Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 8, No. 5, p. 164-174, 2016
http://www.innspub.net

INNSPUB
RESEARCH PAPER

OPEN ACCESS

Carbon Sequestration Potential of Fruit Tree Plantations in Southern Philippines

Mark Daryl C. Janiola, Rico A. Marin

Department of Forest Resources Management-College of Forestry and Environmental Science, Central Mindanao University, Musuan, Bukidnon, Philippines

Article published on May 27, 2016

Key words: Carbon sequestration, Fruit plantation, *Mangifera indica*, *Nephelium lappaceum*, *Sandoricum koetjape*

Abstract

Global warming is recently considered a major concern worldwide due to massive emissions of greenhouse gases to the atmosphere. Trees are seen as one of the mitigating measures of this problem due to its role in carbon sequestration. This study is aimed to assess the carbon sequestration potentials of 15-year-old Mango (*Mangifera indica* Linn.), 12-year-old Rambutan (*Nephelium lappaceum* L.) and the 32-year-old Santol (*Sandoricum koetjape* Merr.) in Bukidnon. Potential carbon sequestered was determined in various carbon pools (trees, understorey, litters and soil) of the three different fruit crop plantations. Field measurements and laboratory analysis were used to measure biomass density and carbon stocks of the samples. Results revealed that among the three plantations, the 32-year-old santol plantation had the highest value of total carbon stored with 203.62 ton/ha. This was followed by the 15-year-old mango plantation with 122.34 ton/ha. The 12-year-old rambutan plantation had only 112.18 ton/ha carbon storage. In terms of carbon pools, the soil had the highest carbon stocks in all plantation at 113.21 ton/ha, 96.76 ton/ha, 67.56 ton/ha for santol, rambutan and mango, respectively. The carbon stocks for the trees were next highest with 86.02 ton/ha (Santol), 52.46 ton/ha (mango) and 13.13 ton/ha (rambutan). The least among the carbon pools is the understory with 0.5 ton/ha, 0.7 ton/ha and 0.36 ton/ha for rambutan, mango and santol plantations, respectively. Findings of this study suggest that fruit tree crops are potential carbon sink and must be promoted as a land-use practice to help mitigate climate change.

***Corresponding Author:** Rico A. Marin ✉ ricomarin@yahoo.com

Introduction

Forests are crucial to the well-being of humanity. Furthermore, it provides foundation for life on earth, through ecological function and furnished a wide range of essential goods and services (Carandang, 2005). Today, world's forests are under pressure due to the modernization of life and increasing human population. According to Carandang (2005), conversion and degradation of forests are forms of forest destruction.

Climate change and global warming are the associated effect due to the destruction of world's forest. Another form of forest destruction, which is also a contributor to the increase of atmospheric carbon is land use change of forest. Increasing agricultural productivity is a primodial concern in many developing countries like the Philippines and it is a driver of change for land use purposes in the forest (Sace, 2002).

The deteriorating global environment and destruction of forest around the world had generated concern among nations, governments, and international organization (AFPSOS, 2009). Carbon has been associated with evolving discussion of climate change and global warming (Bowyer *et al.,* 2012). On the positive note, however, tropical forest had the largest potential to mitigate climate change and global warming through conservation of existing carbon pools (Lasco and Pulhin, 2009).

Today, a lot of researches have been conducted regarding carbon stock assessment. Most of these researches were conducted within natural forest and agroforestry farms. According to van Noordwijk (2002), a more refined Carbon accounting system is clearly needed to clarify changes in the terrestrial carbon storage and to understand the present carbon situation in various land cover types to include grassland, agricultural land and fruit tree crop plantation. The interest of this study is to determine the carbon stock of fruit crop plantation, which is believed to have very limited information on carbon stock at present.

Materials and methods

Location of the study

A study was conducted in the fruit tree plantation project of Bukidnon, Philippines. The three fruit plantations were the 15-year-old Mango (*Mangifera indica* Linn.) Plantation, 12-year-old Rambutan (*Nephelium lappaceum* L.) Plantation and 32-year-old Santol (*Sandoricum koetjape* Merr.) Plantation.

