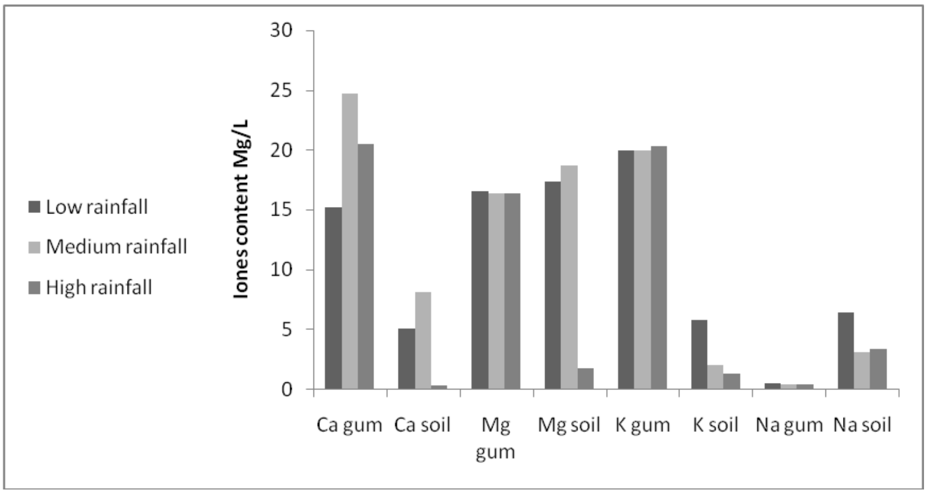
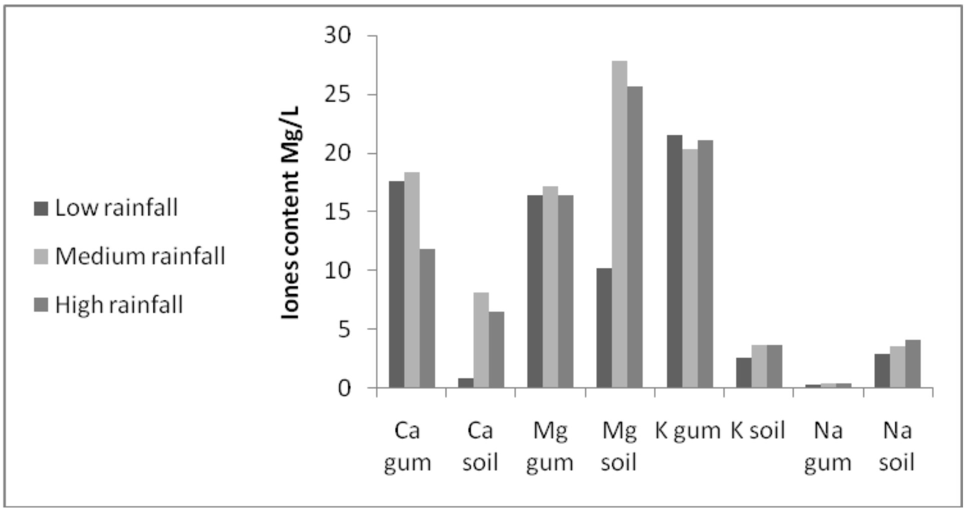


(a)



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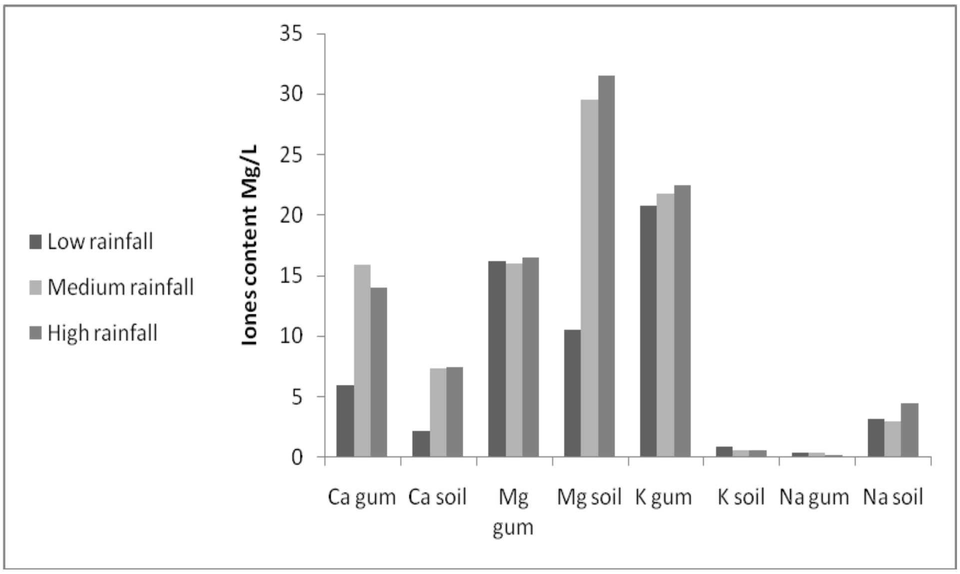

(c)

Fig 1. Mineral contents of gum Arabic in sandy (a), clay (b) and gardud (c) soils

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V. CONCLUSION

The study showed that Ca, K, Mg and Na are the main determinations of the gum viscosity of *A. senegal* var. senegal. The soil characteristics within gum belt are major factors that influence the gum arabic production and quality and further research is needed especially on the effect of soil micronutrients on gum quality. Further research is necessary to identify the provenances with high gum production and quality under the different agro-ecological zones within gum Arabic belt of Sudan.

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