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EFFECT OF TAPPING INTENSITY AND TREE DIAMETER ON GUM ARABIC YIELD OF *ACACIA SENEGAL* (L) WILD IN SOUTHERN ETHIOPIA

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ABSTRACT

Gum arabic, a natural product used in numerous industries, is obtained from species of *Acacia senegal*. Ethiopia is one of the producer countries with large potential for future sustainable production. Until now gum arabic production from Ethiopia comes mainly from collection on naturally oozing tears of Acacia species. Tapping to improve production quality and quantity is not common practice in Ethiopia. This study investigated the effect of tapping of *A. Senegal* trees on gum arabic yield. A factorial experiment arranged in randomized complete block design (RCBD) in which four levels of tapping intensity and three levels of tree size (diameter classes) was used. Gum yield increased with tapping intensity but decreased with increasing tree size (diameter). Gum yield also decreased from first to second picking rounds. The results show that gum yield can be increased significantly by tapping, which can be used to boost income of the producing rural community.

KEYWORDS: Borana, woodland, gum Arabic, tapping.

INTRODUCTION

Gum arabic is a dried exudate obtained from the stem and branches of *Acacia senegal* trees (FAO, 1999). Gum arabic is a natural product with wide industrial uses; hence it is a product traded on international market. Several African countries and local farmers in the resource area are benefiting from its production and trade. Gum arabic is produced through natural oozing or stem wounding, a practice called tapping. Ethiopia is one of the producer countries in Africa with huge potential for future sustainable production. Most of the current gum arabic production in Ethiopia is through collection from natural exudates (Mulugeta Lemenih, 2005). Collection is mostly carried out by cattle herders, women and children from tree trunks and branches. Collections are not restricted to gums on trunks and branches but also fallen pieces are picked from the ground, a practice that deteriorates the quality of the gum supplied to market (Mulugeta Lemenih 2005).

Tapping for the production of gum arabic involves removing sections of the bark with a sharp material (e.g. axe) (Girmay Fitiwi and Mulugeta Lemenih, 2010). Tapping is practiced to enhance yield quantity and quality. For instance, tapping activities increased gum arabic yield by 77.42% as compared with untapped trees in Kenya (Wekesa et al., 2009). However, in the production system in Ethiopia, there has been no experience of tapping acacia trees, which is mainly due to lack of knowledge about the impact of tapping on yield and quality. The aim of this study was to investigate the effect of tapping intensity and tree diameter class on gum arabic yield thereby to develop optimum tapping intensity based on stem diameter for *A. senegal*.

MATERIALS AND METHODS

The study site

The study was conducted in Yabello district of the Borana lowlands in southern Ethiopia. The district co-vers an area of 5550 km^2 with the altitude range of 1350 - 1800 m.a.s.l (Coppock, 1994) (Figure 1). The area is characterized by a bimodal rainfall pattern. The main rainy season with 60% of the annual precipitation is between March and May followed by a cool dry season between June and August. The short rainy season with 40% annual precipitation occurs from September to November, and this also followed by the long dry season that extends from December to February.

The mean monthly and annual rainfalls are 48 mm and 587.2 mm respectively. The mean monthly minimum and maximum temperatures of the district are 15.6 and 18.8^{0}C**,** respectively, with a mean annual temperature of 18.3^{0}C (Coppock, 1994).

The dominant vegetation types are *Acacia*, *Boswellia* and *Commiphora* (ABC) Genera and bush savanna, mixed with perennial grasses such as *Chrysopogon aucheri, Cinchrus ciliaris, Themeda triandra* and *Sporobolus phyramidalis* (Ayana Angasa, 2007). The main soil types of the region are red sandy-loam soil, comprise 53% s and 30% clay and volcanic light colored silty clay and 17% silt and Vertisols (Coppock, 1994).