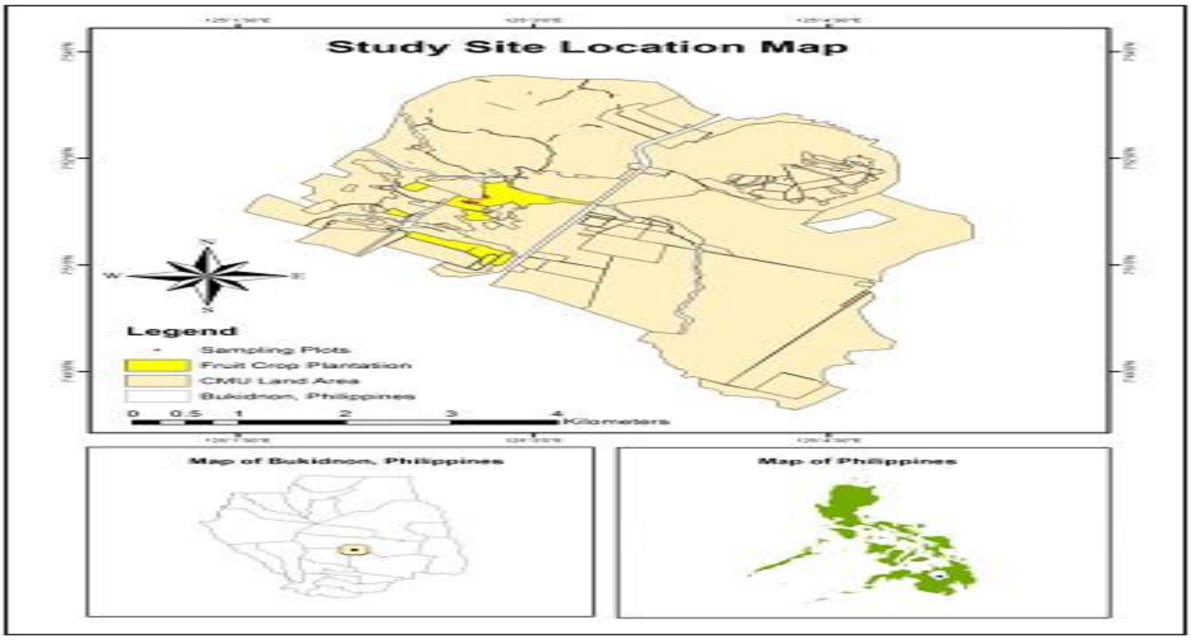


Fig. 1. Location map of fruit crop plantation production.

The area was located at the center of the province of Bukidnon which belonged to the third climatic type of the Philippines, having no very pronounced season usually from November to April and the rest of the year was wet. The elevation of the area ranged from 200-260 meters above sea level (Fig. 1).

Sampling design

The study made use of the Randomized Complete Block Design (RCBD) replicated two times. The treatments of the study includes:

A= 12-year-old Rambutan Plantation

B= 15-year-old Mango Plantation

C= 32-year-old Santol Plantation

Establishment of sampling plot

The established nested sampling plots were based from the method used by Hairiah, *et.al* (2010). Two 5 m × 40 m plots were being established in each fruit plantation. Nested plots of 1 m × 1 m and 0.5 m × 0.5 m were established within the 5 m x 40 m for soil, for litter and understory sampling, respectively. With the used of GPS receiver, geoposition of each plot was recorded.

Carbon stock calculation

Aboveground

Live tree biomass

Data collection to estimate carbon density was conducted using the methods described by Hairiah *et al.* (2010). This method had been applied in many carbon related studies in the Philippines.

Two 200 m² (5 m × 40 m) quadrats were established in each fruit plantation. The two quadrats represent replication per site. The plot was established by running a 40 m centerline through the area. The trees with Diameter at Breast Height (DBH) of 5 cm to 30 cm were measured as samples within 2.5 m of each side of the 40 m centerline. A sample plot of 20 m × 100 m was established per site to measure the diameter and height of tree greater than 30 cm DBH.

For carbon computation of fruit trees, the equation by Unruh *et al.* (1993) as cited by (Abucejo, 2012) was used was used.

$$Cft\ (kg) = (Yftb)\ (0.45)$$

Where:Cft = Carbon yield of fruit trees

Yftb = Fruit tree biomass = ($\exp[-2.4090 + 0.9522 * In(D^2HS)]$)

D = DBH (cm)

H = Tree Height (m)

S = Wood density equivalent to 0.57

0.45 = Carbon Content of fruit trees

Understorey Biomass

Destructive sampling technique was employed within the 5 m × 40 m quadrants. Four 1 m × 1 m sampling plots were nested randomly for understorey sample collection. For litters, a 0.5 m × 0.5 m was nested uniformly in the lower left of 1 m × 1 m sampling plot. For understorey, all vegetation less than 5 cm dbh were harvested within the 1 m × 1 m quadrants. Total fresh sample was weighed in the field and after which a sub-sample of about 300 g was taken for oven drying and carbon content analysis.

For litters, all undecomposed plant materials and crop residues within 0.5 m × 0.5 m were collected. Total fresh weight was then recorded in the field. A sub-sample of about 300 g was taken for oven-drying and carbon content analysis (Hairiah *et al.,* 2010).

