Assessment of gum yield of *Sterculia setigera* Del. in relation to diameter and trees condition

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Abstract

Sterculia setigera Del. is well-known in Sub-Saharan Africa as a multipurpose tree species, especially due to the economic value of its gum. The present study carried out in the Kantindi experimental station was a contribution to the valorization of *S. setigera* in Togo. It sought to appraise the gum yield capacity of *S. setigera* according to stem girth and target trees' condition. Trees tapping were carried out on forty non-burnt trees and twelve burnt trees with a girth equal or greater than 90 cm. Trees were tapped from 1 to 5 April 2014 and gum harvest occurred three weeks later, on 30th April 2014. The mean value of gum exudate from trees early burnt is higher than those obtained from non-burnt trees, respectively 103.2 ± 68.5 g and 64.4 ± 35.3 g. Gum yield increased with diameter increase. Even thought the mean gum yield seems greater on burnt trees than non-burnt trees; the statistical tests showed no significant difference (p = 0.095). In contrast, there is a significant difference according to tree diameter (p = 0.047). Further studies will evaluate both quantitatively and qualitatively methods of gum tapping, nursery plants production, and regeneration techniques.

Keywords: *Sterculia setigera*, gum, yield, tree diameter, ecosystem services, Togo

Évaluation de la productivité en gomme de *Sterculia setigera* Del. en fonction du diamètre et de l'état de l'arbre

Résumé

Sterculia setigera Del. est bien connue en Afrique subsaharienne comme espèce à multiples usages et en particulier pour l'importance économique de sa gomme. La présente étude, réalisée dans la station expérimentale de Kantindi, est une contribution à la valorisation de *S. setigera* au Togo. Elle a évalué la capacité de production de gomme de *S. setigera* en fonction du diamètre et de l'état du pied. La saignée des arbres a été réalisée du 1er au 5 avril 2014 sur 40 pieds seins non brûlés et 12 pieds brûlés de circonférence g≥90 cm. La récolte de la gomme est intervenue trois semaines plus tard, le 30 avril. La valeur moyenne de gomme exsudée sur les pieds précédemment brûlés est supérieure à celle des arbres sains, respectivement 103,2 ± 68,5 g et 64,4 ± 35,3 g. La quantité de gomme exsudée augmente suivant la circonférence. Même si la productivité moyenne en gomme est plus grande sur les pieds brûles que les pieds non brûles, les tests statistiques montrent qu'il n'existe pas de différence significative (p = 0,095). Par contre, une différence significative s'observe en fonction de la circonférence du pied (p = 0,047). Des études complémentaires examineront les méthodes quantitative et qualitative de production de gomme, les techniques de production des pépinières et de régénération.

Mots-clés: *Sterculia setigera*, gomme, production, circonférence, Togo

INTRODUCTION

It is known that poverty is one of the important causes of plant resources degradation. However, the preservation of the natural capital is one of the components of the long-lasting development, with the economic growth, social fairness, territories' steadiness and life quality (Louina, 2006). Consequently, forest genetic resources management is a priority. This challenge could be achieved by providing to indigenous, often poorest population, a sustainable income through the promotion of non-timber forest products (NTFPs). There is a wide range of NWFPs with a great economic importance such as gum provided by several tree species. One of these gum species found in West Africa is *Sterculia setigera* Del.

S. setigera is a multipurpose and valuable savannah tree belonging in the Sterculiaceae family (Cronquist, 1968) or in the Malvaceae family (APG III, 2009), growing under wide ranges of soils and ecological ecosystems. However, it enfolds gravelly soils and rocky hills (Sacandé et Sanon, 2007). It is mainly known in sub-Saharan Africa for its medicinal uses and gum economic value (Henric, 2001; Tor-Anyiin et *al.*, 2011; Atakpama et *al.*, 2012; Hamidu, 2012; Atakpama et *al.*, 2015; Ndiaye et *al.*, 2012). It is also used for cosmetic, fodder and cultural purposes (Idu *et al.*, 2008; Mbow et *al.*, 2013a; Mbow et *al.*, 2013b). *S. setigera* is recognized as a high economic value species and it gum is exploited since several decades in Senegal (Henric, 2001).

