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Analyzing the Effect of Management Strategies on Gum *Talha* Yield from *Acacia Seyal*, South Kordofan, Sudan

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ABSTRACT : The present study was carried out from September 2007 to February 2008 in Umfakarin natural forest reserve, South Kordofan, Sudan. The objective was to analyze the effect of different management strategies on yield of gum *talha* from *Acacia seyal*. A total of 493 single target trees were selected, based on their diameters, and assigned to tapping treatments in three different stand densities (making a total of nine treatments per stand density). The treatments are as follows: tapping date with three levels (first of October, 15 October and first of November) and two levels of local tapping tools (*sonki*, and *makmak*). Untapped trees were used as control. The first picking of gum was started fifteen days after tapping while the subsequent pickings were done in intervals of fifteen days. Yield per tree throughout the season was obtained by summing up the gum yield from all pickings. Yield throughout the season (from first to the last picking) were analyzed. General linear model (GLM) was used to test the effect of different tapping treatments on the yield of gum *talha*. Post hoc test after analysis of variance (ANOVA) based on Scheffe test was performed to examine the differences in gum yield as a result of different management strategies. The results showed that tapping has a significant influence on gum yield. Analysis of pick-to-pick yield indicated that only three treatments in dense stand density showed a decreasing pattern while the rest of treatments either have constant or unclear patterns. The results of the present study were based on a single season data and that may underscore the real effect of *Acacia seyal* stands´ management strategies on gum *talha* yield. Conducting gum yield experiments in permanent trial plots are highly recommended in order to analyze gum yield of seasonal time series.

Keywords : *Acacia seyal*, Gum *talha*, Management strategies, Tapping treatments

Introduction

Sudan leads the world in the production and exportation of gum Arabic and accounts for about 80 percent of the world's gum Arabic production (Abdelnour, 1999; Abdelnour and Osman, 1999; Forests National Corporation, FNC, 2007; Tadesse *et al*., 2007). At the end of the 1990s, Sudan contribution was ranged between 70–90% of the world's production (Elmqvist *et al*., 2005). However, gum production in Sudan has declined with increasingly variations from year to year due to deforestation (Rahim, 2006), and price policies (Elmqvist *et al*., 2005). Consequently, Sudanese gum share in the world markets has declined sharply below 50 percent (Couteaudier, 2007).

Gum Arabic is one of the main agricultural export commodities produced in traditional rain-fed agriculture in Sudan (Abdelnour, 1999; IIED and IES, 1990). The product is mainly obtained from the stem and branches of *Acacia senegal* tree (Abdelnour, 1999; Ballal *et al*., 2005a; IIED and IES, 1990; JECFA, 1997). Other closely related species such as *Acacia seyal* also produces gum however, it is friable and inferior to the formal ones (Anderson *et al*., 1984; FAO, 1995; Hall and McAllan, 1993; JECFA, 1997; McAllan, 1993).

In Sudan, *Acacia seyal* is mainly managed for the production of fuelwood (Elsidding, 2003) as it produces good and dense firewood (Orwa *et al*., 2009). The species is found to produce a significant amount of gum (locally named as gum *talha*) and contributes to about 10

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percent of Sudan's gum production (Gum Arabic Company, GAC, 2008). The development of production and yield of gum from *Acacia senegal* overtime was analyzed by Ballal (2002) for eight years from 1993-2000, and IIED and IES (1990) over a period of 1958 to 1988. An analysis of data from 1949-2008 indicates that production of gum *talha* in Sudan is variable overtime (GAC, 2008); however, the amount of produced gum is generally increasing with an average annual production of 3100 metric tones. The variation in gum production could be attributed to environmental factors, such as rainfall and temperature, (Ballal, 2002; Chiveu *et al*, 2009), deforestation (Rahim, 2006) and price polices (Elmqvist *et al*., 2005). Ballal (2005b) revealed a positive relationship between yield of gum *hashab* and rainfall. However, for the case of gum *talha*, El Wasila (1994) reported that gum *talha* is collected when there is a short fall in production of gum *hashab*. This reason might explain the huge variation in production of gum *talha* over time beside the factors mentioned above (Ballal, 2002; Chiveu *et al*., 2009; Elmqvist *et al*., 2005; Rahim, 2006). Little is know about reaction of *Acacia seyal* trees to different management regimes. Several scholars have assessed some managerial factors such as stand density, tapping techniques and time of tapping on productivity of gum *talha* (Ali, 2006; Fadl and Gebauer, 2004; Mohammed and Röhle, 2011). However, analysis of gum *talha* yield and pick-to-pick yield has given little attention. Information on gum *talha* yield and the analysis of yield determinants strategies is paramount important as it provides useful information for developing good management regimes of *Acacia seyal* tree. The objective of the present study was to analyze the effect different management strategies on gum *talha* yield from *Acacia seyal*.