The carbon content analysis was done at the Soil and Plant Analysis Laboratory (SPAL). Combustion method or dry ashing was done in order to determine the carbon content of plant and litter samples. The method used volatile solids (largely carbon and nitrogen), then burned at laboratory furnace at 500-600 °C leaves off and leaving only the ash. By weighing the ash and applying percentage conversion of ash and volatile solids that burned off, the carbon content was determined.

Understorey and litter samples were calculated using the equation by Hairiah *et al.* (2010).

WT= (TFW (kg)×SDW (g))/(SFW ×A)
Legend:
WT = Total Dry Weight (kg)
TFW = Total Fresh Weight (kg m2)
SDW = Subsample Dry Weight
SFW = Subsample Fresh Weight
A = Sample Area

C Stored=Total dry Weight × C Content

Below ground

Roots

Since the method for root biomass determination was not yet standardized, an allometric equation was used to determine root biomass and carbon (Lunsayan, 2008).

Root biomass was calculated through the use of allometric equation from (Cairns *et al.,* 1997).

Root Biomass = exp [- 1.0587 + 0.8836 * In (AGB)]
Where: exp = raise to the power of
In = natural logarithm of
AGB = Aboveground biomass
C Stored = Root biomass density x C content.

Where: A default value of 45% was used to determine the carbon stored in root biomass, which was an average carbon content of wood samples collected from secondary forests from several locations in the Philippines (Lasco & Pulhin, 2000) as cited in Labata *et al.*, (2012).

Soil

For soil sampling, two methods were applied, the destructive soil sampling and undisturbed soil sampling. By using the same nested sampling plot, the soil samples were collected. For the undisturbed soil sampling, samples were gathered in the 1 m × 1 m sampling plot and destructive soil samples were gathered at 0.5 m x 0.5 m, of which samples were derived from 0-30 cm depth soil layer and about a kilogram of soil sediments were taken for organic analysis using Corg (Walkey and Black) Method (Hairiah *et al.,* 2010) at the SPAL in Central Mindanao University. The soil samples for bulk density determination was collected in undisturbed spot of 1 m ×1 m sampling plot and a 5.4 cm × 10 cm soil core cylinder was used in collecting the samples by driving the soil core cylinder into 0-10 cm depth soil layer (Hairiah *et al.,* 2010).

Soil Carbon was calculated through an equation:
Carbon density (Mg ha^{-1}) = weight of soil × %SOC
Where: Weight of soil (Mg) = bulk density × volume of 1 hectare
Bulk density (g/cc) = Oven-dried weight of soil / Volume of canister
Volume of canister = $\pi r^2 h$
Volume of one ha = 100m ×100m × 0.30m
Total C stored = C stored (t/ha) × area (ha).

Data analysis

The test of significant difference among treatments was determined using the Analysis of Variance (ANOVA). Duncan Multiple Range Test (DMRT), on the other hand, was used in comparing treatment means. The Statistical Package for the Social Sciences (SPSS) version 16 was used in the data analyses**.**

Results and discussion

The inventory of fruit trees in sampling plots were summarized in Table 1. The 12 year old rambutan plantation had 27.5 mean sampled trees with mean height and diameter of 7.33 m and 23.44 cm, respectively. For the 15-year-old mango plantation, it had 34.5 mean sampled trees with 12.96 m mean height and 32.41 cm mean diameter. On the other hand, the 32-year-old santol plantation has 39 mean sampled trees with average height and diameter of 16.91 m and 37.03 cm, respectively. Data showed that among the three plantations, santol being the oldest (32 years) had the greatest diameter and height while the rambutan plantation (12 years) had the least being the youngest of the three plantations.

Soil condition

Table 2 shows the soil properties of the three plantations. The result for the soil condition among the three plantations signifies that all three plantations were at good condition.

As observed, the santol had the highest value among the three plantations for soil pH, OM, OC, N and K. Findings revealed that the soil condition of the 32-year-old santol plantation is better compared to the sites for mango and rambutan plantations. According to Imoro *et al.* (2012), the soil pH largely controls plant nutrient availability and microbial reaction in the soil, especially the soil organic matter. Further, he said that organic matter content is often related to soil fertility. Accordingly, organic matter act as reservoir of plant nutrients especially the three important macronutrients (NPK) and micronutrients (Okunwo *et al.*, 2012). Furthermore, the presence of this nutrients influence plant growth and affect vegetation structure.

Table 1. Inventory of fruit trees for the three sites.

