Carbon sequestration by *Dacryodes edulis*: Implication for the opportunities of Payment for Environmental Services (PES)

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Abstract:

In order to fight against climate change through the development of profitable systems of production, it was necessary to study the influence of propagule of *Dacryodes edulis* on the carbon sequestration in plantations containing African Plum and to deduce their opportunities to the PES. The present study was carried out in the experimental plots of ICRAF at Mbalmayo. From the data collected, the results have shown that the average biomass, carbon stock and CO2 sequestered are higher in cutting's plots (268.1 ± 191.3) compared to the populations of marcots (217.4 ± 127.9) and of seedlings (131.0 ± 93.63). No significant difference was observed between CO2 sequestered in the population of cuttings and marcots ($F_{2;\,85} = 5.256$; $\rho = 0.569 > 5\%$). An evaluation of the potential incomes that could be generated from the different types of propagules gave 129,595 Fcfa/ha, 105,085 Fcfa/ha and finally 63,320 Fcfa/ha for the population of cuttings, marcots and seedlings respectively. The implication for the opportunities related to the PES via the CDM increase with the capacity of CO2 sequestration indicates that the populations of trees from cuttings will offer more incomes in the case of carbon market than those from other propagules.

1.1. INTRODUCTION

Climate change, revealed by scientists, challenged the international community and triggered awareness of many observations made and actions (IPCC, 2007). In this issue, sectors related to changes in land use such as agriculture, livestock and forestry are placed among the main contributors to global warming (Bonnal, 2009) but may, under certain conditions, be the main 'artisans' of sequestration of greenhouse gas emissions. On the other hand, the crucial role of forests in the adaptation and mitigation of climate change has been demonstrated over the last decade. In fact, the CO2 in the atmosphere is known as one of the main human activities that contribute to global warming (Arrouays *et al.,* 2003; Sonwa *et al.,* 2003). Agricultural techniques and forest exploitation are the main sources of CO2 emissions in the tropics (Tsalefack, 2011) and represent 20% of emissions from human activities (Koskella, 2000). But in developing, trees absorb CO2 and can help to sequester carbon in their biomass. The Kyoto Protocol of December 1997, following the UNFCCC (United Nations Framework Convention on Climate Change), stresses on the need to protect the carbon stored in forests (at the level of trees and soil), as well as any activity like afforestation and / or reforestation that sequesters atmospheric carbon which causes climate change. Therefore, forest management policies are the real issues in the debate on global climate (FAO, 2011). It is important that the forestry sector finds ways to cope, in the context of national forest policies, challenges and opportunities posed by climate change adaptation and mitigation. According to Markandya *et al.,* (2011), countries should change their forest policies to give more weight to sink and storage capabilities while taking into account the promotion of appropriate adaptation responses. **[**Among the mechanisms put in place to enable countries to capitalize on their forest management policy in order to meet the challenges imposed for regulating the global climate existing Reducing Emissions from Deforestation and Degradation: REDD (Subedi *et al.,* 2011)**]**. This mechanism adopted at the Conference of the Parties to the Convention on Climate Change at Bali in 2007, aims at encouraging developing countries to reduce greenhouse gas emissions from deforestation and degradation of their forests through financial compensation (Anonyme, 2007).

