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Effect of Tree Locust Infestation and Artificial Defoliation on Viscosity and Optical Rotation of Gum Arabic Produced from *Acacia Senegal*

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Abstract

The present study was conducted in two locations in Acacia Agricultural Company (Nawa and Elrahad locations) for three successive seasons; 2007/2008, 2008/2009 and 2009/2010), 37 km south east of El Obeid city, North Kordofan State. The objective is to access the effect of tree locust infestation (natural defoliation) and artificial defoliation on gum arabic quality. Experiments were conducted, where four blocks were chosen randomly, and the following treatments were arranged in a randomized complete block design: control (no defoliation), light natural defoliation (LND), moderate natural defoliation (MND), high natural defoliation (HND), light artificial defoliation (LAD), moderate artificial defoliation (MAD) and high artificial defoliation (HAD). Trees in all treatments were tapped and the gum was collected. The results revealed that in both natural and artificial defoliation the mean values of gum viscosity at different blocks and treatments for all seasons decreased at all levels of defoliation compared to the control. In all levels of defoliation, gum viscosity was higher in artificial defoliation than in natural defoliation. Defoliation reduced gum viscosity and the reduction was statistically significant ($P \leq 0.001$) between all means except between light natural defoliation and light artificial defoliation. The correlation between all levels of defoliation and gum viscosity is shown in Appendix 1. There was a negative correlation between all levels of defoliation and gum viscosity which arranged from - 0.94 to - 0.99 for natural and artificial levels of defoliation, respectively. Results show that the means of gum specific optical rotation at different blocks and treatments were negative values. Defoliation reduced gum specific optical rotation but there was no significant difference between means in all treatments.

Keywords

Tree Locust, Defoliation, Acacia Senegal, Gum Viscosity, Optical Rotation

1. Introduction

Gum arabic is one of the main crops produced in the traditional rain-fed agricultural sub-sector in Sudan. It is a non timber forest product of the genus *Acacia*; namely *Acacia senegal* L., locally called *hashab* tree [4 and 22]. Among the main constraints of the production of gum arabic are insect pests, particularly the Sahelian tree locust, *Anacridium m. melanorhodon,* arabic name: Sari al leil (night wonderer), the name "Sari al leil" which means "The nocturnal vagabond" [13 and 4]. There are about a dozen species and a few are economically important pests. These are:

a. aegyptium (Linné, 1764), the Egyptian Tree locust,

distributed from the Mediterranean zone to the Middle East

b. melanorhodon (Walker, 1870) and *A. wernerellum* (Karny, 1907), found in Africa, the Sahel and Sudan

c. arabafrum (Dirsh, 1953), in East Africa and Arabia;

d. moestum (Serville, 1838), in South Africa.

In the Sudan, *A. melanorhodon* and *A. wernerellum* have a wide range of distribution in the east at the Red Sea maritime plain and it has been noticed breeding regularly in the Red Sea hills. From there it extends south as far as Eritrea and on the west through Kassala to the Nile valley. It appears to be most abundant in the south- west (Darfur and Kordofan) where it is the pest. From Khartoum it extends up the Blue Nile and Gezira district, between the Blue and White Niles [2]. According to [15] there are five to six instars for male of *A. m melanorhodon* and six or seven for female. [7] recorded six instars for both male and female, while only five nymphal instars were recorded by [13 and 19]. Copulation takes place after the first rains and copulating pairs stay on trees until eggs lying begins (June-July). Eggs are laid in damp soil during the rainy season 10-20 days after copulation. A female lays 1-3 egg pods containing 150-200 eggs. The incubation period takes two weeks but no evidence of diapause has been found. The eggs hatch to give hoppers. If hatching take place before the mid of August, the situation will become more severe. First instar hoppers live on the ground or roost on low branches in loose groups, their diet is flexible and miscellaneous eating different forbs (non-graminaceous diet). They are geophilic negatively geotropic and strongly positively phototropic. Their arboreal behavior is more obvious from the third instars. They climb on *Acacia sp* and *Balanites sp* trees and eat their leaves. When hoppers populations are dense, with few perches, they swarm but do not move in cohesive groups. The development of the hopper stages takes 48-69 days; the first fledglings appear in September-October ([13, 15 and 16]. Imagoes remain in a resting maturity stage until the first rain of the following year in May- June [13 and 4]. Tree locusts are important occasional pests of fruit trees, rice, sorghum, and cotton. In tropical regions, gum arabic producing acacias are the most severely affected trees. Swarms of migrating imagoes (gregarious phase) chronically attack them in the dry season thus reducing gum production. [18, 22, 4 and 6]. [9] reported that a winged locust weighing 2 grams, during its gregarious phase, can eat an amount of fresh leaf equivalent to its body weight per day, and a swarm covering $1Km^2$ (50 million locusts) can consume a hundred ton of vegetal material. In the Sudan, [3] reported that the infested area in 1987 was estimated at 20000 ha, increasing to 224000 ha the following season, reaching an unprecedented level in 1989 of 1.366.762 ha. It was the most serious outbreak of tree locust, because the entire gum arabic belt in western, central and eastern regions of the country were infested and gum production decreased. Damage was reported mainly on *A. senegal* in addition to other *Acacia* species, *B. aegyptiaca*, *Z. spina christi*, fruit trees and sorghum in the milky stage. In mid-60s around 50,000 tons of gum was annually exported, but that decreased steadily to 18.000 tons during the 1990's [8]. Over the last two decades and since the inception of the drought years during the 1970's coupled with pest outbreaks, gum arabic production has decreased significantly [23]. Quality measures for non-wood forest products are almost lacking, except for gum Arabic, and this includes basic grading and cleaning operations (excluding physiochemical properties). Except for export supplies, products are hardly graded. In general, there are no processing or quality requirements to be observed by producers. Large quantities are sold according to weight or volume, regardless of quality. However, producers have developed experience and some skills by which they could differentiate between good and inferior quality products which, in most cases, is based on the origin (source) of the produce. Nevertheless, there is no basis for carrying out grading and standardization processes. In general, the quality (viscosity and optical rotation) of the product alone doesn't influence the pricing system, and research in the field of viscosity and optical rotation of gum arabic is neglected or paid little and/or no attention, Within the *Acacia senegal* species, the main factors affecting grades of gum Arabic quality are different botanical sources (varieties), tapping methods, harvesting period, environmental factors and insects factors [11, 2 and 1]. [17 and 5] reported that the viscosity of gum arabic is affected by a number of factors which include biotic and non-biotic factors. [14] reported the economic importance of tree locust and its devastating effects on the quantity and quality of gum arabic.