Measurements	Plantation		
	Rambutan	Mango	Santol
Mean No. of Trees	27.5	34.5	39
Mean Average Height (m)	7.33	12.96	16.91
Mean Average Diameter (cm)	23.44	32.41	37.03

Biomass and carbon production

Table 3 shows significant difference in biomass production among the three fruit plantations. Results show that Santol plantation (32-yr old) had the highest amount of biomass production for trees amounting to 166.71 ton/ha. For mango plantation (15-yr old), tree biomass is 100.71 ton/ha. However, biomass production of mango and santol plantations does not differ significantly. This can be attributed to the fact that both plantations had average diameter greater than 30 cm and average height greater than 10 m. On the other hand, rambutan plantation had the lowest amount of biomass produced with 24.70 ton/ha. This is due to its size having a diameter range of 21.67 cm to 25.20 cm and average height of below 10 m. However, based on the size of trees, rambutan can be classified under the medium size fruit tree (Morton, 1987).

Table 2. Soil analysis of the three fruit tree plantation.

Plantation	pH	%OM	%OC	Total N (%)	Extr. P ppm	Exch. K ppm
Rambutan	4.97	4.24	2.47	0.12	4.06	45.00
Mango	4.93	3.06	1.78	0.10	1.25	40.50
Santol	5.69	5.26	3.06	0.17	1.97	255.00

Tree biomass is directly proportional to its diameter at breast height (DBH) and total height.

In fact, Brown (2002) as cited by Gibbs (2007) reported that DBH is 95% of the total biomass. In this study, santol plantation presents the greatest biomass production, which can be due to its huge average diameter and height. On the other hand, Mango and rambutan plantations had lesser biomass due to its smaller diameter and height.

Significant difference was shown among the three fruit plantations for aboveground carbon stock. Santol fruit trees had mean carbon density of 75.02 ton/ha which was observed to be the highest among the three plantations. This was followed by mango plantation with a total carbon stock of 45.29. Rambutan plantation, on the other hand, had carbon stock of only 11.12 ton/ha and is the least among the three plantations. Cubillas (2009) stated that carbon storage was directly proportional to biomass density.

Thus, like biomass, the same ranking of carbon storage per site had resulted. Rambutan plantation having smaller sizes and volume also resulted to have the least biomass and carbon content. Pedregosa (2009) had also parallel findings on the 40-year-old rubber plantation being the greatest in biomass compared to the 25-year-old and 5-year-old rubber plantation. Accordingly, older trees undergone photosynthetic activity with much longer time compared to young trees and consequently are absorbing and storing more carbon (Lunsayan, 2008). This may explain why the 32-year-old santol plantation had the greatest carbon stock among the three fruit trees measured in this study.

Table 3. Biomass and carbon production of different pool area.

Fruit Plantation	Fruit Trees (ton/ha)		Understory (ton/ha)		Litter (ton/ha)		Roots (ton/ha)		SOIL (ton/ha)
	Biomass	Carbon	Biomass	Carbon	Biomass	Carbon	Biomass	Carbon	Carbon
Rambutan	24.70 ^{b}	11.12 ^{b}	1.06 ^{a}	0.50 ^{a}	3.93 ^{a}	1.79 ^{ab}	4.46 ^{b}	2.01 ^{b}	96.76 ^{a}
Mango	100.71 ^{a}	45.29 ^{a}	1.51 ^{a}	0.70 ^{a}	3.25 ^{a}	1.62 ^{b}	15.95 ^{a}	7.17 ^{a}	67.56 ^{a}
Santol	166.71 ^{a}	75.02 ^{a}	0.78 ^{a}	0.36 ^{a}	6.93 ^{a}	3.43 ^{a}	25.74 ^{a}	11.60 ^{a}	113.21 ^{a}
CV (%)	16.32	16.30	40.76	44.56	25.12	19.13	16.59	16.71	12.70

Mean of the same letters are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT).

The understorey biomass shows no significant difference among the three plantations. Mango plantation had the highest biomass density of 1.51 ton/ha, while santol plantation had the least with 0.78 ton/ha.

The difference of the understory biomass for each plantation site was observed to be influenced by the understory vegetation present in this study. Both 15-year-old mango plantation and 12-year-old rambutan plantations are dominated by carabao grass (*Paspalum conjugatum*).

The only difference among the two plantations was that mango plantation had taller understory vegetation than to the rambutan plantation. For santol plantation, the understory vegetation was prone to weeding and disturbance due to the presence of road network. Pedregosa (2009) stated that factors like openness of canopy and presence of road network may affect the growth of the understory vegetation. Santol plantation had also a closer canopy due to its large tree sizes. Close canopy makes understory receive less intense light than in plants with open canopy. Ostrom (2005) mentioned that attribute of light environment had significant impact on plant growth and vigor. Further, he stated that crown with densely packed leaves may transmit less light than one that consist elongated leaves with sparse crowns.