Black Africa is an integral part of climate negotiations because it is the location of the second largest forest in the world: the Congo Basin (Perthuis *et al.,* 2009). A study by Bellassen, (2009) showed that shifting cultivation was the primary cause of deforestation and degradation of forests in the Congo Basin. Therefore, the promotion of integrated technique and sustainable development of land could make a substantial contribution to REDD. Agroforestry has been recognized for decades as an approach to land management that can satisfy the necessary requirements for sustainability and profitability of REDD process, useful for adaptation to climate change. Agroforestry practices would be a preferred option in Africa to fight against global warming (Kwaku *et al.,* 2008). Carbon storage in agroforests based cocoa is now recognized and even quantified. The total carbon in cocoa plantation is 179 tons / ha against 275 in secondary forest (Nolte *et al.,* 2001; Sonwa *et al.,* 2003). In addition, emissions of greenhouse gas from natural fluoride in cocoa are respectively 739, 136.33 and 8.51 for FCO2, FNO2 and CFH4 (ASB, 2000). The approval of REDD mechanism in Bali 2007 led to a general mobilization on the need to generate information on carbon stocks in the carbon sink potential existing systems including land use. At the national level, existing data include not only forest types (Dziedjou *et al.,* 2011) but also some forestry plantations (Brown *et al.,* 2005) and agroforestry systems (Sonwa *et al.,* 2003; Zapfack, 2005; Avana *et al.,* 2009). This assessment gives an idea of the stock of carbon in the system but does not provide sufficient information on the contribution of different species to that pool. Rather, this information could guide the selection of species for the implementation of systems that do not only have socio-economic potential but also prove a strong capacity for carbon sequestration. In the region of Wet Tropical Africa, many species of trees have been identified as priorities for participatory domestication. These species provide people with food, medicines, fibers and significant income for their daily well-being (Ayuk *et al.,* 1999). Previous studies have assessed the phenotypic and genetic species as a basis for selection of the best genotypes. The vegetative propagation techniques have been developed for the selection and spread of best genotypes. Many other studies have evaluated the integration strategies that can maximize the ecological and socio economic contribution of these species at the level of agro-ecosystems. However, There is very little discussion on quantification of these ecological services, particularly in terms of carbon stock, as well as the influence of the type of propagule on the production of these services.

In fact, it has been shown that the rate of carbon sequestration varies according to the species since it depends on the longevity of the tree. The giant sequoia (*Sequoiadendron giganteum*), the largest tree in the world in terms of volume can store 500 tons of carbon for over 2000 years (Hartman *et al.,* 1997). Furthermore, sequestration capacity of species is expressed as biomass that is depending on the density of the various species involved. Fir forests (87 t C / ha), beech forests (84 t C / ha), Douglas-fir (45 t C / ha) (IFN, 2005). **[**Similarly, conifers store 106 t C / ha in monospecific plantation against 86 t C / ha in mixed plantation eucalyptus - conifers (Kanowski *et al.,* 2010)**]**, it therefore becomes important to evaluate the ability of sequestration of agroforestry species in general and *Dacryodes edulis* in particular **[**which is in active domestication by farmers**]** in order to facilitate the evaluation of this ecosystem service generated by the system of production based on these species. In the context of its research program on participatory domestication of fruit trees and medicinal plants, the World Agroforestry Centre (ICRAF) seeks to evaluate the potential of agroforestry systems and species; to contribute to the adaptation on climate change. This study falls within this context and will aim to answer the following research questions:

1. What is the influence of the type of propagule on the capacity of carbon sequestration on the monospecific plot of *Dacryodes edulis*?

2. What are the incomes that could be generated from carbon sinks based on *Dacryodes edulis* in case of the opportunities of Payment for Ecosystem Services?

The general objective of this study was to contribute to the improvement of knowledge for the assessment of carbon stock provided by agroforestry species and to deduce the potential benefits that could be produced in case of payment for the carbon market for farmers engaged in the domestication of fruit trees and medicinal plants. More specifically, our main aims were to:

- Characterize plots of *D. edulis* according to the type of propagule ;
- Evaluate the influence of the type of propagule on the aboveground biomass and root biomass of different plots and deduce their corresponding carbon stocks;
- Estimate and compare the ecological value (potential gains generated in case of carbon market) for different types of propagules for plots made up of African Plums.

