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Natural root suckering of *Sclerocarya birrea* (A. Rich.) Hochst. in Togo

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Abstract: Knowing how well fruit species root sucker naturally, can be used to start development programs, based on methods to multiply vegetatively, which do not cost much, especially in zones of adverse pedoclimatic and socioeconomic conditions. This study was carried out on the densities of natural root suckers of *S. birrea* in three areas (reserved forests, mature and new fallows), as well as on particular characteristics of these root suckers. This up to date study shows that the amount of root suckers in the mature fallows (34.28 ± 22.28 root suckers / ha) is significantly superior (p = 0.005) to those of the new fallows (12.36 ± 7.98 root suckers / ha). 41.1% of mature *S. birrea* produces some, and more than 70 % of the mature ones, which root sucker, have 1 to 3 suckers. Half of the root suckers are carried by roots with a diameter between 2 and 4 cm. Under the crown of the mother plants, we can count 41 % of the root suckers, whereas the rest grow in the full light. Less than 17 % escaped by creating adventitious roots. These root suckers ability could be used for woodland management.

Key words: wild fruit trees, root suckering, land use, domestication.

Introduction

The role of biodiversity in naturally occurring fruit trees, especially in periods of scarcity, has been known for a long time to improve the conditions of life for rural African populations which are living in unfavourable conditions. To improve the production of wild fruit trees in rural African zones, studies of vegetative propagation have already been done (Harivel *et al.*, 2006; Belem *et al.*, 2008; Meunier *et al.*, 2008;

Ky-Dembélé *et al*., 2010; Morin *et al*., 2010; Noubissié-Tchiagam *et al*., 2011; Washa *et al*., 2012). Amongst these naturally occurring fruit species in zones strongly anthropized, those that have the best potential of regeneration are those that, as well as a sexual reproduction (rare, the most often happens after a dry season), show a natural tendency to multiply vegetatively (Ouédraogo *et al*., 2006; Vieira *et al*., 2006; Vaughan *et al*., 2007).

In Togo, studies of root suckering have, up until now, only been done on *Isoberlinia spp* (Dourma *et al*., 2006). It would be helpful to look into the value of naturally occurring fruit trees, such as *Sclerocarya birrea* (Anacardiaceae), which are classed amongst the "food plants threatened with extinction" in Togo (Akpavi *et al*., 2012). Because of it multiples purposes *S. Birrea* is one of the important agroforestry species in northern Togo and very often came across in fields and fallows (Folega *et al*., 2013). Our study on some of the characteristics of natural root suckering of *S. birrea*, a dioecious species, has the objective of evaluating the ability to root sucker in a natural environment. This would allow, in the near future, starting trials of artificial induction of root suckers and root cuttings to be able to transplant the most productive clones in a rural environment for the benefit of local populations (Akpavi *et al.,* 2012).

Methodology

Area of Study

The study is taking place in the north of Togo in the Sudanian area. The area of study is characterised by a rainfall (from June to September) of 800 to 1100 mm per year. The annual temperature has an average of 28°C. The landscape is made of plains and plateaux, overhung by cuestas and hills. The soil is tropical ferruginous. Agriculture (arable and livestock) is the main economic activity of the region. The cover crops of these savannas, due to farming business, are overexploited for the production of biomass energy (wood) and of non-timber forest products. These activities are carried out at the expense of conserving plant resources (Agbogan *et al*., 2012).

Gathering of data

Natural plant root suckering has been studied in 35 plots of 50 x 100m (in total 17.5 ha), which were installed in June 2011 in three types of plant formations in the North of Togo: 14 for the reserved forests, 11 for the mature fallows and 10 for the new fallows. The reserved forests explored are mature woodland formations subtracted to agriculture. It is the Reserve of the Lutheran church of Lokpano, the sacred woods of Tami and the woodland of Kpapolga at the border of the reserve Oti-Mandouri. It's worth noting that "natural root suckering" involves several natural phenomena (physiological stresses, occasional wounds by rodents or insects, stamping damage by cattle, agriculture, etc.). It is different to inducing root suckering (artificial) which is done for the purpose of studies, by cutting the root; this won't be studied here. The distinction between "new" or "mature" fallows has been established by the observation of remains of agricultural activities, whether they have been recent, or not, by the density of *S. birrea* on the woodland, and by information collected from villagers.