The mango and rambutan, on the other hand, had more open canopy, thus, more understory are observed in these plantations due to more light reaching the ground. In an open canopy, the understory is able to photosynthesize adequately using such light from the sun.

The age of stand, the spacing and sizes of canopy gaps, species and the multi-layering of foliage within the stand all influence understory (Pett and Franklin, 2000). Furthermore, they stated that the amount of light reaching the understory varied greatly and overall understory conditions were influenced by canopy structure as indicated by the higher correlation between the herb-shrub layer and the canopy-light environment.

For understorey carbon, the mean carbon density among the fruit plantations was found to be insignificant. The 15-year-old mango plantation had a mean carbon of 0.70 ton/ha, while the 32-year- old plantation had the least with 0.36 ton/ha.

Table 4. Percentage of different aboveground carbon pool.

Plantation	Fruit Tree	Understorey	Litter	Total AGC
Rambutan	11.12 (83%)	0.50 (4%)	1.79 (13%)	13.4
Mango	45.29 (95%)	0.70 (1%)	1.62 (4%)	47.61
Santol	75.02 (95%)	0.36 (1%)	3.43 (4%)	78.81

The findings for understory carbon among the three plantations show that the age of plantation does not affect the amount of carbon being stored. Despite being the oldest among the 3 plantations, santol turned out to have the lowest amount of understory carbon. This is due to the closeness of the canopy of the santol plantation. Light cannot easily penetrate the understory layer, thus, the growth of the understory in santol plantation is low. Bartels and Chen (2013) supported that overstory broad leaf composition had direct positive effect on shrub layer and herb layer. According to Cubillas (2009), the growth of understory vegetation in natural forest is dependent to sunlight, thus, the thicker the forest canopy, the lesser the light penetration for the understory vegetation especially herbaceous plants, making them out-numbered. In rambutan and mango plantations, the canopy is quite open where light easily penetrates the understorey layer, thus, plants grow and thrive vigorously.

Table 5. Percentage of different belowground carbon pool.

Plantation	Root	Soil	Total BGC
Rambutan	2.01 (2%)	96.76 (98%)	98.77
Mango	7.17 (10%)	67.56 (90%)	74.73
Santol	11.60 (9%)	113.21 (91%)	124.81

For litters, no significant difference in biomass density was observed among the three fruit plantations. The litter biomass density of santol plantation had the highest value among the three plantations amounting to 6.93 ton/ha. Rambutan plantation had 3.93 ton/ha while mango plantation had the least with 3.25 ton/ha.

Branches, leaves and fruit crop residues that fell on the forest ground (litter) had a corresponding biomass density, thus, the more litter harvested, the greater biomass density it produced (Lunsayan, 2008). As observed, santol leaf litters were broader in size and had longer petiole (18 cm long) compared to rambutan and mango plantation. Rambutan leaves are alternately pinnate compound 7-30 cm long which is attached to a 1-2 cm petiole while mango had evergreen alternate leaves with petioles 2.5-3.0 cm long. Full grown leaves may be 10-32 cm long and 2-5.4 cm wide (Morton,1987). Furthermore, santol plantation also produces more litters since among the three plantations, santol is older and had wider canopy.

In terms of carbon from litters, santol plantation had the highest value with 3.43 ton/ha followed by rambutan plantation with 1.79 ton/ha. The mango plantation had the lowest carbon stock at 1.62 ton/ha. This result is supported by the fact that the older santol fruit trees had denser canopy and greater coverage compared to mango and rambutan plantation. Thus, the santol plantation will most likely shed greater amount of dry leaves than rambutan and mango. This can be due also to the dry leaves and petioles of the 32-year-old santol trees which are bigger in size and would thereby give greater volume of litters.

On the root biomass of fruit trees, the three plantations showed significant difference. Santol plantation showed the greatest value with 25.74 ton/ha. This was followed by mango plantation with 15.95 to/ha and rambutan plantation had the least with only 4.46 ton/ha. The result may explain that the root biomass is positively related to aboveground biomass. The equation by Cairns *et al.* (1997) uses the aboveground biomass of fruit trees to determine its root biomass. According to Law (2002) as cited by Patricio and Tulod (2010), the mass of leaves and stem is proportionally scaled to that of its roots in a mathematically predictable way. This can be the reason why santol plantation had highest mean in terms of root biomass because among the three it has the largest diameter, while rambutan had the least diameter making it to have least root biomass density. Findings revealed that below ground root carbon among the three plantations shows significant difference. The 32-year-old santol plantation had the highest value for root carbon with 11.60 ton/ha. The 15-year-old mango plantation was second with 7.17 ton/ha, while the rambutan plantation had the least at 2.01 ton/ha.

Table 6. Percentage table of different carbon pool compartment.