MATERIALS AND METHODS

Study area

The study was conducted at Umfakarin Natural Forest Reserve (12° 29′-12° 35′ N; 31° 17′-31° 20′ E), South Kordofan, Sudan during September 2007 and February 2008. There are three types of soils: sand, clay and sandy clay locally called *gardud*. The average annual rainfall is 400 mm and the seasonal flooding is the most conspicuous feature in the forest as described by Mohammed and Röhle (2011). The forest lies within the gum Arabic belt of the Sudan and dominates by *Acacia seyal* stands which represent more than 80 percent of the forest and forming either pure or mixed stands of different densities. The species occurs naturally in an area so called *Acacia seyal- Balanites* zone and classified as low rainfall woodland savannah on clay (El Amin, 1990; Mustafa, 1997; Sahni, 1968).

Data Collection and analysis

Data were obtained from *Acacia seyal var. seyal* natural stands with different densities, namely dense, medium and slight. The stand densities were determined based on number of trees per hectare i.e. 396, 271 and 209 for dense, medium and slight, respectively. Based on their diameters, 493 single target trees were selected from the three different stand densities (dense = 166, medium = 161 and 166 trees for slight density). The selected target trees were exposed to tapping on first and fifteenth of October, and first of November using two local tapping tools (*sonki* and *makmak*) in addition to untapped trees used as control. The first collection or picking of gum was made fifteen days after each tapping while the following pickings (7-9) were done in intervals of fifteen days. Gum yield per picking for each individual tree was collected and dried under room temperature for 3 days and then weighed using a sensitive balance. Total gum yield per tree was obtained by summing up the gum yield from all pickings of each tree. Yield throughout the season i.e. from the first to last pickings, were analyzed. General Linear Model (GLM) was used to test the effect of different tapping treatments on the average and pick-to-pick gum yield. Post hoc test after the analysis of variance (ANOVA) based on Scheffe test (Zar, 2009) was performed for comparing gum yield of different

pickings and the averages of gum yield for the different treatments.

RESULTS

Effect of tapping treatments on gum talha yield and yield trends

Total gum yield per tree, yield per picking and number of individual trees per each tapping treatment are shown in Table 1. The highest average gum yield (56 g/tree/season) was obtained by 16 individual trees when tapped by *sonki* on first of October in medium stand density. The minimum average gum yield (only 2.3 g) was recorded by 16 untapped trees on fifteenth of October in dense stand density. Data from this table show that gum yield of the different pickings are roughly similar across all tapping treatments. Fig. 1 demonstrates the effect of stand density on pick-to-pick yield which indicates no clear pattern of gum yield for medium and slight densities. However, in dense stand density, the results show a decreasing pattern in gum yield.

Results of the regression analysis under GLM/UNIVARIATE showed that at least one treatment is different. Post-hoc comparison tests after ANOVA based on Scheffé test was applied to detect the differences in gum yield among tapping treatments. The differences in gum yield among the treatments are summarized in Table 2. The results of

Table 1. Effect of management strategies on gum *talha* yield from *Acacia seyal* in South Kordofan, Sudan 2007/2008.