When the difference between a natural seedling and a root sucker was not morphologically visible, excavations were made to determine the vegetative origin of the regeneration. Therefore the young ones (*S. birrea* with dbh < 5 cm) with a root system showing a taproot system are considered to have grown from seed and those whose roots are horizontal and superficial are considered to have come from root suckers.

The seedlings usually only survive a few months after the start of the dry season, apart from in some plots. In the plots, the number of root suckers per tree, the distance that separates them from the mother plant, the depth and the circumference of the root carrying the sucker(s), if they release themselves or not, have been observed or measured. All the mature *S. birrea* (dbh > 5 cm) have been counted. A root sucker is considered established if it has strong adventitious roots, other than those from the parent plant and/or if its junction with the parent plant has necroses.

Processing of data

The number of mature trees and root suckers in each plot of 0.5 ha has been used to calculate the average densities per hectare and to illustrate some diagrams, which enables us to compare the variability of the number of mature trees or of root suckers per plot following a degree of increasing anthropization: the reserved forests, the mature fallows and the new ones. The calculations of the averages with the standard deviations, the diagram's and analysis of variance (on the threshold of 5 % by the test of Turkey) have been done with the help of the software Minitab16.

The parameters linked to the root suckering (frequency, number of root suckers per tree, the average distance relative to the parent tree, average depth of the root which is suckering, percentage of independent root suckers) have been calculated with the Excel spreadsheet and carried over onto tables.

Results

***Variability's of the rate of trees and root suckers of* S. birrea**

The average density of mature *S. birrea* decreases following a gradient of anthropization (Figure 1a).

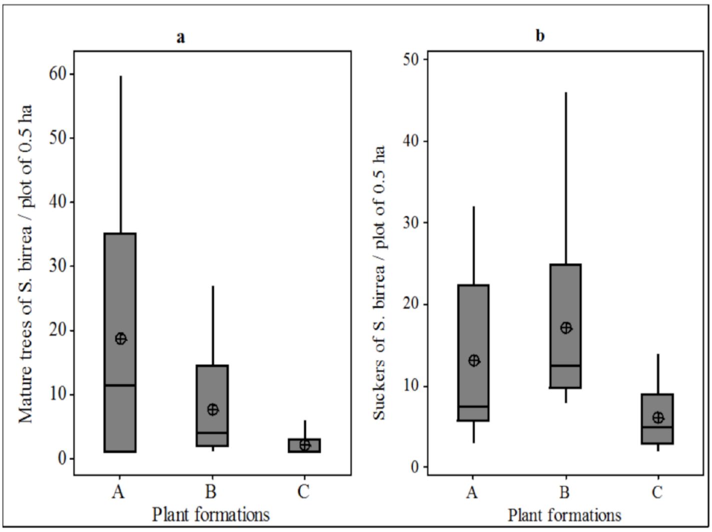

Figure 1 - Variability of the number of mature trees and root suckers per plot in plant formations.
Note: A (Reserved forests); B (Mature fallows); C (New fallows)

The average density of mature *S. birrea* in the reserved forests (37.4 ± 40.96 trees / ha) is about 2.5 times bigger than those in the mature fallows (15.28 ± 15.8 trees/ha), but doesn't have a significant difference (p = 0.074). It is 8.94 times bigger and significantly different (p = 0.015) than those in the new fallows (4.18 ± 3.28 trees/ha). The average density of mature *S. birrea* in the mature fallows is 3.65 times bigger than in the new fallows with a slight significant difference (p = 0.032).

The average density of root suckers (rs) in the mature fallows (34.28 ± 22.36 rs/ha) is bigger, but not significantly different (p = 0.388) to those of the reserved forests (26.40 ± 20.44 rs/ha). Additionally, it is significantly (p = 0.005) different and almost three times bigger to the average density in the new fallows (12.36 ± 7.98 rs/ha). The average density of root suckers in the reserved forests is more than the double of those in the new fallows, with a slight significant difference (p = 0.048).