Plantation	Fruit Tree	Understorey	Litter	Root	Soil	Total C
Rambutan	11.12 (10%)	0.50 (1%)	1.79 (1%)	2.01 (2%)	96.76 (86%)	112.18
Mango	45.29 (37%)	0.70 (1%)	1.62 (1%)	7.17 (6%)	67.56 (55%)	122.34
Santol	75.02 (37%)	0.36 (1%)	3.43 (2%)	11.60 (5%)	113.21 (55%)	203.62

The result in root carbon density reflects only the trend result for aboveground biomass and carbon density of which the 32-year-old santol plantation had the highest followed by the 15-year-old mango and 12-year-old rambutan plantations.

This is because of the fact that aboveground biomass was used in the equation by Cairns *et al.* (1997) to determine the root biomass and root carbon. As discussed by Cubillas (2009), carbon storage was directly proportional to biomass density, thus the same ranking of carbon storage per site had resulted.

The soil mean carbon density among the three plantations shows no significant difference. Santol plantation had a total soil mean carbon of 113.21 ton/ha, rambutan plantation had 96.76 ton/ha and mango plantation had 67.56 ton/ha. The insignificant difference of the three plantations can be due to the uniformity of soil OM of the said sites. According to Henry (2010), most of the soil carbon is found in the 0-30 cm depth soil layer. Moutinho (2005) also described that 30% of soil carbon stock can be found in the 0-5 cm soil layer.

Aboveground total carbon

The total aboveground carbon of the three fruit plantations showed significant difference at 0.05 level (Table 4). Santol plantation had a total mean carbon of 78.81 ton/ha while mango plantation had 47.61 ton/ha. The least was the rambutan plantation with 13.4 ton/ha.

Findings showed that the santol plantation dominates the aboveground carbon. This can be due to its diameter and height which is greater compared to the other two fruit plantations. Expectedly, the result of the carbon storage is dependent on the biomass production because carbon sequestration is a function of biomass production (Lunsayan, 2008). Further, since trees had the highest biomass density, consequently, it stores the highest amount of carbon among other aboveground biomass compartment (understorey and litter). Labata (2012) reported that 85-94% of the aboveground biomass can be stored in trees. Further, litter was only 2-6% and herbaceous vegetation accounts only to 1-13%. In this study trees showed 83-95% total aboveground carbon, understorey with 1-4% and litter with 4-13%.

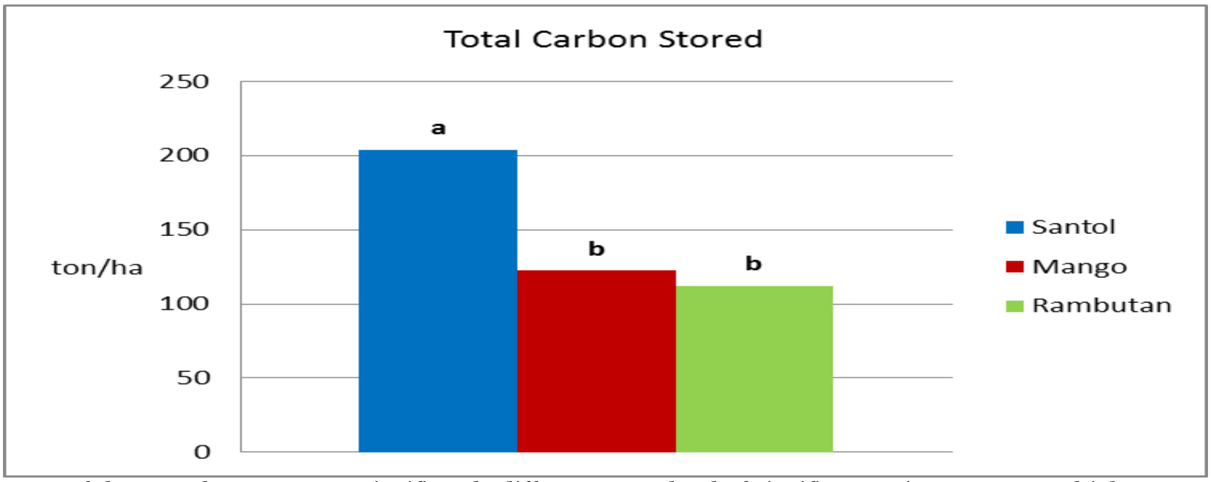
Below ground total carbon

No significant difference was noted for belowground carbon among the three plantations. However, santol plantation had the highest belowground mean carbon of 124.54 ton/ha. Rambutan plantation had 98.77 ton/ha, while mango plantation had 74.74 ton/ha.

