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An overview of Carbon sequestration potential of Rubber tree plantations

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ABSTRACT

Rubber trees capture atmospheric CO2 through photosynthesis, reduces Carbon (C) from the atmosphere and store it for several decades in the plant tissues as biomass. The central carbon pools in rubber plantation are biomass that are above ground, below ground and dead organic material. Sequestering atmospheric CO2 into long-lived wood biomass through afforestation and reforestation is a vital tool to mitigate global warming and climate change. We reviewed the existing information of carbon stocks in rubber tree plantations considering the biomass above ground, biomass below ground, dead organic materials and latex harvested. Past studies on contributions of rubber plantations to climate change mitigation with focus on Carbon stocked in tree biomass above and below ground showed that rubber plantations constitute C stocks comparable to some agroforestry or forestry systems. However, the global Greenhouse Gas (GHG) emissions balance needs to consider the establishment of rubber plantations on previous land use.

Keywords: Carbon sequestration, carbon stock, rubber plantations, land uses, climate change mitigation

1. INTRODUCTION

Rubber (Hevea brasiliensis Müll. Arg.) is one of the most economically important tree crops in tropical areas of the world. Rubber plantations provide natural rubber latex and rubber wood for several downstream industries. In addition to giving latex and wood, rubber plantations also help to purify the air we breathe by capturing harmful Carbon Dioxide (CO2) and reducing Global Warming. Rubber trees grows up to 40 meters (m) high in natural forest but does not exceed 25m in height when cultivated. Rubber tree is a perennial crop by nature that is usually cut-down and replanted after 35 years when latex yields decreases to an uneconomic level (Mesike et al., 2010). According to Warren-Thomas et al., (2018) and Ziegler et al., (2009), there has been significant commercial expansion of natural rubber in the tropical rainforest region. The Southeast Asia countries such as Thailand, Indonesia, Vietnam, and Malaysia produces almost 83% of natural rubber in the world (Blagodatsky et al., 2016).

The expansion in the cultivation of natural rubber is driven by the increase for natural rubber demand in China and India. According to the land area planted for rubber has increased to 14.1 million ha over the last three decades. The increase in the land area planted for natural rubber is visible in the Mekong region and Cote d'Ivoire in Africa. This expansion of natural rubber is expected to increase with a projection of 2.4% per annum in the next decade (IRSG, 2019). Climate change is a major environmental problem in the world. Climate change is defined as the emission of greenhouse gases (CO2 CH4 N2O) as a result of direct or indirect burning of non-renewable resources. According to FAO, (2002), the tropical rainforest contains the most significant living biomass on very delicate soils and it may lose its fertility completely when precise cutting are performed.

According to IPCC, (2006) about 1.5 billion tons of carbon is released into the atmosphere each year due to tropical deforestation for agricultural expansion when forests and grasslands are cleared, burned and converted to agricultural systems. Agriculture contributes to over 20 percent of worldwide anthropogenic greenhouse gas emissions. According to Houghton et al., (2012), land-use system and land-cover change contributed about 33% of the global carbon emissions for the past 150 years. However, the current relative contribution of global carbon emissions has declined to about 13 % annually (Houghton et al., 2012). Notwithstanding, the IPCC has posited that tropical deforestation is estimated to release about 1.9 billion tons of carbon into the atmosphere each year.

There is a growing interest of researcher in the world in reducing the emissions rate of greenhouse gases from agriculture related activities. However, increased land-use system such as forestry and agroforestry systems will significantly reduce the atmospheric greenhouse gas levels for more extended periods. According to Soto-Pinto et al., (2010) and Verchot et al., (2007), tree crop plantations can sequester carbon for more extended periods with minimum annual fluctuations and also have a high significant sequestration potential when compared to regular tropical agriculture. However, Liguori et al., (2009) has argued that annual crop like maize can fix more carbon than tree crops in any given year.

Still, their biomass decomposes very fast and carbon is sequestered to the atmosphere very fast. Although, establishment of rubber plantations can drive deforestation but they have large potentials to sequester atmospheric carbon into the biomass and soil at the end of rotational cycle than other tropical crops such as oil palm, cocoa, citrus (Kongsager et al., 2013; Sun et al., 2017). In addition, rubber production is likely to grow the economies of the tropical countries with relatively low net carbon emissions. The underlying goals of this paper review the information pertaining to biomass carbon, soil organic carbon (SOC) present in rubber tree plantation and the effects of land –use change.

2. CARBON STOCK IN RUBBER PLANTATIONS

The central carbon stocks in rubber plantations are the aboveground biomass (AGB), belowground biomass (BGB), soil organic carbon (SOC), and other minor components such as litter layer and dead wood. Collected latex is also considered when calculating the carbon sequestration potential of rubber plantations. The carbon stocks estimate in rubber plantations can be determined by three main factors: viz, (1) plantation age; (2) plantation management (tree density, latex tapping and fertilization) and (3) environmental and edaphic conditions controlled by the local climate and topography. The third factor is the primary determinant for the size of SOC stocks – an essential part of total ecosystem carbon (TEC). SOC has the most extended lifetime if undisturbed, and it contains historical land use and local edaphic conditions. Carbon sequestration potentials of rubber trees were estimated in several studies over the years.