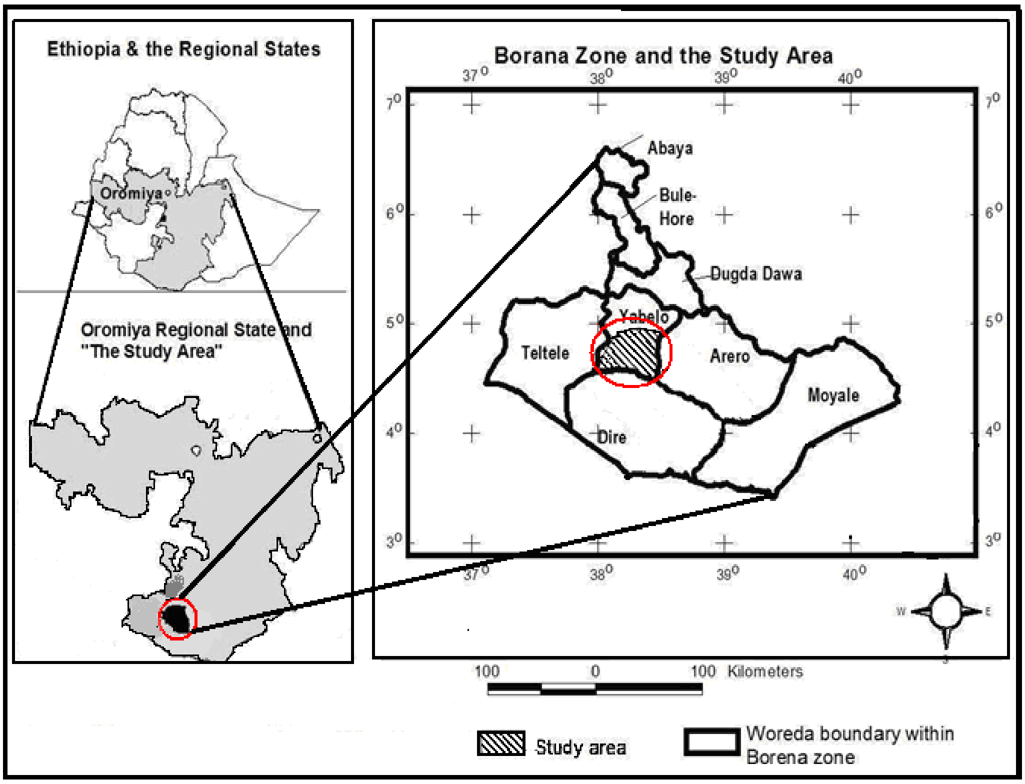


Figure 1 Location of Yabello, the study area.

Data Collection and Design

The study involved a factorial experiment where four levels of tapping intensity and three levels of tree size (diameter class), in total 12 treatment combinations, were combined and arranged in a randomized complete block design (RCBD). Three blocks (replications) were used. The four tapping intensities tested were: untapped (control), four spot tapping, six spot tapping and eight spot tapping. For the tree size treatment, size classes of 3.0 – 6.0 cm, 6.1-9.0 cm, 9.1 – 12.0 cm diameter classes were used. Trees in these diameter classes were referred to as small, intermediate and large trees, respectively. Three blocks of size 100 x 100 m composed of natural population of *A. senegal* trees were selected along a slope gradient to form the blocks. The blocks were separated by 100 m. Within each block, all *A. senegal* trees were counted and measured for DBH using caliper. They were classified according to the above diameter classes. From each block, 36 sample trees were selected randomly according to 12 treatment combinations; each treatment combination was applied on three *A. senegal* trees. A total of 108 (36*3) sample trees were used in the study. The trees were marked properly with a label that represents the treatment combination name and replication number.

Tapping was made by a traditional axe by wounding the bark of the sample trees at the DBH (1.3 m) on the east and west facing sides of the trunk. Equal number of spots having a length of 10 cm and width of 3 cm each were applied in eastern and western side of the trees (Howes, 2001; Wekesa *et al.*, 2009). Each consecutive spots were separated by 10 cm. Gums were collected in two picking rounds: the first picking was 30 days after tapping and the second picking was 20 days after the first picking. The collected gum was dried at room temperature for one week (Mohammed and Rohle, 2009) and weighed.

DATA ANALYSIS

The data on gum yield was analyzed in a two-way ANOVA using statistical analysis system (SAS-Version 9). Mean separation for significantly different means was conducted by using Duncan's multiple range test (DMRT). The relationship between gum arabic yield, tapping intensity and tree diameter class was computed using Pearson's correlation coefficient and linear regression. Two sample paired t-test was carried out to compare the first and second picking rounds.