1.2. MATERIALS AND METHODS

1.2.1. PRESENTATION OF THE STUDY AREA

The study was conducted in the experimental plots of World Agroforestry Centre at Mbalmayo where the plots of marcots, seedlings and cuttings of *D. edulis* were implemented. Mbalmayo is the head of the Division of Nyong and So'o in the central region of Cameroon, located about fifty kilometers in the south of Yaoundé (Figure 1: Location of the study area within Cameroon).

Mbalmayo is located between the northern latitudes 3 ° 30" to 3 ° 58" and East longitude 11 ° 20" to 11 ° 40". Due to this privileged location and its stretching in latitude, the area has a high diversity of ecosystem conditions that contain flora and fauna equally rich and diversified. The relief of Mbalmayo is flat in its entirety and includes volcanic slopes and rocky sediment from Nyong river near the coast which is a rainforests area with bimodal rainfall. On the hydrographical plan, Mbalmayo is a water reserve of Yaoundé with its water treatment factory on the river Nyong of Akomnyada. This is the most important river of that area, 640 Km long which flows into the Gulf of Guinea. With its climate type 'Guinea' hot and humid, Mbalmayo has an average daily temperatures of 25 ° C and a rainfall ranging from 1 500 to 2 000 mm per year, distributed in two distinct wet seasons for two crop cycles and agricultural calendar spread with staggered sowing and harvesting. The vegetation consists of dense forests semi-deciduous and evergreen.

1.2.2. DESCRIPTION OF EXPERIMENTAL PLOTS

Three plots were used as a basis for this study: a plot of mixed trees from cuttings and marcots, a plot of trees from marcots and a plot of trees from seedlings.

1.2.2.1. Plot mixed cuttings and marcots

In the mixed plot of cuttings and marcots, the African Plums were planted in association with other woody species. These woody species were ayous (*Triplochiton scleroxylon*) and Bibolo (*Lovoa trichilioides*) that had a large canopy preventing sunlight to easily reach the average stratum of African Plum. In this plot, the plants of cuttings and marcots were transplanted in April 2000 on an area of 5184 m^2 at a spacing of 12 m x 9 m for cuttings. It was a dual gauge in which the distance between two consecutive plants in a planting line is 12 m and that between two consecutive lines of planting is 9 m (E = 12 m x 9 m). This spacing gives trees a rectangular configuration (2 plants of a line of planting and two other plants of next planting line occupy the top of a rectangle). The vital space presented by 4 cuttings of this population was 108 m^2. The survival rate calculated by the ratio between the number of trees survived (48) and the number of trees originally planted in the plot (52) was 92%. The total number of alive cuttings in the plot were 52 from which were selected trees for the experiment. Amongst the 48 alive cuttings, 30 of them were selected to proceed with the experiment. Regarding the marcots, the distance between two consecutive plants in a planting line was 25 m and that between two consecutive lines of planting was 8 m (E = 25 m x 8 m). This dual gauge gives rise to a rectangular configuration and a living space of 200 m^2 (Figure 2: Marcot's plant with multiple stems).

1.2.2.2. Plot of trees from marcots

Although we had only 19 marcots in the mixed plot of marcots and cuttings, the experiment continued in another population of marcots close to the plot of seedlings thus providing a total of 28 marcots that formed the basis for this study. In this new population, 9 trees survived from the 12 originally planted at a spacing of 7 m x 6 m on a surface of 487.2 m^2. The vital space of this new population was 42 m^2.

1.2.2.3. Plot of trees from seedling origin

A single spacing was adopted to plant trees in the seedling plots since the distance between two consecutive plants in a planting line was the same as that between the lines. **[**This single spacing (5 m x 5 m), resulted in a square configuration and a vital space of 25 m^2**]**. The trees of this grove were introduced in 2001 on an area of 2150 m^2. For this experiment to be conducted, 30 trees were selected from the population of 92 trees. Almost all the trees planted survived in the seedling plot (98%). The maintenance of different plots was mainly by clearing weeds. The placing of marcots was also observed in different plots, with the aim of creating tree nurseries from marcots as shown in figure 3: aerial marcotting of *D. edulis*.