The no significant difference of belowground can be due to the very high soil carbon content in the three sites. This is because most of the belowground total carbon is found in soil and constitute about 90-98%. Roots constitute only 2-10% carbon of total belowground (Table 5).

Total carbon

The overall carbon storage shows significant difference among the three plantations (Fig 2). The 32-year-old santol had the greatest amount of carbon stored among the three plantations with 203.62 ton/ha. Its difference from mango and rambutan is significant (Table 6). The 15-year-old mango plantation had a total carbon stock of 122.34 ton/ha, while rambutan plantation had the least value with 112.17 ton/ha. However, its difference with mango plantation is not significant.



Mean of the same letters are not significantly different at 5% level of significanceusing Duncan Multiple Range Test (DMRT).

Fig. 2. Graphical presentation of total carbon stock.

The result for the total carbon stored among the three fruit plantations only shows that the santol plantation dominates in terms of total carbon storage. This can be due to its age and size of santol trees. The greater the size of the vegetation, the most likely to contain more C stocks. According to Sabukti *et al.* (2010), the existence of trees with diameter more than 30 cm in a certain land use system makes a large contribution to the total carbon stocks. As observed in all the carbon pool, the aboveground components especially the fruit trees shows the greatest amount of biomass present as well as the carbon.

Age, size, species and type of forest may influence amount of carbon storage. In the study of Pedregosa (2009) the 40 year old rubber plantation had 292.36 Mgha-1 carbon stocks then followed by 25 year old and 5 year old rubber plantation with 238.39 Mgha-1 and 2.56 Mgha-1 carbon stocks, respectively. In the study of Lasco *et al.* (2000), forest had carbon stocks of 392.96 ton/ha being the highest, followed by yemane, mangium and mahogany plantation with 294.16 ton/ha, 275.42 ton/ha and 192.02 ton/ha carbon density, respectively. While in the study of Lunsayan (2008) the 16-year-old carribean pine plantation had 258.19 ton/ha carbon stocks then followed by 14-year-old and 5 year old carribean pine plantation with 212.15 ton/ha and 155.52 ton/ha, respectively.

The aboveground carbon pool shows high amount of carbon amounting to 10-36% of the total carbon stored, tree gives off significant part to the aboveground carbon. Litter amounts only to 1-3% and understorey only amounts to 1-2% of the total carbon stored. However, among the carbon pool, soil had the highest component amounting to 55-86% of the total carbon. Soil can sequester more carbon because it is where decomposition takes place from all the litter debris and leaves of the tree, dead herbaceous plants and continuous growth and death of roots (Bajuyo, 2012). The soil carbon is about two thirds of the terrestrial biosphere carbon pool.

Conclusion

Fruit crop plantations are indeed potential as carbon sink and are helpful in mitigating climate change. The potentials of fruit trees to sequester carbon can be comparable to that of forest trees and the fact that these crops are also providing food and income to the farmers. The promising contribution of fruit tree plantations in solving food shortages and climate change problems should encourage the Local Government Units, Government and non-government organizations in promoting and expanding these land-use practices for food security and for global warming mitigation purposes.

References

Abucejo J. 2012. Analysis of the Economic and Environmental Services of Two Agroforestry Projects in Caraga Region, Philippines, Unpublished MS Thesis, Central Mindanao University, Philippines, 35.

APFSOS. 2009. Asia-Pacific Sector Outlook Study II. Philippine Forestry Outlook Study. Forest Management Bureau. Food and Agriculture Organizations of the United Nations Regional Office for Asia and the Pacific. Bangkok, 6.

Bajuyo I. 2012. Carbon Sequestration Potential of Mangrove Plantation in Taytay, El Salvador, Misamis Oriental, Unpublished Undergraduate Thesis, Central Mindanao University, Philippines, 29.

Bartels SF, Chen H. 2013. Interactions Between Overstorey and Understorey Vegetation Along An Overstorey Compositional Gradient. Journal of Vegetation Science **24(3),** 546-548.

Bowyer J, Bratkovich S, Frank M, Howe J, Stai S, Fernholz K. 2012. Carbon 101: Understanding Carbon Cycle and the Forest Carbon Debate. Dovetail Partners Inc,, 2.

Brown S. 1997. Estimating biomass and biomass change of tropical forest: A primer, FAO Forestry paper **134,** 58.

Brown S. 2002. Measuring carbon in forests: current status and future challenges Environmental Pollution **116(3),** 363-372.

Cairns M, Brown S, Helmer E, Baumgardner G. 1997. Root Biomass Allocation In The World's Upland Forests. Oecologia **111(1),** 1-11.

Carandang A. 2005. Forest Resources Assessment, National Forest Assessment: Forest Policy Analysis Philippines. Forest Resources Assessment Programme, Forestry Department. Food and Agriculture Organization of the United Nations Working Paper **101/E**, 1-35.