RESULTS AND DISCUSSION

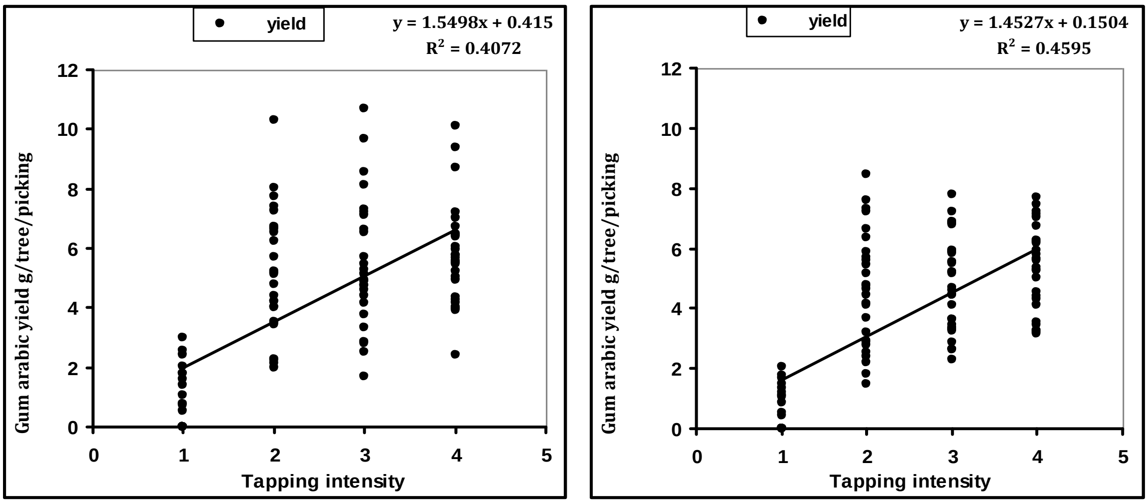
Gum arabic yield differed significantly ($P < 0.05$) between the different tapping intensities during the two picking rounds (Table 1). Tapped trees generally provided significantly higher yield than untapped or control trees. The gain in yield by tapping ranged from 628-704% during the first round picking and 848-958% during the second round picking over the untapped trees. This finding conforms to similar studies in the Sudan where tapping yielded far more yield than untapped trees (Ballal *et al.*, 2005b).

There was a significant positive correlation ($r = 0.64$, $p = 0.0001$) and ($r = 0.68$, $p = 0.0001$) between tapping intensity and gum arabic yield in the first and second picking rounds, respectively (Figure 2). Hence, by increasing tapping spots per tree yield increases and this is in fact similar with results reported from other studies on *Boswellia papyrifera* for frankincense (Asmamaw Alemu and Abeje Eshete, 2007) and on *A. sengal* from Sudan (Ballal, *et al*. 2005a). However, other studies (e.g. Fadl and Gebauer, 2004) also reported irregular gum, yield increment due to tapping intensity from *A. seyal* tree.

On the contrary, tree size was negatively related to gum yield. During the two picking rounds the highest yield was obtained from trees in the smallest diameter class (3.0-6.0 cm) than the other classes (figure 3). This result was also consistent with the works of Wekesa *et al.*,

(2009) and that of Abdalla, (2005). This is believed to be related to root architecture and physiological activities of the trees that directly reflected in the stress level of the trees. In smaller trees have fewer fine root numbers that intersects in the surface soil layer and also lower root density with increasing soil depth, hence reduced ability to tap water from large volume and depth of soil. This makes small sized trees to experience high water stress during dry seasons resulting them to produce more gums when tapped (Wekesa *et al*., 2009).

In terms of picking cycles, significant difference (t = 2.59, P = 0.01) was observed in gum arabic yield between first and second picking rounds (Figure 4). The first round yield was greater than the second round yield across all intensity and diameter class by the fac-



(a) (b)