2. Materials and Methods

2.1. Field Survey

Four blocks in each location (Elrahad and Nawa location) were selected randomly. Each block was divided into 7 plots (experimental units). In each plot (treatment) there were 15 *Hashab* trees. The treatments were arranged in a randomized complete block design (RCBD). the treatments were: control, light natural defoliation (5 of 15 trees were caged with tree locusts to be completely defoliated i.e. 33% naturally defoliated), moderate natural defoliation (10 of 15 trees were caged with tree locust for complete defoliation i.e. 66% naturally defoliated), high natural defoliation (all the 15 trees were caged with tree locusts and completely defoliated i.e. 100% naturally defoliated), light artificial defoliation (5 of 15 trees were completely defoliated with 1% diluted ethereal defoliant spray i.e. 33% artificially defoliated), moderate artificial defoliation (10 of 15 trees were completely defoliated with ethereal defoliant i.e. 66% artificially defoliated) and high artificial defoliation (all the 15 trees were completely defoliated with ethereal defoliant i.e. 100% artificially defoliated). Both artificially and naturally defoliated trees were selected randomly. The control and the trees in other treatments which were not naturally or artificially defoliated were sprayed weekly using neem seed water solution extract 1% as recommended by [21] as antifedant and repellent for tree locust and other pests.

2.1.1. Collection and Preparation of the Neem Seeds

Fruits of neem tree (*Azadirachta indica*) were collected from Elobeid area, washed and left to dry. The seeds were then decorticated and the kernels were ground into a fine powder, stored in a glass jar tightly closed and kept at room temperature.

2.1.2. Preparation of Neem Seed Aqueous Extracts (Aqu-extr)

One kilogram of the prepared neem seed powder (N.S.P) was mixed with 40 liters of water as recommended by [21] in a bucket and stirred vigorously using a wooden stick and left overnight. The mixture was stirred again before it was filtered using a piece of cloth. The filtrate was mixed with liquid soap as an emulsifier at a ratio of 4:1 (v/v), 1% gum Arabic solution as a sticker and anti-oxidant and 1% molasses as uv-light protecting.

2.1.3. Tapping and Gum Collection

Trees in all treatments were tapped during the period from mid-October to end of November using a tapping tool (Sunki) made of steel with a long wooden handle; the first picking of gum began 40 days after tapping followed by a series of subsequent pickings up to seven pickings at 14 days interval. Gum in each treatment was collected, mixed and weighed separately. The percentage of loss in gum produced is calculated in all levels of defoliation with respect to gum produced in the control.

2.2. Laboratory Experiments

2.2.1. Preparation of Gum Samples

Gum nodules in each treatment were dried at room temperature, and then cleaned by hand to ensure a quality free from sand, dust and other impurities, then ground using a mortar and pestle, sieved and kept in labeled containers for qualitative analysis.