Cubillas M. 2009. Carbon Stock Assessment of Selected Forest Patches in Musuan, Maramag, Bukidnon. Unpublished Undergraduate Thesis, Central Mindanao University, Philippines, 29-30.

Gibbs HK, Brown S, Niles JO, Foley JA. 2007. Monitoring and Estimating Tropical Forest Carbon Stocks: Making REDD a Reality. Environmental Research Letters **2(4),** 1-13.

Hairiah K, Dewis S, Agus F, Ekadinata A, Rahayu S, Van Noordwijk M. 2010. Measuring Carbon Stock Across Land Use Systems: A Manual. Bogor Indonesia. World Agroforestry Centre. 55-102.

Henry M. 2010. C Stocks and Dynamics in Sub Saharan Africa. Dissertation Submitted to Paris Institute of Technology for Life, Food and

Environmental Sciences (AgroParis Tech) and Doctoral School on Integrated Systems in Biology, Agricultural Sciences, Geosciences, Water Resources, Environment (SIBAGHE), 26.

Imoro ZA, Dery DA, Kwado KA. 2012. Assessment of Soil Quality improvement under Teak and Albizia. Journal of Science and Environmental Management **3(4),** 92.

Labata MM, Aranico EC, Tabaranza AC, Patricio JHP, Amparado RFJr. 2012. Carbon Stock Assesment of three Selected Agroforestry System in Bukidnon, Philippines. Advances in Environmental Sciences International Journal of the Bioflux Society **4(1),** 5-11.

Lasco R, Lales J, Arnuevo Ma.T, Guillermo I, de Jesus A, Medrano R, Bajar O, Mendoza C. 2000. Carbon Dioxide (CO2) Storage and Sequestration in the Leyte Geothermal Reservation, Philippines, Proceeding World Geothermal Congress, 639-643.

Lasco RD, Pulhin FB, Cruz RVO, Pulhin JM, Roy SSN. 2005. Carbon Budget of Terrestrial Ecosystem in The Pantabangan-Carranglan Watershed. AIACC Working Papers **10,** 1-23.

Lunsayan D. 2008. Carbon Sequstration Potential of Carribean Pine (*Pinus carribea*) Plantation in Malaybalay City, Unpublished Undergraduate Thesis, Central Mindanao University, Philippines, 30-40.

Morton J. 1987. Fruits of Warm Climate. Julia F. Morton, Miami, FLL. [Online] Available at 199-201, 221-239, 262-265. http://www.hort.purdue.edu/newcrop/morton/mango_ars.html

Moutinho P, Schwartzman S. 2005. Tropical Deforestation and Climate Change. © Amazon Institute for environmental Research. Washington DC, USA 71. 1-132.

Okonwu K, Mensah SI. 2012. Effects of NPK (15: 15: 15) fertilizer on some growth indices of pumpkin. Asian Journal Agric. Res. **6,** 137-143.

Ostrom BJ. 2005. Effects of Forest Structure on The Understory Light Environment and Growth Potential of Oak Seedlings In A Close Canopy Riparian Forest. Published Thesis. Auburn University, Alabama, 8-10.

Patricio, JHP, Tulod AM. 2010. Carbon sequestration potential of Benguet pine (*Pinus kesiya*) plantations in Bukidnon, Philippines. Journal of Nature Studies **9(1),** 99-104.

Pedregosa D. 2009. Carbon Stock Assessment of Rubber Tree (*Havea brasiliensis*) Plantation in Musuan, Maramag, Bukidnon, Unpublished Undergraduate Thesis, Central Mindanao University, Philippines, 29-34.

Pelt R, Franklin J. 2000. Influence of Canopy Structure on the Understory Environment in Tall, Old Growth, Conifer Forest. NRC Canada. Canadian Journal for Researches **30,** 1236-1243.

Sabukti R, Lusiana B, Noordwijk Mvan. 2010. Aboveground Carbon Stock Assessment for Various Land Use System in Nunukan, East Kalimantan, 24-29.

Sace C. 2002. Greenhouse Economics. Munoz, Nueva Ecija, Philippines, 1.

Unruh JD, Houghton RA, Lefebvre PA. 1993. Carbon Storage in Agroforestry: An Estimate for Sub-Saharan Africa. Climate Research **3,** 39-52.

Van Noordwijk, M, Subekti R, Hairiah K, Wulan Y, Farida A, Verbist B. 2002. Carbon Stock Assessment for a Forest-to-Coffee Conversion Landscape in Sumber-Jaya (Lampung, Indonesia): From Allometric Equation to Land Use Change Analysis **45,** 75-86.