Density	Date	Tool	N	Yield (g) per picking number									Total (g)
				1	2	3	4	5	6	7	8	9	
Dense	1st Oct.	Makmak	21	0.55	5.39	5.54	6.34	5.94	4.36	2.10	1.61	0.91	32.74
		Sonki	16	0.82	7.46	7.43	3.98	3.47	7.33	1.75	1.71	2.74	36.69
		Untapped	12	0.28	0.30	0.13	0.88	0.58	0.64	0.52	0.00	0.00	3.79
	15th Oct.	Makamk	24	3.55	3.67	3.06	2.32	1.39	0.70	1.28	0.65		16.62
		Sonki	19	3.92	4.68	2.09	1.50	1.31	1.91	0.75	0.95		17.11
		Untapped	16	0.00	0.61	0.38	0.56	0.13	0.00	0.58	0.00		2.26
	1st Nov.	Makamk	27	9.71	4.67	4.32	0.96	2.94	2.55	0.66			25.81
		Sonki	21	3.47	3.11	4.28	2.25	1.23	3.62	4.60			22.56
		Untapped	10	0.00	2.61	2.65	1.49	1.33	0.00	5.10			13.18
Medium	1st Oct.	Makmak	17	0.72	2.41	4.09	2.13	4.09	1.46	0.84	0.30	1.11	17.15
		Sonki	16	0.57	9.45	8.29	10.87	8.53	8.55	3.07	4.25	2.49	56.07
		Untapped	15	0.00	0.00	0.00	0.00	0.48	0.53	0.12	0.00	0.00	1.13
	15th Oct.	Makmak	24	0.78	1.63	2.30	0.84	0.53	1.74	0.45	0.70		8.97
		Sonki	23	0.88	2.23	2.92	3.80	0.56	0.62	0.46	0.66		12.13
		Untapped	7	0.18	3.40	1.46	0.20	0.00	0.59	0.38	0.26		6.47
	1st Nov.	Makamk	21	0.39	3.98	2.20	3.67	0.48	0.83	1.08			12.63
		Sonki	23	0.40	0.98	1.24	0.74	0.26	0.41	0.49			4.52
		Untapped	15	0.10	0.67	1.36	0.47	0.88	0.03	0.00			3.51
Slight	1st Oct.	Makmak	17	1.28	3.64	2.18	7.91	5.34	3.60	1.49	3.26	1.44	30.14
		Sonki	16	0.25	1.10	3.03	0.75	1.99	2.37	0.51	0.46	0.47	10.93
		Untapped	21	0.00	0.89	0.26	0.02	0.91	2.48	0.76	0.30	1.50	7.12
	15th Oct	Makmak	22	2.72	0.19	0.22	1.28	7.28	4.42	1.03	0.27		17.41
		Sonki	18	0.75	0.54	0.75	0.34	1.02	0.21	0.13	0.06		3.80
		Untapped	15	0.44	0.26	0.63	1.37	1.48	0.05	0.05	0.09		4.37
	1st Nov.	Makamk	20	1.65	2.04	1.75	1.78	0.95	0.59	2.59			11.35
		Sonki	21	1.30	2.28	1.71	3.44	1.49	1.56	1.51			13.29
		Untapped	16	0.46	2.27	0.06	3.91	1.03	0.06	0.22			8.01

the comparison tests indicated that gum yield in dense stand density differs significantly from yield in medium ($p \leq 0.01$) and slight ($p \leq 0.001$) densities. No difference was detected in gum yield between medium and slight densities. Gum yields obtained from tapped trees were significantly different ($p \leq 0.000$) from control ones. The results of gum yield comparisons among tapping dates revealed that the significance ($p \leq 0.000$) stemmed from two groups of dates; the first of October vs. fifteenth of October.