Sterculia gum commonly known as "gum karaya" (Jonhson et *al.*, 2005) is an important raw material used in cosmetic, pharmaceutical and food-processing industries due to its phytochemical and physical properties (Elkhalifa et Hassan, 2010). The production of *Sterculia* gum is localized mainly in India (*S. urens*) and Senegal (*S. setigera*) and remains consequently, a meaningful asset for exports (Gomis, 2004). Senegal is the major producer of "gum karaya" in Africa and the second world's largest producer (1500 tons per year) after India (3500 tons per year) (Jonhson et *al.*, 2005; Niang et *al.*, 2010). Considering incomes generated by the yield of gum, a reasonable exploitation of *S. setigera* gum can occupy populations, particularly peasants during the free time (Sène et Ndione, 2004), generate supplement income, and create employments.

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Besides its tremendous economic importance, *S. setigera* undergo an important anthropogenic pressure due to the overexploitation of gum and other organs harvesting, yearly bushfire, grazing, and agriculture practices that induce mortality and reduce the regeneration capacity (Niang *et al.*, 2010; Atakpama *et al.*, 2014a). Moreover, *S. setigera* natural regeneration is low by comparison to other woody species (Ouédraogo et Thiombiano, 2012).

Although *S. setigera* is widespread in Togo, specially abundant in northern region, its gum economic value is ignored by indigenous people (Atakpama *et al.*, 2015). Hence, apart from its organs harvesting for medicinal, dietary, and cosmetic uses (Atakpama *et al.*, 2012; Atakpama *et al.*, 2015), the species is marginalized, less conserved in farmlands as agroforestry tree and its natural stands threatened by fire and grazing.

The present research is to study the gum yield capacity of *S. setigera* according to trees girth and condition in Kantindi experimental station (Tône prefecture, savannahs region) in Togo. Findings would be a way for sustained farmers' livelihoods, especially women income and employment generation in rural areas. Increasing local population income will help for a sustainable use and conservation of plant resources.

METHODOLOGY

Study area

Kantindi is a village situated 0°29'E longitude and 10°30'N latitude. It belongs to Tône district located west of Dapaong, the administrative centre of Savannahs region (extreme north of Togo) (Figure 1). The experimental station is a rocky hill and plateau with sandstone rocks. It is located in eco-floristic zone I, corresponding to Sudanian Endemism Centre (Ern, 1979 ; White, 1986). The climate is Sudanese type with one rainy season from April to October and one dry season from November to March. The rainfall varies between 1000 to 1300 mm/year and the mean annual temperature ranges from 20 and 35°C (Moussa, 2008). The vegetation is constituted by agroforestry parklands dominated by *Parkia biglobosa* (Jacq.) R. Br. ex Benth. and woody savannahs of *Balanites aegyptiaca* and *Sterculia setigera* trees (Atakpama *et al.*, 2014b; Padakale *et al.*, 2015). The main activity of the population is agriculture. At the country scale, the region is known as the most involved in animal husbandry (Atakpama *et al.*, 2016).

Data collection

Among several stands identified during previous studies, the choice of Kantindi station was directed by the availability of the studied species (Atakpama *et al.*, 2014a) and the agreement of the resident persons to fulfil the experimentation. Forty (40) sample trees with good health and normal shape, and a minimum girth of 90 cm at breast height (1.30 m) were considered suitable for gum tapping (Bhattacharya et *al.*, 2003). Added to these trees, 12 others individuals located in farmland, early seriously affected by fire by peasants (in order to dry stems and let space for their crops growth) were tapped at breast height. Each hole was square (10 cm x 10 cm). Holes' depth were based on the thickness of the bark. For each tapping position, holes were spaced at least by 30 cm. Thus, the number of holes varied according to the girth of trees (Table 1). The tapping tool was managed by a welder following a model conceived previously taking into account hole dimensions (Figure 2). Trees were tapped from 1 to 5 April 2014, and the harvest occurred three weeks later, 30th April (Figure 3). Furthermore, dendrometric parameters (girth and height) of target trees and slope were recorded.