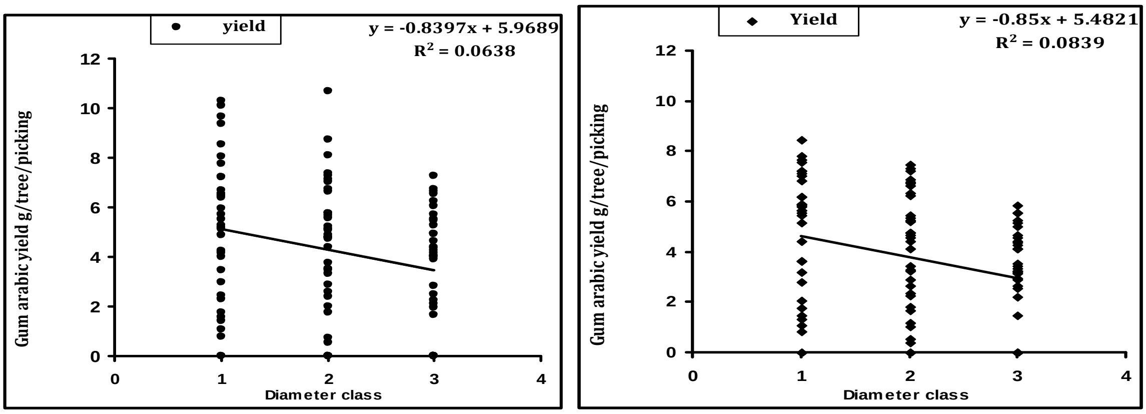
Figure 2: Correlation between yield of gum arabic and tapping intensity in the first picking (a) and second picking round (b) (1 = control, 2= 4 tapping spot per tree, 3 = 6 tapping spot per tree 4 = 8 tapping spot per tree.

Table 1. Gum arabic yield (g) between tapping intensity and tree diameter class in the first picking round (Mean ± SE).

Tapping intensity	Tree diameter class		
	D1	D2	D3
T1	1.33±0.015^{aA}	0.85±0.006^{bA}	0.00±0.00^{cA}
T2	5.96±0.020^{aB}	5.31±0.018^{bB}	4.27±0.028^{cB}
T3	6.32±0.026^{aC}	5.58±0.028^{bC}	4.51±0.105^{cC}
T4	6.68±0.014^{aD}	5.85±0.062^{bD}	4.84±0.031^{cD}

Means within a row that have a different small letter are significantly different from each other and means within a column that have a different capital letter are significantly different from each other ($p < 0.05$).

Plate 1. Tapped tree and the size of gum arabic tears that oozed from tapped spots (Photo: Semegnew T.)



(a) (b)

Figure 3. Linear regression between yield of gum arabic and tree diameter class in the first picking (a) and second picking (b), where 1 = (3.0-6.0 cm), 2 = (6.1-9.0 cm) and 3 = (9.1-12 cm).

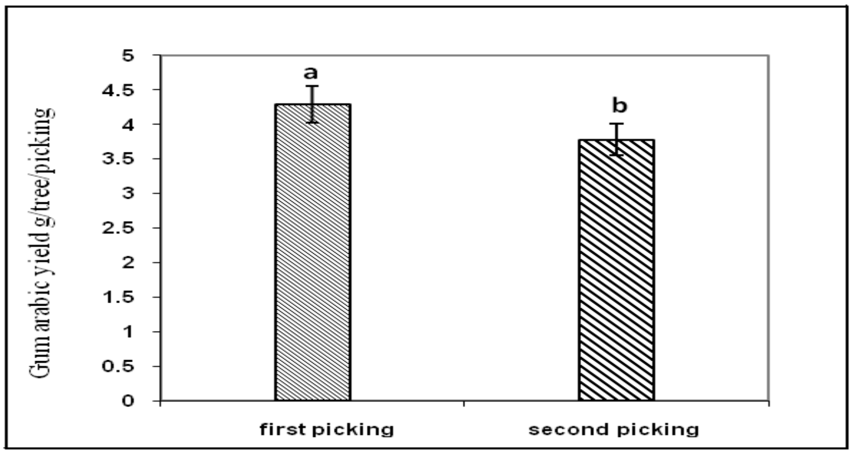


Figure 4. Mean (±SE) of gum arabic yield (g) in the first and second picking round, different letter above the bars indicate significant difference between first and second picking round (t-test, *P < 0.05*).