2.2.2. Gum Viscosity (%)

Gum viscosity is the resistance of gum liquid to shear forces and hence to flow. In each treatment, a sample of 25g of gum powder was taken and dissolved in 100 ml of distilled water. The viscosity of gum solution was measured using a viscometer (model DV.II+ England).

2.2.3. Specific Optical Rotation

The specific optical rotation of gum is a measure (finger print) by which different gum types can be sorted and identified and it has negative values in the case of hashab gum (-22 to -35) and positive for other acacia gums [10]. Solution of gum powder 1% (on dry weight basis) in each treatment was prepared and measured at room temperature using an optical activity polarimeter (type AA-10 automatic polarimeter, England). The solution was passed through filter paper before carrying out measurements; triplicate readings were taken and averaged.

3. Results and Discussion

At Nawa and Elrahad locations, seasons 2007/2008, 2008/2009 and 2009/2010 show that the mean values of gum viscosity at different blocks and treatments for all seasons decreased at all levels of defoliation compared to the control. In all levels of defoliation, gum viscosity was higher in artificial defoliation than in natural defoliation. Defoliation reduced gum viscosity and the reduction was statistically significant ($P \leq 0.001$) between all means except between light natural defoliation and light artificial defoliation (Table 1). There was a negative correlation between all levels of defoliation and gum viscosity which arranged from -0.94 to -0.99 for natural and artificial levels of defoliation, respectively (Table 2).

Table 1. *Mean values of gum viscosity (%) at different blocks and treatments at Nawa and Elrahad locations (seasons 2007/2008, 2008/2009 and 2009/2010).*

Block No.	Gum viscosity %						
	Control	LND	MND	HND	LAD	MAD	HAD
1	35.5	34.5	32.1	30.9	34.6	32.7	31.5
2	34.6	34.5	32.1	30.9	34.6	32.7	31.5
3	34.0	34.5	32.1	30.9	34.6	33.4	31.6
4	34.0	34.5	32.0	30.9	34.6	32.6	31.4
Total	138.1	138	128.3	123.6	138.4	131.4	126
Mean±SE	34.5^{a}±0.09	34.5^{b}±0.03	32.1^{c}±0.03	30.9^{d}±0.02	34.6^{b}±0.2	32.9^{f}±0.1	31.5^{g}±0.1

Mean±SE

Mean values of gum viscosity in each column with same superscript letter showed no significant difference at p = 0.001 as separated by Tukey test.

Table 2. *Correlation between natural and artificial defoliation and gum viscosity (%) at Nawa and Elrahad locations (seasons 2007/2008, 2008/2009 and 2009/2010.*

Level of infestation	Intensity of infestation X	Gum viscosity % Y	XY	X^2	Y^2
LND	5	34.5	172.5	25	1190.3
MND	10	32.1	321	100	1030.4
HND	15	30.6	459	225	936.4
∑	30	97.2	952.5	350	3157. 1
Mean	10	32.4			

R = -0.94

Y = 36 – 0.36 X

Level of infestation	Intensity of infestation X	Gum viscosity % Y	XY	X2	Y2
LAD	5	34.6	173	25	1197.2
MAD	10	32.9	329	100	1082.4
HAD	15	31.5	472.5	225	992.3
∑	30	98.9	974.5	350	3271.9
Mean	10	32.9			

R = -0.99
Y = 36.1 – 0.32 X

Results show that the means of gum specific optical rotation at different blocks and treatments were negative values. Defoliation reduced gum specific optical rotation but there was no significant difference between means in all treatments. These qualitative effects (gum viscosity and specific optical rotation) could be attributed to physiological changes caused by tree locust infestation, because hashab tree absorbed more water through the root system in order to compensate for the loss caused by defoliation. Therefore the tree sap becomes more diluted thus affecting gum viscosity. [7] reported that; in season 1991, gum viscosity was slightly reduced by defoliation although the reduction was not statistically significant as compared to the control, but in season 1992 the gum viscosity was reduced by defoliation and the reduction was highly significant as compared to the control. He attributed this to the internal physiological changes occurred in hashab tree that were caused by tree locust.

4. Conclusion

The gum Arabic tree (*hashab*), *Acacia senegal*, suffers from attack of tree locust *Anacridium melanorhodon melanorhodon* Walk during years of outbreak. This pest causes defoliation, and thus decreases gum quality. Therefore, there is a high necessity to investigate the qualitative effect caused by such pest as a prerequisite for gum specifications and standards. The study recommended that:

Further studies should be conducted for extra investigation in this field as a prerequisite for gum specifications and standards.

References

[1] Abdel Magid, T. D. and E. I. Warrag, 2011. Status and experience of agroforestry in Sudan. Eco-forum. Sudanese Environment Conservation Society and NOVEB.