1.2.2. METHODOLOGY

Units of the population on which the characteristics or variable values were measured are individual trees because they 'are good for estimating average characteristics of trees as the average diameter, average height and volume' (FAO, 2002). The methodological approach used to select trees was the systematic sampling method. According to the writings of Jayaraman *et al.* (1999) and Statcan (2010), the systematic sampling of the trees was to number all the trees of the experimental plot from 1 to N, then choose a number between 1 and K randomly from a table of random number as the starting point of sampling. The number of trees to be selected was given by the following formula:

K + I N / n where

- K= Random number
- I= 0,1,2,3.........n - 1
- N= Population size
- n = Sample size

For example, if K = 15, n = 30 trees, N = 90 trees,

Then, the number of the trees to be selected was given through these calculations:

First tree: 15 + 0 × 90/30 = 15;

Second tree: 15 + 1 × 90/30 = 18;

Third tree: 15 + 2 × 90/30 = 21 …

30th tree: 15 + 29 x 90/30 = 102 - 90 = 17.

Whenever the number found was greater than the size of the population, the number of trees to be selected was determined by substracting the size of the entire population. Through this process, we sampled 30 trees in the plot of cuttings and seedlings. Only 28 marcots formed the basis for this study.

1.2.2.1. Measurement techniques of experimental variables

After determining the sample trees by systematic random sampling method, the parameters measured were:

- The total height (TH) of each selected tree;
- The Diameter at Breast Height (DBH);

- The height (HC) and the diameter (DC) of each tree crown sampled.

1.2.2.1.1. Total tree height (TH)

The total height of an individual tree was estimated using the Blume Leiss apparatus. It is an apparatus having the shape of a quarter circles with 4 scales in meter and a fifth in degree. To measure the height of a tree, the observer must be placed at a horizontal distance of 15, 20, 30 or 40 meter depending on the height of the tree so as to simultaneously view the top and the collar of the tree. It scans the tree at the collar and takes a first reading H1 through sight which accompanies the apparatus and is based on the horizontal distance chosen as the reference. The second scan was done at the top of the crown of the trees and another reading (H2) was taken via the side (Figure 4: Measurement of the total height of a tree and its crown). The total height of the tree was obtained by summing up the first and second reading, that is HT = H1 + H2 (Figure 4).

1.2.2.1.2. Crown height (CH)

To measure the height of the canopy of trees in each plot, a third scan H3 was made using the Blume Leiss at the base of the crown of each tree sampled immediately on the first leaves above the ground (Figure 4: Measurement of the total height of a tree and its crown). The value obtained was substracted from the read value made at the collar of the tree (H1 - H3) during the measurement of the total height. Crown height of the tree was obtained by applying the formula HH = HT - (H1 - H3). On the Blume Leiss, readings were made directly in meters.

1.2.2.1.3. Crown diameter (CD)

Measuring the diameter of the crown was made as follows: poles were placed at the ends East-West of the branches and the distance between these poles were measured using the measuring tape according to the model established by MacDicken *et al.,* (1991).