The seedlings, which are dense in the rainy season, nearly all disappear after the first dry season, apart from in relatively humid environments and areas where grasses are scarce.

The variability of the number of mature trees and root suckers per plot is highlighted by the asymmetry of the distributions in the three types of formations (Figure 1).

The average of suckers per tree in the mature fallows (5.30 ± 5.77 suckers / tree) is significantly higher (p=0.000) than the averages of suckers per tree in the new fallows (2.91 ± 2.16 suckers / tree) and the reserved forests (2.12 ± 1.37 suckers / tree). The variability of the values displayed by the box of the old fallows (Figure 2) shows that we can observe especially in the mature fallows, tens of root suckers around a mature tree or a stump. This variability explains the standard variation well above average.

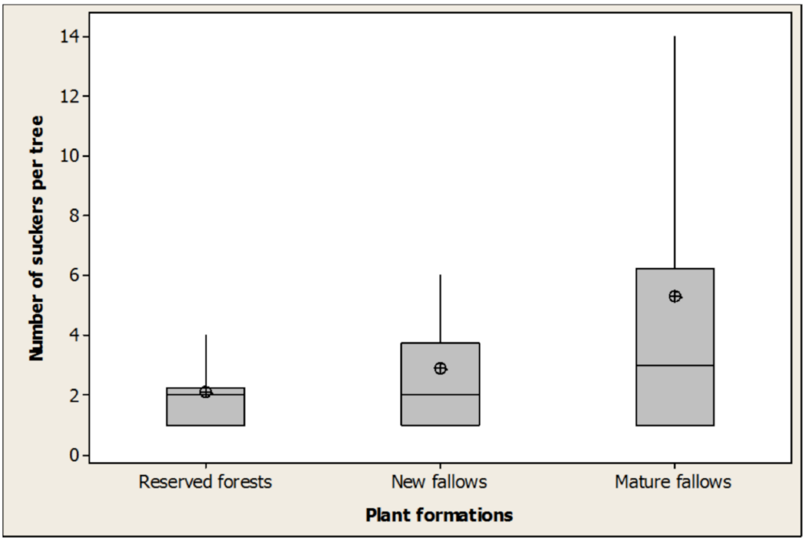

Figure 2 - Variability of the number of suckers per tree in plant formations.

Characteristics of natural root suckering

130 of mature *S. birrea*, out of a total of 316 observed (that is 41.1%) in the 35 plots, make at least one root sucker. Around these 130 trees, 440 root suckers are counted (that is 3.38 suckers on average per tree) and the theoretical density reported per ha is a 27.5 ± 25.82 root sucker in these stands. More than 70 % of mature trees that root sucker carry 1 to 3 root suckers and the 30 % left, between 4 to more than 10 (Table 1).

Table 1 - Percentages of mature S. birrea witch carry one or more suckers.

Number of suckers carries by mature trees	1	2	3	4	5	6	7	8	9	≥10
Percentages (%)	32.28	25.2	12.6	4.72	7.87	5.51	2.36	3.15	0.79	5.52

41 % of root suckers are situated in the shade under the crown of the tree (0 to 4 m) and 59 % are in full light, with a distance of 4 to 24 m from the foot of the parent tree. However, few root suckers (less than 18 %) are observed at more than tens of meters from the mother plant and those that are situated between 16 and 24 m only represent 1 % (Figure 3).

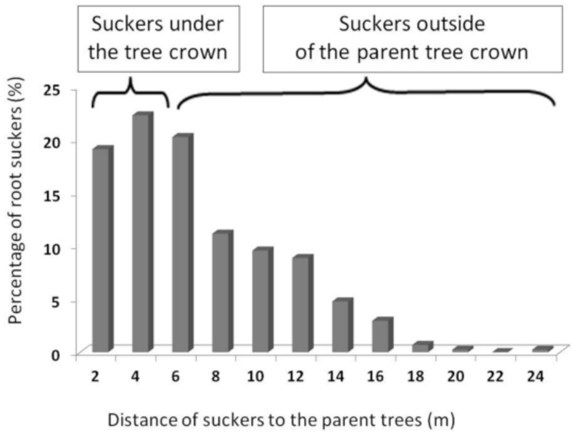

Figure 3 - Percentage of suckers according to their distance from to the parent-trees.