The combined treatments effect on yield

Results of GLM analysis revealed significant positive interactions between stand density and tapping tool (i.e. dense and *sonki*, $p \leq 0.009$; medium and *sonki*, $p \leq 0.000$). Furthermore, negative interactions effect was detected between the three tapping treatments (i.e. between medium, fifteenth of October and *sonki*, $p \leq 0.008$; and between medium, first of November and *sonki*, $p \leq 0.000$). Fig. 2 illustrates the combined effect of tapping treatments on pick-to-pick gum *talha* yield. As can be

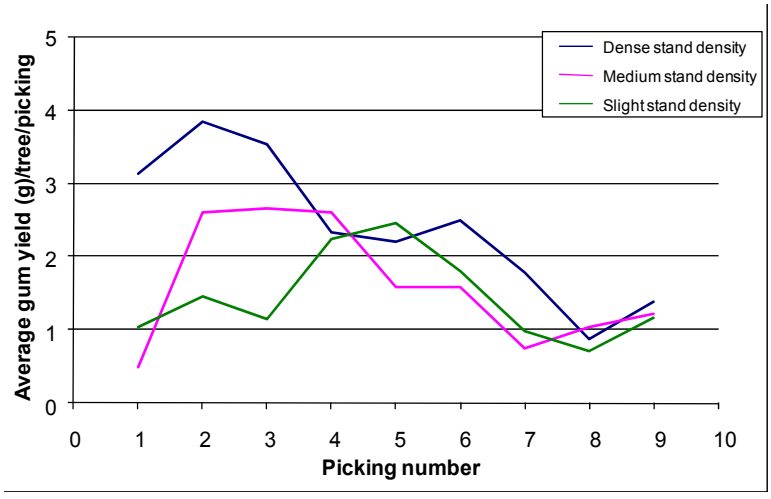


Fig. 1. Effect of stand density on pick-to-pick gum *talha* yield.

Table 2. Multiple comparisons test, based on Scheffe test, after ANOVA for gum talha yield (g).

Factor (I)	Factor (J)	Mean difference (I-J)	SE	Sig.	95% CI	
					Lower	Upper
Dense	Medium	0.875*	0.290	0.011	0.164	1.586
	Slight	1.063*	0.288	0.001	0.359	1.768
Medium	Slight	0.189	0.290	0.809	-0.521	0.899
First of October	Fifteenth of October	1.131*	0.284	0.000	0.435	1.828
	First of November	0.539	0.292	0.182	-0.176	1.253
Fifteenth of October	First of November	-0.592	0.293	0.129	-1.309	0.124
Sonki	Makmak	-0.077	0.274	0.961	-0.749	0.595
	Untapped	1.668*	0.305	0.000	0.922	2.414
Makmak	Untapped	1.745*	0.298	0.000	1.017	2.474

SE = standard error of the difference; CI = confidence interval of the difference.

seen from this figure there are different gum yield trend patterns as a result of combined tapping treatments effect.