1.2.2.2. Methods for estimating biomass, carbon stock and CO2 sequestrated in each population of trees

Carbon stocks measured in the field were represented by trees sampled in each plot. The estimated biomass was done following the allometric method of Chave *et al.* (2005) using the DBH, total trees height and specific gravity of wood [AGB = exp (-2.977 + ln (ρx (DBH) 2) x H)] with ρ = 0.62 for *D. edulis* (Maniatis *et al.,* 2011). According to the work of Djomo *et al.,* (2010), the aboveground biomass equation of Chave *et al.,* (2005) is the best estimator across continents and sites with an average error of 20.3%, making the equation more accurate. By this method, we calculated the biomass of each tree selected, then the corresponding carbon stock in the biomass, by multiplying the value of biomass by 0.47 (Gurung, 2008) and finally the atmospheric CO2 sequestered by the tree. This latter value was estimated by multiplying the carbon stock in the tree by 3.6663 (TFF 2009; Minh *et al.,* 2009). These parameters were also calculated for the root part of the trees (root biomass, root carbon stocks and CO2 corresponding to the carbon stock). The only difference for this second phase of calculation was that the root biomass was estimated using the equation of Cairns *et al.* (1997) established as follows: RB = exp [-1.3267 + 0.8877 x ln (AGB) 0.1045 (ln AGE)]. The total atmospheric CO2 sequestered by the trees were estimated by adding to the atmospheric CO2 sequestered by the aerial part of the tree corresponding to the carbon stock in the roots. The evaluated parameters (aboveground biomass, root biomass, aboveground carbon stock, root carbon stock, CO2 sequestered by the aerial part and CO2 corresponding to the stock of carbon in the root) were converted to their average component by taking the ratio between the total value of each type of propagule and the number of trees sampled in each plot.

1.2.2.3. Method of assessing the ecological value

Ecological Value, the frequency marketing of the ton of carbon on the voluntary market depends on the selected standard. Among these standards include the VCS (Voluntary Carbon Standard) that encourage monitoring every 5 years of avoided GHG emissions (Ecosystems marketplace, 2009). This monitoring must be submitted via a report that determines the granting of VCUs (Voluntary Carbon Unit) and therefore the ability to generate tradable units on the voluntary carbon market. This implies six payments after 30 years.

In this study, in order to evaluate the potential gains generated in the case of the implication for the opportunities of Payment for Ecosystem Services, it was necessary for us to consider a square configuration on a surface of 1 ha assuming a uniform standard and average spacing of 10 m x 10 m. In relation to this spacing, it resulted in a vital space of 100 m^2. Trees density (given by dividing the total area of the parcel by the vital space) was 100 trees per hectare. The Ecological Value considered here was the monetary value expressed in CFA that could be obtained by selling the carbon sequestered by trees via the carbon market in different plantations of *Dacryodes edulis* in order to deduce the propagation technique this, will be more profitable in PES programs.

In the European carbon market, the average price of a tonne of CO2 sequestered by trees is estimated at 25 euros (Garrouste, 2009; Aertsens *et al.,* 2012, Minh *et al.,* 2009), and may fluctuate. This value expressed in US Dollars and in CFA gave an equivalence of 34.71US Dollars or 17711 FCFA (CoinMill.com - The Currency Converter from 14/03/2014 and of 16/09/2011). It has been used to evaluate one of the opportunities of Payment for Environmental Services of the different types of propagules by taking the number of tons of carbon sequestered per hectare in the plantation of *D. edulis* where seedlings, cuttings or marcots were multiplied by the monetary value of the ton of C.

Ecological value = [Nt C / ha (depending on the type of propagule) x 34.71USD or 17711 F CFA].

1.3. RESULTS

1.3.1. Influence of the type of propagule on the aboveground biomass of trees

The values of average aboveground biomass per tree were 130.5 ± 94.87 Kg, 105.3 ± 63.3 Kg and 63.01 ± 50.56 Kg for trees from cuttings, marcots and seedlings respectively. The analysis of variance showed that there was a significant difference ($\rho = 0.022$) between the average biomass of trees from seedlings and the trees from cuttings and marcots.

1.3.2. Variation in root biomass of trees depending on the type of propagule

The average tree root biomass ranged from 12.72 ± 9.63 Kg for the seedling to 25, 16 ± 16.16 Kg for those from cuttings (Table 1). In addition, a positive correlation was observed between aboveground biomass and root biomass ($r = 0.89$, $\rho = 0.014$).

1.3.3. Influence of the type of propagule on the aboveground carbon stock of trees population

The average aboveground carbon stock by type of plot is presented in Table 1, it is clear from this table that the stock was significantly ($\rho = 0.039$) higher in plots with trees from cuttings and marcots compared to trees from seedlings.