[2] Abdel Nour, H. O, (2011). Forestry in the two Sudans, Technical report. Ex-Director Forests National Corporation. Forestry Consultant. P. O. Box 8116 Amarat, Khartoum, Sudan. HCENR, 2003.

[3] Abdulla, A. A. (1990). Review of the (1989-1990) Situation of Grasshoppers, Tree Locust and African Migratory Locust in the Sudan. And outlook for (1990 -91). Ministry of Agriculture. PPD- Khartoum North- Sudan.

[4] Cirad (2006): *Anacridium* spp • Contact: prifas@cirad.fr.

[5] Elamin, E. E., Blal M. E., Mahmoud A. E. (2013). Gum Arabic (*Acacia Senegal* (L.) Willd) Viscosity in Relation to Rainfall and Soil Metal Ions.

[6] Elamin, H. M., Roth and Taha, M. E. (2008). The Consequences of Defoliation of Gum Arabic Tree (*Acacia senegal*) by Sahelian Tree Locust (*Anacridium melanorhodon melanorhodon*) for the Gum Producers in North Kordofan State, Sudan, October 7-9, 2008 Conference on International Research on Food Security, Natural Resource Management and Rural Development. Tropentag 2008, University of Hohenheim.

[7] Elbashier, E. M, (1994). The Impact of Defoliation by the Tree locust (*Anacridium melanorhdon melanorhodon* Wlk.) on the Gum Arabic.

[8] Eldukheiri, I. (1997). Pest change of future prospects of traditional rainfall farming in North Kordofan, Sudan. Ph.D. Dissertation, Technische Universtität München, Germany.

[9] Evans, C. S. and Bell, E. (1979). Non-protein amino acids of Acacia species and their effect on the feeding of the acridids A. melanorhodon. The 2nd ed., Oxford University Press, Oxford.

[10] FAO (1991). Food and Nutrition, Paper 49 Specifications for Identity and Purity of Certain Food Additives.

[11] FRA (2010). Global Forest Resources Assessment, Country Report, Sudan. FAO, Rome.

[12] Gum Arabic Company (2000). Analysis of gum Arabic supply dimensions, paper (Arabic issued) presented by the administration research and development, Gum Arabic Company in February 2000. Khartoum, Sudan.

[13] Johnston, H. B. (1932). Notes on two locusts of minor economic importance in the Sudan. Bulletin of Entomological Research 23 (1), pages 49-64. Londres.

[14] HCENR (2016). Republic of Sudan Ministry of Environment, Forestry and Physical Development. The Higher Council for Environment and Natural Resources. Sudan Fifth National Report to the Convention on Biological Diversity.

[15] Luong, M. H., Launois and Popov, G. B. (1997). *Anacridium m. melanorhodon* (Walker, 1870) Acrididae – Cyrtacanthacridinae. Pamphlet, collaborative work Cirad, DLCO, OCLALAV, Rhone-Poulenc agro. isbn: 2-87614-289-9.

[16] Meinzingen, W. F. (1993). A guide To Migrant Pest Management in Africa. FAO. Rome, Italy.

[17] Mujawamariya, G. and Burger, K., (2012). Quality of Gum Arabic in Senegal: Linking the Laboratory Research to the Field Assessment. Wageningen University, the Netherlands.

[18] Pastre, P. S., Samolikowski, G. and Thewys, E. (1988). Locusts and grasshoppers control: deltamethrin file. ROUSSEL OCLALAV- DIVISION AGRO. Paris, France.

[19] Popov, G. and Ratcliffe, M. (1968). The Sahelian Tree Locust *Anacridium melanorhodon* (Walker); Anti-Locust Memoir 9. Ministry of Overseas Development. Anti-Locust Research Centre, College House, Wrights Lane, London, W. 8 No 9: 48 pp.

[20] Schmutterer, H. (1969). Pests of crops in Northeast and Central Africa. Gustarv Fisher Verlag. Stuttgard, Portland, USA.

[21] Siddig, S. A. (1991). Evaluation of neem seed and leaf water extracts and powder for The control of insect pests in the Sudan. Tech. Bull. No. 6 Shambat Research Station, Khartoum, Sudan.

[22] Taha, M. E. (2000). The Socio-economic Role of *Acacia senegal* in Stainable Development of the Rural Areas in the Gum Belt of the Sudan. Ph.D. Thesis Dresden University of Technology, Germany Institute: Institute of International Forestry and Forest Products, Tharandt, Germany.

[23] Taha, M. E. (2006). The Socio-economic Role of *Acacia senegal* in Sustainable Development of Rural Areas in the Gum Belt of the Sudan. ISBN 3-9809816-4-9. Dresden University of Technology.