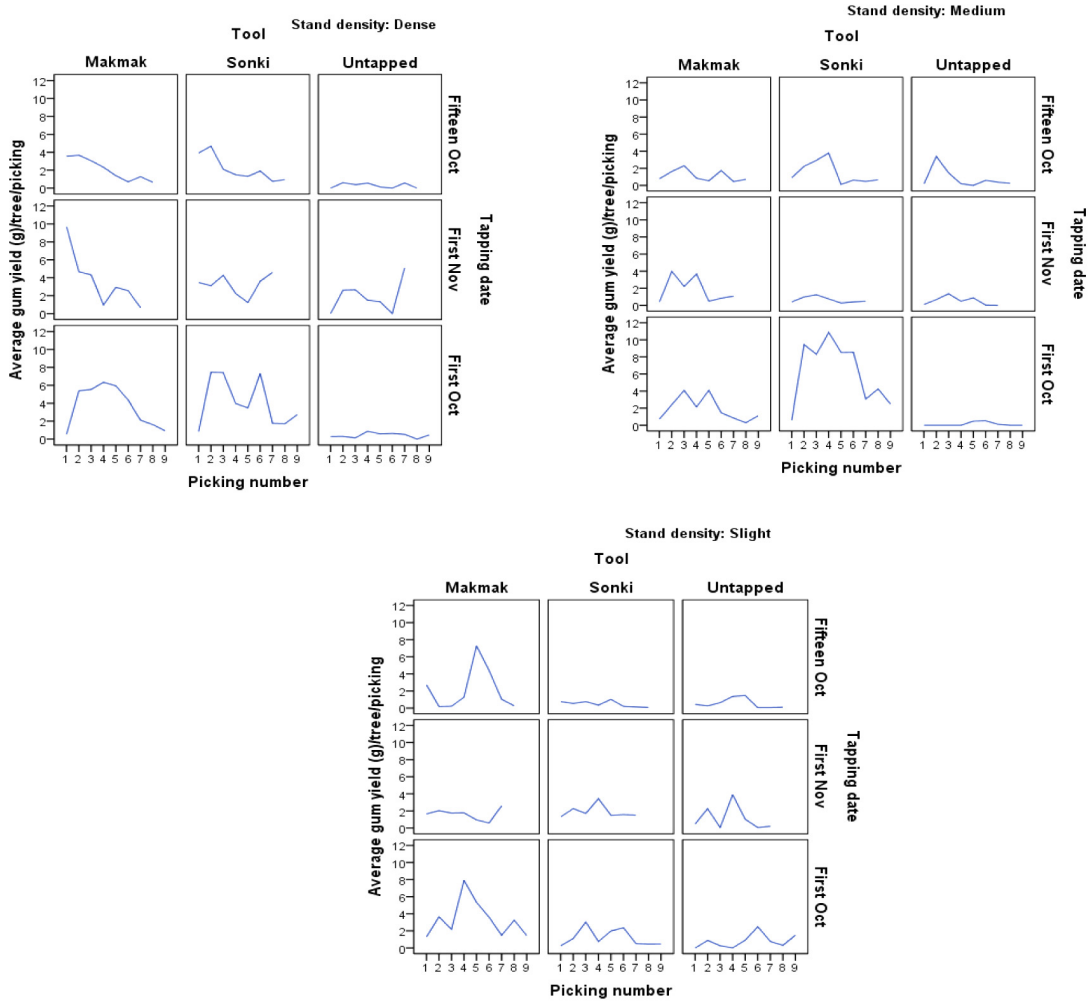
DISCUSSION

Gum talha yield variability limiting factors

The results GLM/UNIVARIATE provide useful information to identify the significant effect of tapping treatments on yield of gum *talha* throughout the season and to explore the nature of the relationship between yield and each tapping treatment. In this study, significant variations occurred among yields of gum *talha* as a result of tapping treatment. These results emphasizing the importance of management strategies and their effect on gum *talha* production.

Pick-to-pick variability in gum talha yields

Patterns of gum *talha* yield variability (pick-to-pick variability) can be classified into four types. First, increasing patterns, in which gum yields tend to increase steadily. The present results clearly demonstrated no increasing pattern of gum yield due to the effect of tapping treatments. Second, decreasing patterns, where an obvious decreasing pattern could be observed such as



Effect of tapping tool and date of tapping on pick to pick yield of gum *talha* (top left: dense stand density; top right: medium stand density; bottom: slight stand density).

Fig. 2. Combined effect of tapping treatments on gum *talha* yield.

yield in dense stand density when trees were tapped on first of November by *sonki* or on fifteenth of October by *sonki* and *makmak* (see Fig. 2, for the dense stand density). Third, the constant patterns, in which yields show a constant pattern from the first picking to the last one as in most gum tapping treatments of the medium and slight stand densities (see the same figure for medium and slight densities). Fourth, no consistent patterns, in which yields tend to increase or decrease differently from one pick to the next. Such pattern can be observed in the three stand densities of the same figure.

CONCLUSION

The results of the present study demonstrate how trees of *Acacia seyal* react to different management strategies. The results showed that tapping has a significant influence on average gum *talha* yield. However, results of yield analysis detected that tapping treatments have no influence on pick-to-pick yield. Nevertheless, the results recognized three basic patterns of gum *talha* yield. These are decreasing, constant and no consistent patterns. It is worth mentioning that data for this study were collected from a single season and that may underscore the real effect of *Acacia seyal* stands´ management strategies on gum *talha* yield. Therefore, conducting gum yield experiments in permanent trial plots is highly recommended in order to analyze gum yield of seasonal time series. The findings of this study could serve in promoting the production of gum *talha* and other gum producing tree species in Sudan.

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