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17th - 19th APRIL 2007

Kingwood Resort
MUKAH, SARAWAK

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CARBON SEQUESTRATION IN BIOMASS OF IMMATURE-RUBBER, BANANA AND PINEAPPLE INTERCROPPING SYSTEM

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INTRODUCTION

Carbon sequestration in soil or the net removal of CO_2 from the atmosphere into long-lived soil carbon (C) pools has received a lot of research attention but less so for plant biomass C pools. However, C sequestration in plant biomass is considerably huge especially in forest ecologies. The potential of agricultural cropping systems (soils and crops), particularly crops, acting as sinks for the greenhouse gas CO_2 is huge, thereby reducing CO_2 levels in the atmosphere. In the case of the crops, CO_2 from the atmosphere is fixed into the crops through photosynthesis. In the soil, C is fixed in the form of organic matter in the soil from the litter of plant materials. Agriculture also acts as a source of CO_2 emissions through biomass burning, deforestation, tillage, fossil fuels burning and land degradation.

To mitigate the problem of greenhouse gases, the Intergovernmental Panel on Climate Change (IPCC) at a meeting held in Kyoto, Japan in 1997, reached an agreement (Kyoto Protocol) to reduce greenhouse gas emissions (UNFCCC, 2003). There are provisions in the protocol, which has resulted in the emergence of the concept "Carbon Trading" wherein countries can gain points for undertaking actions that reduce the level of CO_2 emissions into the atmosphere. In the protocol, agricultural systems are considered as both greenhouse gas emitters and sinks.

There is active research worldwide to understand more fully the complex nature of the earth's C cycle and the role agriculture can play in its management to mitigate CO_2 emissions into the atmosphere and the consequent effects on our environment (USDOE, 1999; Pandey, 2002; Laclau, 2003).

This study involved the use of a computer simulation model to estimate the potential C sequestration (C fixed) in the biomass of an intercropping system of immature-rubber, banana and pineapple.

MATERIALS AND METHODS

A FORTRAN computer model, **SURHIS** (**S**haring and **U**tilisation of **R**adiation intercepted in a **H**edgerow-**I**ntercropping **S**ystem), was developed for simulating daily solar radiation interception and biomass production of immature-rubber, banana and pineapple intercropping system. Biomass (dry matter) accumulation or crop growth was modelled based on the net biomass resulting from the difference between crop photosynthesis and respiration as shown simplistically in equation 1.

$$G = \left[A_d (30/44) - R_{m,T} \right] / C \qquad [1]$$

G	= Biomass growth rate	(kg dry matter ha^{-1} d^{-1})
A_d	= Total daily rate of gross CO_2 assimilation	(kg CO_2 ha^{-1} d^{-1})
R_m	= Maintenance respiration and	(kg CH_2O ha^{-1} d^{-1})
C	= Assimilate required for dry matter production	(kg CH_2O kg^{-1} dry matter)

The amount of carbon sequestered in the biomass of rubber, banana and pineapple was estimated based on the relationship shown in equation 2 (Thenkabail *et al.*, 2003; CSITE, 2003).

$$1 \text{ kg dry weight} = 0.5 \text{ kg carbon} \qquad [2]$$

RESULTS AND DISCUSSION

Tables 1, 2 and **3** show the potential C fixed in immature-rubber, banana and pineapple crop biomass respectively at 265 days after field planting (DAP) for different cropping scenarios. The results indicate that substantial amounts of carbon is fixed in the crop biomass of the intercropping system 265 DAP. About 10, 13 and 1 t C ha^{-1} was fixed by rubber, banana and pineapple, respectively. Although banana showed a higher fixation capacity, rubber is a better long-term crop pool because of its perennial life cycle. However, the banana and pineapple crops after harvest can be of long-term benefit if the crop residue is not burned but ploughed back into the soil or allowed to decompose. This will increase the carbon pool in the soil. In the case of rubber, leaf litter and decomposing dead roots and stems/branches can also add to the soil carbon pool. Sathaye and Ravindranath (1998) reported that agroforestry systems have the potential to sequester an average yearly estimate of about 25 t C ha^{-1} over 96 million ha of land in India, and 6-15 t C ha^{-1} over 75.9 million ha in China. These values are less than that of the rubber, banana and pineapple intercropping system, which total 25 t ha^{-1} of C for only 265 DAP. This shows the vast potential of this intercropping system to sequester carbon.

It is evident in the results that banana and pineapple, if grown alone as a monocrop can fix about 29% and 91% more carbon respectively per hectare compared to the intercropping system. This is in part due to the high plant population densities of these crops in the monocrop scenarios.

Carbon sequestered in plant biomass can be converted into economic terms if so desired for carbon trading especially for rubber, which falls into the category of forest crops and so can be used for carbon trading according to the Kyoto protocol.

Table 1 The simulated potential C fixed and dry matter (DM) for up to 265 days after planting of rubber for a field plot for two cropping scenarios

Cropping Scenario	PPD (ha^{-1})	Carbon Fixed (t ha^{-1})	Dry Matter Yield (t ha^{-1})
Monocrop	485	13.0	25.99
Intercrop	485	13.0	25.94

Table 2 The simulated potential C fixed and dry matter (DM) for up to 265 days after planting of banana for a field plot for three cropping scenarios

Cropping Scenario	PPD (ha^{-1})	Carbon Fixed ($t\ ha^{-1}$)	Dry Matter Yield ($t\ ha^{-1}$)
Monocrop	1,680	13.9	27.9
	1,800	14.0	28.0
Intercrop	880	10.1	20.3

Table 3 The simulated potential C fixed and dry matter (DM) for up to 265 days after planting of pineapple for a field plot for three cropping scenarios

Cropping Scenario	PPD (ha^{-1})	Carbon Fixed ($t\ ha^{-1}$)	DMY ($t\ ha^{-1}$)
Monocrop	50,000	11.6	23.2
	55,000	11.7	23.7
Intercrop	7,040	1.0	2.1

CONCLUSIONS

From the results of the potential amounts of carbon that can be sequestered by the crops alone in this intercropping system, research need to be done to quantify the full potential C sequestration of whole crop-soil systems and not limited to soil only.

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