1.3.4. Variation of root carbon stock in tree base on the type of propagule

The root carbon stocks from trees population had presented the same trend as the root average biomass of trees in each plot. Indeed, the results indicated that these carbon stocks in trees population from cuttings (11.83 ± 7.597 Kg) and marcots (9.827 ± 5.272 Kg) were significantly ($\rho = 0.014$) higher than the same carbon stock obtained in the plot of trees from seedlings (5.98 ± 4.527 Kg) (Table 1).

1.3.5. Influence of the type of propagule on CO_2 sequestered by the aboveground part of the trees

The average amount of atmospheric CO_2 sequestered by the aerial part of the trees was 224.8 ± 163.5 Kg, 181.4 ± 108.6 Kg, 109.1 ± 87.13 Kg for the plots of cuttings, marcots and seedlings respectively (Table 1). The interpretation of these results can be justified by the growth of trees and their ages. As for the separation of the mean, the analysis of variance stating that there were no significant differences regarding the average CO_2 sequestered by the aerial part of the trees in the plots of cuttings and marcots ($\rho = 0.550 > 0.05$). However, the sequestration by the aerial part of the trees was maximum in the plots of cuttings (224.8 ± 163.5 Kg), and then decreased gradually in the plots of marcots (181.4 ± 108.6 Kg) and seedlings (109.1 ±

87.13 Kg) with a significant difference (ρ = 0.014).

1.3.6. Influence of the type of propagule on the amount of CO_2 related to the root carbon stock of the trees

The CO_2 related to the carbon stored in the roots biomass of the trees presented a similar trend to the aerial carbon stock in different

1.3.7. Influence of the type of propagule on the CO_2 sequestered by the trees

To estimate the total atmospheric CO_2 sequestered by a tree, we summed the CO_2 sequestered by the aerial part to that of the corresponding root carbon stock. The value obtained was then multiplied by the total number of sample trees after which the value was then divided by 30. This process was repeated in the other plots with respect to the number of sample trees in the plot (Figure 5: Average atmospheric CO_2 sequestered by trees in each plot depending on the type of propagule). On this figure, the histograms affected by the same letter are not significantly different at 5% probability.

This graph shows that the CO_2 sequestered by African Plum depends on the propagation method used. It is higher for trees from vegetative propagation (cuttings: 268.1 ± 191.3 Kg; marcots: 217.4 ± 127.9 Kg) with no

parcels with significantly higher amounts sequestered in trees from cuttings (43.36 ± 27.85 Kg) and marcots (36.03 ± 19.33 Kg) compared to those of seedlings (ρ = 0.038). This CO_2 related to root carbon stock has evolved in the same direction as the aboveground carbon stock in different plots (Table 1: Value of mean aboveground biomass, root biomass, carbon stocks and CO_2 sequestered by the population of trees from cuttings, marcots and seedlings).

significant difference (ρ = 0.552) than trees from seedlings (131.0 ± 93.63 Kg).

The analyses also showed that in the populations of *D. edulis* studied, there was a positive correlation between the diameter, the height of the crown and carbon sequestration (r = 0.606, ρ = 0.212) in the 3 types of propagules.

1.3.8. Potential gains generated in case of the implication for the opportunities of Payment for Ecosystem Services

From the results obtained above, it appears that a tree of African Plum of 10 years of age and with respect to the origin of the type of propagule (cuttings, marcots and seedlings) sequestered 268.1 $KgCO_2$; 217.4 and 131.0 $KgCO_2$ respectively. By extrapolating these values to the density of 100 trees per hectare, we obtain 26810 $KgCO_2$/ha, 21740 and 13100 $KgCO_2$/ha. These values gave 26.810; 21.740 and 13.100 tons of atmospheric CO_2