There are wide variations in the growth of rubber in various tropical and subtropical regions due to different climate patterns, altitudes, and soil types (Brahma et al., 2018; Choudhary et al., 2016; Grieco, 2011; Kongsager et al., 2013; Liu et al., 2017; Maggiotto et al., 2014; Yang et al., 2016). In a separate study that was conducted in China by Cheng et al., (2007) and Song and Zhang, (2010), they found a high carbon sequestration potential in rubber plantations in China. In fact, Cheng et al., (2007) concluded that rubber plantations could sequestrate about 272.08 tC/ha within a 30-year-life span, while Song and Zhang, (2010) estimated about 123.49 tC/ha carbon stock for a plantation with a higher elevation of about 550-600m. In another experiment conducted in West Africa region, Kongsager et al., (2013) has estimated the biomass in four tree crops in Ghana with focus on rubber, cocoa, oil palm and orange.

The most considerable carbon content of 214 tC/ha was found in rubber plantations while cocoa, orange and oil palm plantations have a much lower carbon content of 65 tC/ha, 76 tC/ha and 45 tC/ha respectively. In an experiment carried out by Day, (2005) to estimate the average carbon stock in 51,510 ha of rubber plantations in North-Eastern states of India, he observed that the average carbon stored in rubber plantations was about 136tc/ha out of which 92.7tc/ha was from soil and 2.40tc/ha was through litter fall and undergrowth vegetation. In another work carried out in Xishuangbanna, China by Nizami et al., (2014), to study the effects of rotation length on the C stocks in rubber plantations, he found that the total carbon stocks was 186.65 Mg C/ha and concluded that more extended rotational lengths have higher carbon stocks in below-ground carbon stock after four consecutive rotations.

In a similar experiment by Yang et al., (2017) and Yang et al., (2019), about 148Mg C/ha carbon stock was estimated in old rubber plantations in Xishuangbanna, China. In the conclusion of the study conducted by Kiyono et al., (2014), in Northern Laos, it was posited that carbon stock of 50.0Mg C/ha in the biomass of a rubber trees of economic life of 30 years was much greater than carbon stock of 18.6Mg C/ha of a five years fallow period slash-and-burn agricultural system.

3. EFFECT OF LAND USE CHANGE

Song and Zhang, (2010) have argued that land use by cultivating rubber plantations in the short-term leads to carbon sequestration. Also, Fox et al., (2014) have also argued that land use change from swiddening (slash and burn) agriculture to a rubber plantation can also lead to carbon but, carbon stocks in land use types vary and dependent on the development stage, management type, location etc of the plantation (Ziegler et al., 2012). According to Fox et al., (2014), Rotational swiddening agriculture were classified into fallow phases of different lengths, such as short length of less than five years; medium length of 5 to 10 years and long length of 10 to 25 years. Depending on the type of length, the amount of carbon sequestration for a land use type can vary. According to Petsri et al., (2013), conversion of forest to rubber plantation usually results to strong loss of C.

In another study carried out by Ziegler et al., (2012), they observed that there was a slight mean positive trend for long-term land fallow when swiddening agriculture is substituted with rubber plantation. They concluded that when a secondary forest is converter to a rubber plantation for prolonged term, it sequesters carbon of about 250 Mg C/ha. When a sole rubber plantation system is converted to rubber agroforestry system, the C sequestration potential of the plantation increases. In a study carried out in Indonesia by Palm et al., (1999), they found that carbon stocks increased from 46Mg C/ha to 89Mg C/ha when a 30 years rotational rubber were compared with permanent jungle-rubber. In a similar study in Indonesia, it was observed by that there was an increase in carbon stocks from 38Mg C/ha to 91Mg C/ha when a sole rubber system were converted to a rubber agroforestry system.

4. CONCLUSION

Rubber trees absorbed carbon dioxide in the atmosphere and stored it in its biomass, litter, and understory vegetation and in the soil. With this, rubber plantation can act as carbon sink. Rubber plantation have the potential to partially mitigate greenhouse gases by trapping carbon in the atmosphere. Carbon sequestration potential in rubber plantations is achieved by establishing rubber plantation on degraded forest or agricultural land. For example, the transformation of agrarian to grassland ecosystems is a common problem, and converting these land-use types into rubber plantations could sequester carbon and also generate income and foreign exchange from produce. However, converting mature forest to agrarian usually results to large carbon debts except when it is cultivated with rubber trees where the carbon payback time is around 40 years. Therefore, rubber plantations are established in low-carbon, severely degraded agricultural or forest land.

Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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