This moving away seems to be linked to the diameter of 1.3 m from the parent tree (Figure 4): so, for example, at more than 10 m from the trunk for diameters of 60-70 cm.

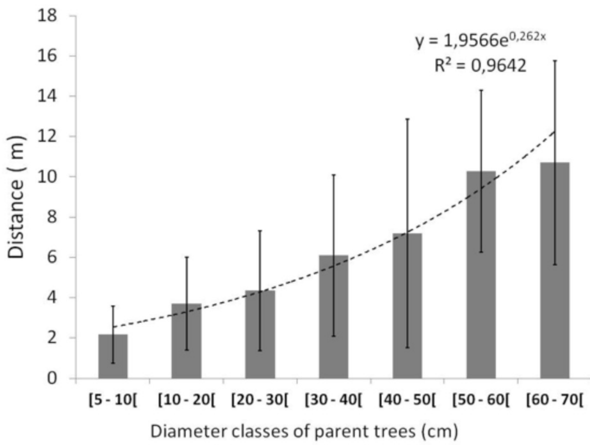

Figure 4 - Remoteness of suckers according to the diameter of the parent tree.

Half of the root suckers come from roots buried at a depth from top to 4 cm (Table 2).

Table 2 - Percentage of suckers according to the depth of the parent root.

DEPTH CLASSES (cm)	[0 - 4]	]4- 8]	]8 - 12]	]12 - 16]	]16 - 20]
PERCENTAGE OF SUCKERS (%)	54,76	37,98	6,13	0,45	0,68

Amongst the roots that have been exposed (by agriculture, erosion, stamping from animals), one fifth make root suckers. Almost all (92.74 %) the roots suckers are carried by roots do not exceed the depth of 8 cm (Table 3).

Table 3 - Percentage of suckers according to the diameter of the parent root.

Centres of diameter class (cm)	]0 – 2[	[2 – 4[	[4 – 6[	[6 – 8[	[8 – 10[	≥ 10
Percentage of suckers (%)	21,14	53,40	13,63	9,32	2,27	0,24

More than 88 % of root suckers are carried by roots of 1 to 5 cm of centre of diameter class, of which respectively 53.40 %, 21.14 % and 13.63 % for the classes of diameters [2-4[, [0-2[and [4-6[centimetres (Table 3).

Very few root suckers (<17 %) produce new roots (Table 4) and 83 % stay connected to the parent plant without necrosis of the parent root. No layers have been observed.

Table 4 - Percentage of establishment of suckers according to the remoteness.

Remoteness of suckers (m)	Number of suckers per mature tree	Percentage of establishment (%)
[0 - 2[	1.75 ± 1.53	0
[2 - 4[	1.98 ± 1.70	2.05
[4 - 6[	1.87 ± 1.19	4.77
[6 - 8[	1.65 ± 0.93	3.18
[8 - 10[	1.86 ± 1.32	2.05
[10 - 12[	2.16 ± 2.43	2.77
[12 - 14[	1.85 ± 1.21	0.68
[14 - 16[	4.2 ± 2.37	1.14
[16 - 18[	2.5 ± 2.12	0
[18 - 20[	1 ± 0	0
[20 - 22[	0	0
[22 - 24[	1 ± 0	0

Discussion

Abundance of **S. birrea** *and of its root suckers in these three types of formations*

Agriculture is one of the important factors in the deterioration of ligneous stands ligneux (Hall *et al.*, 2002; Gouwakinnou *et al.*, 2009). Indeed, the need to fell trees to grow crops explains the difference of density between reserved forests and the new fallows. The strong density of mature *S. birrea* in the protected forests highlights the importance of protecting areas for the conservation of species, in particular *S. birrea* as Shackleton *et al.* (2003) and Gouwakinnou *et al.* (2009) showed. However in these formations, the few seedlings, which germinate, only survive in the wet season, just like the seedlings of most species of tropical savannas (Bationo *et al.*, 2005; Ouédraogo *et al.*, 2006). Whereas in anthropized formations like fallows, the ability of root suckering favours it's regeneration (Hall *et al.*, 2002; Bellefontaine, 2005; Harivel *et al.*, 2006; Noubissié-Tchiagam *et al.*, 2011; Abdourhamane *et al.*, 2014).