sequestered per hectare in the plantations of cuttings, marcots and seedlings respectively. It also gave 7.317 t C sequestered / ha in the plot of cuttings; 5.933 t C sequestered / ha in the plots of marcots and finally 3.575 t C sequestered / ha in the population of seedlings. It should be noted that these results do not take into account the carbon stored in vegetation above the soil, the roots of other plants than *D. edulis* in the sub - soil, litter on the forest floor, dead wood, soil and wood products for long period of existence. Considering the average price of a tone of carbon 34.71 US Dollars or 17711 FCFA (CoinMill.com - The Currency Converter from 14/03/2014 and of 16/9/2011), the population of cuttings, marcots and seedlings studied could generate 253.973 USD or 129595 CFA francs, 205.934 USD or 105085 CFA francs and finally 124.088USD or 63320 CFA francs per hectare of plantation after 11 years in populations of vegetative propagation (cuttings and marcots) and 10 years in the plots of seedlings (Figure 6: Evaluation of ecological value in FCFA / hectare in different populations). On this figure, the same letters means that the difference is not significant. Similar studies can be done over time without including other carbon stocks to determine the age at which net emissions will be zero for African Plum and advocate the exploitation of trees.

1.4. DISCUSSIONS

- The aboveground Biomass depends on growth parameters such as diameter, height and wood specific density, and the difference observed result in better growth of trees from cuttings and marcots compared to those from seedlings. Furthermore, seed and cuttings were planted from the biomass contained in the segments of the vegetative apparatus. This was not the case of plants from seedlings obtained from seeds sown directly in the field.
- For the root biomass, it was evaluated using the equation of Cairns *et al.* (1997) which takes into account not only the aboveground biomass, but also the age of the trees. The differences observed between root biomass of trees from cuttings and marcots and those from seedlings reflected both the difference of age and the difference in aboveground biomass of these three types of propagules. This difference could also be explained by the rapid growth of trees from marcots and cuttings as compared to those from seedlings.
- According to the stock of carbon, it appeared from the estimating methods used that the stock of carbon in tree biomass is 47% biomass of the tree. Therefore, the difference observed between the trees from the three types of propagule reflected the already obtained for the aboveground biomass above.

- The difference observed with respect to carbon sequestration in different populations could be explained by the rapid growth of trees from vegetative propagation compared to the trees from seedlings, as well as the ages of trees. In addition, CO_2 sequestered by trees was assessed using the biomass which was estimated using DBH, trees height, which were all growth parameters. Futhermore, seed of cuttings and marcots developed from biomass contained in the segments of the vegetative system which initially contained a substantial amount of carbon stored. On the other hand, cuttings and marcots were planted one year before seedlings.
- According to the relationship between the diameter, the height of the crown and carbon sequestration, it is well known that the characteristics of crown influence tree growth and therefore their biomass, carbon stocks and their ability to sequester carbon. Indeed the crown of the trees bears leaves responsible for the photosynthesis which is the process by which green plants absorb CO_2 from the atmosphere and store carbon while rejecting oxygen in the air.

CONCLUSION

This work had several objectives including the study of the influence of the type of propagule of African Plumb on the capacity of carbon sequestration and subsequently, the evaluation of the implication of PES of carbon sinks made of *D. edulis*. According to the results, it was found that: The potential of CO_2 sequestration by African Plum were higher in the plot of cuttings and marcots compared to trees from direct seedings. Evaluating the impacts that would result from carbon market showed the same trends as those observed for carbon sequestration based on settlement patterns. The plantations of African Plumb based on cuttings and marcots were more profitable than those installed from seeds. By combining these value incomes obtained from the marketing of African Plumb fruits and timber exploitation of *D. edulis* sold as fuel, the profits generated by the agriculture of *Dacryodes edulis* are improved. In addition, the combination of *Dacryodes edulis* - *Theobroma cocoa* could increase carbon sequestration and increase the income of farmers.

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