Tor of about 12%. While mean yield across all tapping intensity and diameter class was 4.29 g per tree for the second round picking this was 3.77 g. Similarly, Wekesa *et al.*, (2009) reported gum arabic yield to decrease from first to second picking round. Moreover, Ballal *et al.*, (2005a) and Abdalla, (2005) stated that the first and second picking have an important factor in gum arabic production and could be used as an indicator for the prediction of total gum arabic yield. On the other hand Ballal *et al.*, (2005b) pointed out that gum arabic production increase from first pick, reached its peak in the second pick, decreased slightly in the third pick and then fell subsequently up to eight pick. This reduction of gum arabic yield from first to second picking rounds might be due to sealing of some part of the wounding spots after the first picking time which makes exudation going on only in small holes of the wounding spots.

Table 2. The overall gum arabic yield (g)/tree/two-picking rounds.

Tapping intensity	Diameter classes (cm)		
	3.0-6.0 cm (D1)		
	1st picking	**2nd picking**	**Total yield**
T1	1.33	0.96	2.29
T2	5.96	5.46	11.42
T3	6.32	5.7	12.02
T4	6.68	6.35	13.03
	6.1-9.0 cm (D2)		
T1	0.85	0.53	1.38
T2	5.31	4.6	9.91
T3	5.58	4.59	10.17
T4	5.85	5.50	11.35
	9.1-12 cm (D3)		
T1	0	0	0
T2	4.27	3.73	8
T3	4.51	3.92	8.43
T4	4.84	4.02	8.86

In terms of overall productivity per tree and year, various studies reported wide variations in yield per tree. For instance, Badi *et al*. (1989) reported the yield of 0.5–0.6 kg/tree/year; FAO (1995) 250 g/tree/season; Ballal *et al*. (2005b) 10.8 g/tree/season; Chemulanga *et al*. (2009) 0.66-0.81 g/tree/season; Wekesa *et al.*, (2009) 5.15 g/tree/season. The mean yield reported from this study for the two picking rounds, which is 10.35g/tree/season (by excluding the control treatment) is more or less similar to yield reported by Ballal *et al.*, (2005b) and higher than that of Wekesa *et al.*, (2009) and Chemulanga *et al*., (2009) but lower than reported by Badi *et al*., (1989) and FAO (1995) (Table 2). This difference in yield of gum arabic might be due to seasonal and site variations. During the experimentation time there was low temperature, which may create difficulty in producing higher amount of gum arabic yield.

For example, with regard to temperature IIED and IES, (1989) reported that a high temperature at tapping time is conducive to high gum production while a low temperature seems to seal off the gum exudation points, resulting in low yield. Similarly, increase in yield associated with increase in the mean maximum daily temperature of the area and increased stress on the tree (Abeje Eshet, 2002; Kindeya G/Hiwot, 2003).

CONCLUSIONS AND RECOMMENDATION

The results of this study revealed that yield of gum arabic increases with increasing tapping intensity. Higher gum arabic yield was observed in tapping practice than untapped (natural collection). However the reverse is true for diameter classes. The higher gum arabic yield was resulted in small diameter (3- 6 cm) than middle (6.1-9.0 cm) and large diameter class (9.1-12 cm). Within untapped treatment combination there was no yield at all in large diameter class in the first and second picking rounds. Several researches have confirmed that small diameter class trees produce more gum arabic than larger diameter trees. Therefore, for sustainable use of the species, commercial gum arabic tapping should be conducted at early stage and when *A.senegal* trees have more than 9 cm dbh, it can be used for other values, like fodder, firewood, charcoal etc. With regarding to number of picking rounds, the first gum picking round appears to be an important factor in gum arabic production and could be used as an indicator for the prediction of the total gum yield for *A.senegal.* Because first picking yielded more gum than the second picking round. Finally, based on this study, tapping intensity at 8 spots per tree could be used as optimum tapping practice for all tree diameter classes (3-6 cm 6.1-9 and 9.1-12 cm) for sustainable production of gum arabic. The following recommendations are also forwarded:

- This study was conducted from July to mid of September during the short dry season in the area. We expect that gum arabic yield would be much greater than reported had the experiment was done during the long dry season (December-March) which is the main gum Arabic production period in the area. We therefore suggest further research is needed during this long dry season;
- The impact of tapping intensity on the tree health, physiology and reproduction should be investigated to balance yield with tree vitality; hence to insure sustainability, and
- To make advantage of the yield increment from tapping, training of the producers is essential as this practice is not known in the area yet.

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