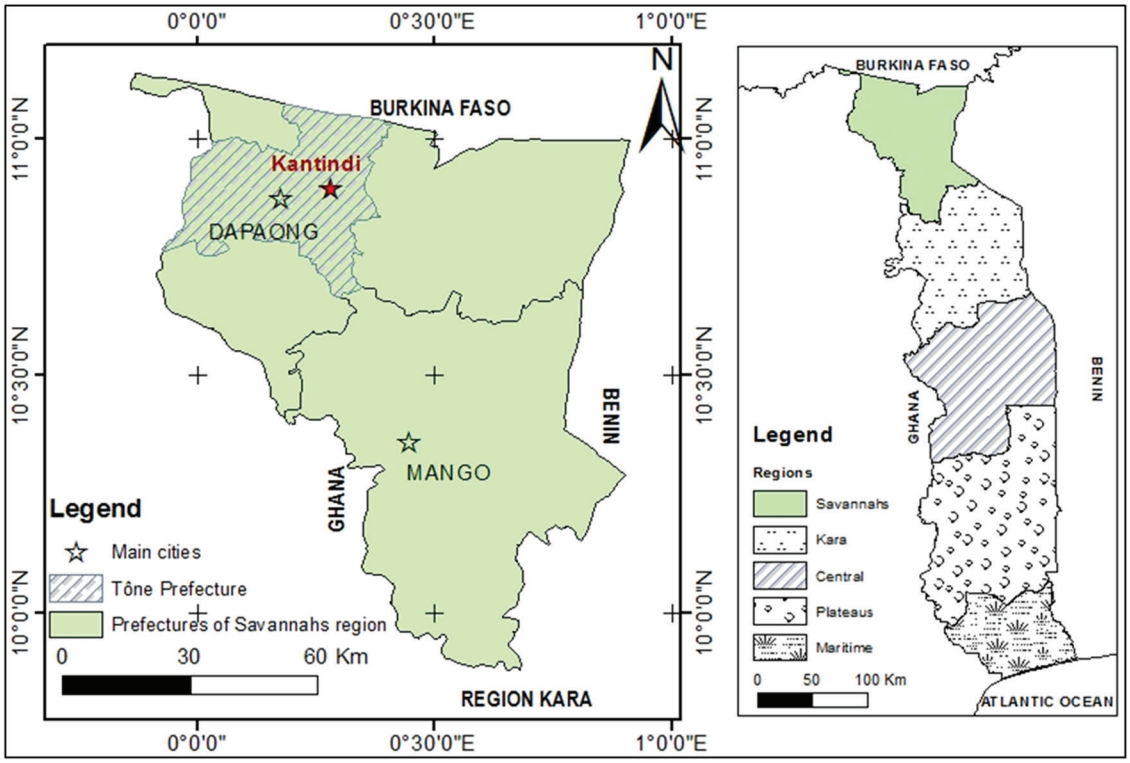

Figure 1: Location of experimental site

Table 1: Number of blazes depending to trees girth

Girth (in cm)	Number of blazes
90-120	2 equally spaced
120-150	3 equally spaced
150-180	4 equally spaced
≥ 180	1 blaze at every 30 cm

***Figure 3: Gum sample harvested** (W. Atakpama, June 2010)*

Data analysis

Data collected were processed using Microsoft Excel spreadsheet and Minitab 16 software. The gum pellets harvested were sun dried and then weighted by a digital electronic balance. The interrelationship between diameter and gum yield were achieved by weighting the mass of gum (in g) by trees girth (in cm). To compare the variation of gum exudation by girth, three (3) girth classes were established (girth [90-120[cm, [120-180[cm, and ≥ 180 cm). Moreover, the effect of fire on yield of gum was determined by comparing mean mass of gum exudate according to the condition of stem. Burned trees' gum exudate was compared to the mean yield gum of 12 non-burned trees corresponding to the two less and the two greater gum exudate trees of each class defined above. The difference between variables was performed using ANOVA One-way analysis according to Fisher test method.