The largest number of root suckers per plot in the mature fallows could result in intensive root suckering in the anthropized sites (Dourma *et al.*, 2006; Noubissié-Tchiagam *et al.*, 2011). Indeed ploughing the land helps the induction of root suckers by wounds or sectioning superficial roots of *S. birrea*. When the fields are cultivated, the root suckers are often killed off (Gouwakinnou *et al.*, 2009); when these fields are left in fallows, they are covered in root suckers. Illegal felling of trees, trampling by cattle, fires, are also other factors of induction of suckering (Dourma *et al.*, 2006) and would explain the appearance of root suckers in the reserved forests and their increase in the mature fallows. In Togo, the low density of root suckers of *S. birrea* in fallows, compared to those of *Isoberlinia spp.* observed by Dourma *et al.* (2006), is explained by the low density of mature *S. birrea* and without doubt, *S. birrea* does not root sucker as well as *Isoberlinia spp.*

Potential of root suckering

In one same stand, root suckers are not seen on all of the mature *S. birrea*. This ability to root sucker can be explained by differences in genotype (Vaughan *et al.*, 2007; Belem *et al.*, 2008; Stenvall *et al.*, 2009; Robinson *et al.*, 2012; Eusemann *et al.*, 2013) and physiology (Stenvall *et al.*, 2009; Till-Bottraud *et al.*, 2012), particular within individuals of the same species. The variability of the number of root suckers per parent tree can be explained by the differences of pedoclimatic conditions and by the importance of traumas undergone by the same forest stand (Bellefontaine, 2005; Vieira *et al.*, 2006; Meunier *et al.*, 2008; Mundell *et al.*, 2008; Renkema *et al.*, 2009; Kleinschroth *et al.*, 2013). A high rate of root suckers of *S. birrea* is observed in quarries at the edge of cliffs (personal observation).

Roughly 17 % of root suckers have shown (during our inventory) an independent root system, like those of other woody species, which are released naturally with the degeneration of the parent root (Jacq *et al.*, 2004; Bellefontaine, 2005). It would be interesting to watch if this percentage gets higher with time.

Implications of the regeneration of S. birrea by root suckering

The ability of certain *S. birrea* to root sucker, in particular outside of the crown of the parent trees, seems to be an advantage for the forest stand management, provided that the adventitious root system is well balanced. For this purpose, studies on root suckering induction should be done in Togo in order to complete the results obtained in the North of Cameroon (Noubissié-Tchiagam *et al*., 2011). In the framework of domesticating species, these trials of root suckering induction, of at least three years, would allow us to study the quality of rooting, the earliness of fruiting and the speed of growth in height. It would be necessary to repeat the trials of root suckering induction in different seasons to understand the best times to try and stimulate root suckers on the most productive clones chosen by rural populations.

Trials to multiply the plants by root cuttings (Hayashi and Appezzato-Da-Gloria, 2009; Stenvall *et al*., 2009; Ky-Dembélé *et al.,* 2010; Farahat and Lechowicz, 2013), a technique that is very similar to root sucker induction, would also allow the production of selected plants with a view to domesticate.

Conclusion

S. birrea shows a natural predisposition to regenerate by natural root suckering in fields and fallows in the North of Togo. Promoting this assisted regeneration in the fields for the local populations, would allow them to keep the few surviving seedlings and also any vigorous root suckers to replace older, less productive trees. The goal of this is to develop methods of vegetative propagation at a very low cost, like the induction of root suckering in the fields or fallows, and root cuttings which are rooted where the farmer wants to grow them. It is best to make a selection of female trees, as this species is dioecious.

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