RESULTS

Twenty-three (23) from forty (40) targets trees had exudate gum. The rate of non-reactive individuals corresponds to 38.2%. The yield of gum varies from one stem to another and tends to increase from smaller to larger girth. As the girth increases, the gum exudation tends to increased linearly (Figure 4). Group mean values of gum harvested according to the three (3) girth classes using Fisher method showed no significant difference ($p = 0.047$). Pairwise comparison among girth classes (confidence level = 98.0 %) had a significant difference between the smaller, and larger classes with confidence interval from 0.44 to 67.0 while there is no significant difference between the first and the second girth classes (confidence interval extends from -42.1 to 26.8) (Table 2). The mean value is higher for larger girth class and lower for the smallest girth class (Table 2, Figure 5).

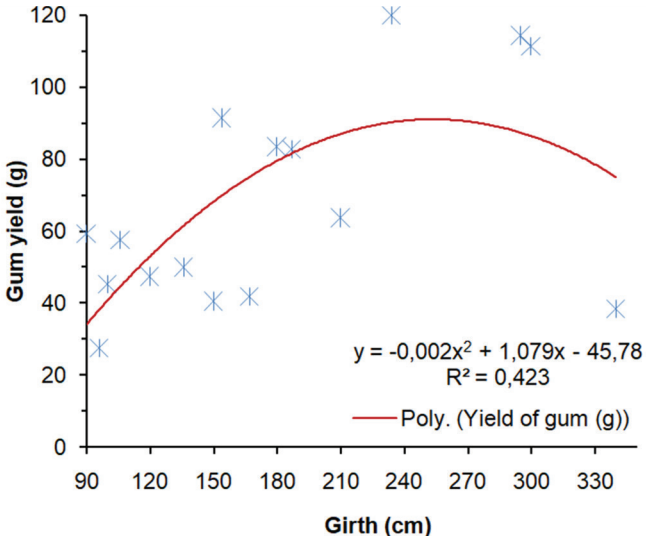

Figure 4: Yield of gum exudate according to the increase in girth

Comparing weighted yield of gum in relation to the condition of trees (burnt and non-burnt) showed that fire increased the gum exudation. Mean value of gum exudate from the trees early burnt is higher than those obtained from non-burnt trees, respectively 103.2 ± 68.5 g and 64.4 ± 35.3 g. The statistic test showed no significant difference between these two values ($p = 0.095$).

***Figure 2: (a) Setigera trees tapping and (b) hole sample** (W. Atakpama (April 2014)*

Table 2: Gum yield (g/stem), standard deviation (StDev) and grouping per girth class

Girth classes	Number of Stems	Mean (g/stem) ± St Dev	Fisher test grouping
[90-120[	8	50.9 ± 23.8	B
[120-180[	7	58.5 ± 25.6	AB
≥ 180	8	84.6 ± 29.1	A

DISCUSSION

Production of gum exudate tends to increase with the increase in girth. A similar observation was described between the girth and the gum yield for the same species in Senegal (Toure et *al.*, 2014) and other exudate trees such as *Sterculia urens* Roxb. and *Boswellia serrata* Triana & Planch. by Mishra (2012) and latex yield for *Hevea brasiliensis* Müll.Arg. by Karunaratne *et al.* (2005). This may be due to the development of gum holes with the increase in girth size of the plant. The development of gum holes from the traumatic parenchyma of *S. urens* by ethephon were pointed out to increase gum exudation (Menon et Babu, 1989). Added to girth, Sène (1994) reported that the gum exudate is lower on cut stems and those with white bark.

The mean yield of gum (64.4 g) was lower than the one reported by Jonhson et *al.,* (2005) in Senegal (750 g to 2 kg/tree). Several causes justified the low value of gum exudate assessed during the present study. The weak productivity could be attributed to limited harvests, only one harvesting had been done while it could be up to 8 by season (Bhattacharya et *al.*, 2003). This is shown by the value reported by Toure et *al.,* (2014) in the same areas, the mean yield of gum varied from 38.7 g to 88.8 g per tree for one harvest according to the season and the site of experimentation. It also depends on the number of holes. For a gum production of 750 g to 2 kg per tree reported for "Parc Arachidier" in Senegal, the number of holes varies between 15 to 30 (Sène, 1994) while during the present study the number of holes was less than 10.

Added to tree diameter, studies of Toure et *al.,* (2014) on gum yield from *S. setigera* showed that the gum yield depends also on the hole depth. The gum exudation is a form of protection by trees against water stress. So, overexploitation of trees in order to maximize the gum yield by increasing hole numbers and their depth (deeply blaze until the xylem) or using stress such as fire are prejudicial for trees survival (Jonhson et *al.*, 2005; Toure *et al.*, 2014), since it diverts nutritive sap and induce plant tissue necrosis.

CONCLUSION

The present study showed that the gum yield of *S. setigera* increased with the increase in girth. The fire induced more yield, but it threatens plant survival. Although the mean yield of gum was greatest in burned trees, the difference was not significant. For a better promotion of *Sterculia* gum in Togo, practical training on methods of gum tapping used in the two world's largest producing countries, India and Senegal, are vital. The knowledge of *S. setigera* trees economic value by the local communities would contribute greatly to its adoption as agroforestry tree. Further studies will explore both quantitatively and qualitatively methods of tapping gum. Furthermore, the effect of site physical local conditions and season on gum yield will be scrutinized. Nursery and regeneration techniques should also be investigated. The outcome of these studies will be helpful for the achievement of the millennium objectives such as the reduction of poverty and lasting environmental management.

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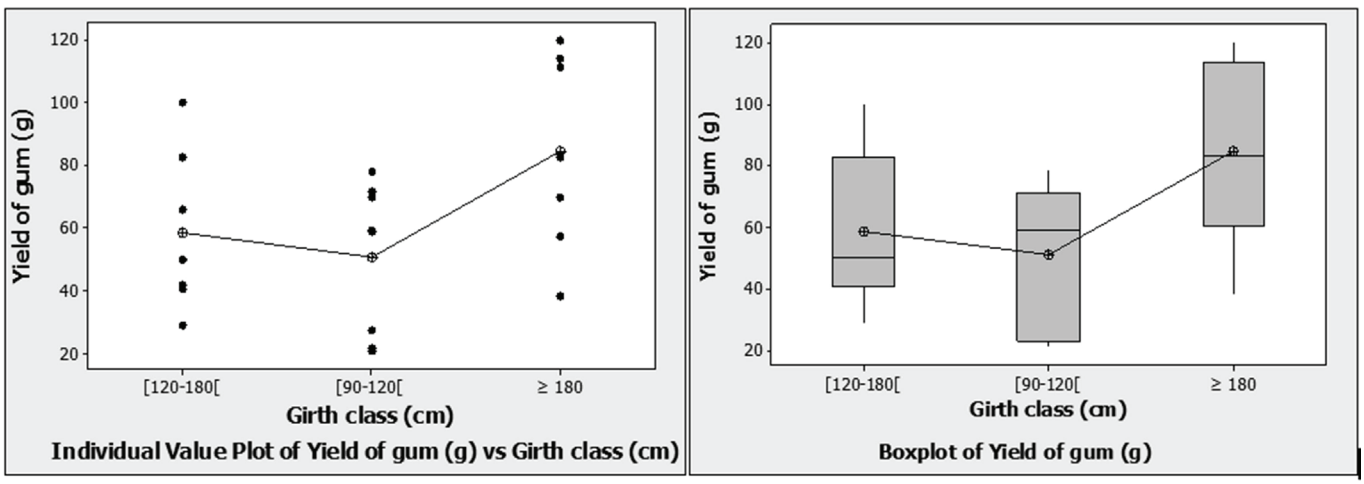

Figure 5: Comparison of gum exudate according to girth classes

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