Greenhouse gas fluxes, global warming potential and emergy evaluation of Quesungual slash-and-mulch agroforestry system

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1. INTRODUCTION

Agroforestry systems have the potential to reduce net emissions of greenhouse gases (GHG): nitrous oxide (N2O), methane (CH4) and carbon dioxide (CO2), and offset the emissions associated with deforestation and land use change from forest to agriculture (Dixon, 2004). However, data on GHG fluxes between soil and atmosphere, in tropical agroforestry systems are limited (Rondon, 2000). Quesungual Slash-Mulch Agroforestry System (QSMAS) is an indigenous system practiced in southern Lempira, Honduras, and it is considered a valuable alternative to traditional slash-and-burn system. QSMAS include management technologies of soil, crops and cover and has four basic principles: (1) no slash and burn, (2) permanent soil cover, (3) minimal disturbance of soil, and (4) efficient use of fertilizer (Weltchel et al., 2006).

2. OBJECTIVES

The main objectives of this study were (i) to assess GHG fluxes and its annual accumulation, in 5 land uses: QSMAS with three different ages (young, medium and mature), slash-and-burn traditional agriculture (SB) and secondary forest (SF), (ii) to quantify global warming potential (GWP) of these land uses and (iii) to conduct an emergency evaluation to quantify resources use and sustainability, in southern Lempira, Honduras (Figure 1 a, b, c).

3. MATERIALS AND METHODS

3.1 Location: This study was conducted in eight farms (14 * 05 N, 88 * 30 W) in Candelaria and Guacilcis districts, southern Lempira, Honduras (Figure 2). This site is a tropical dry forest ecosystem (Holdridge 1967) with igneous rocks from Tertiary (Hellin et al., 1999). The region has a humid tropical climate with annual mean temperature of 25°C, annual rainfall of 1400 mm (rainy season from May to October), slopes between 5 and 50%, and elevations between 200 and 900 masl. Soils are sandy and are classified as Entisols (Lithic Udorthent, USDA classification) related to intrusive and igneous rocks from Tertiary (Heilin et al., 1999).

3.2 Protocol for GHG determination: For monitoring GHG fluxes between soil and atmosphere, we used the closed chamber technique, described by Rondón, 2000 (Figure 3). Annual accumulated fluxes for each land use were calculated using GHG fluxes.

a. GHG sampling: At the beginning of the study, 4 PVC rings (height 8 cm, ø = 25 cm) were located in the 15 plots of 200 m² (5 land uses: SB, QSMAS <2, QSMAS 5-7, QSMAS >10 years and SF, with 3 replicates for each land use). In every closed chamber (60 in total -15 plots and 4 chambers per plot-) and at each sampling date (16 dates), 4 air samples were taken (at 0, 10, 20 and 30 minutes, after installing the chamber -height 10 cm, ø = 25 cm- over the PVC ring). Air samples were extracted from the closed chamber using a syringe with an adapted valve and then introduced into glass containers (pre-vacuumed vials by freeze drying).

b. GHG determination: N2O and CH4 concentrations were determined in the laboratory, using a Shimadzu GC-14A gas chromatograph, equipped with FID (flame ionization detector) and ECD (electron capture detector) for CH4 and N2O detection, respectively. For CO2 concentration, we used a Qubit Systems 5115 gas analyzer, with infrared technology.

3.3 GWP calculation: To calculate GWP of the different land uses, we used CH4 and N2O fluxes between soil and atmosphere, and C stocks from soil and total biomass. In traditional system of SB, we also included direct emissions of CO2, CH4, and N2O, from the biomass burning. GHG fluxes of each land use were multiplied by the global warming potential value, corresponding to the GHG and time horizon used (CO2=1, CH4=27 and N2O=29, in a 20 years time horizon, IPCC, 2001).

3.4 Emergy evaluation: The emergy is a measure of the total energy used in the past to make a product or service. Diagrams were elaborated using data from the 15 plots and transformed reports by other authors. Different emergy indices were calculated using the methodology used by Diemont et al., 2006. The ecological footprint index was derived by dividing the total emergy yielded by a system by the total renewable emergy flows supporting the same system. The sustainability index is an aggregate measure of yield and sustainability that assumes that the objective function for sustainability is to obtain the highest yield ratio at the lowest environmental load.

4. RESULTS

4.1 Global Warming Potential

Maximum value of GWP was found with SB (4040 Mg Eqv. CO2), followed by QSMAS (10530 Mg Eqv. CO2) and SF (1130 kg Eqv. CO2). This high value of GWP showed by SB is related to higher GHG emissions and indicates that this SB traditional system is markedly contributing to global warming than QSMAS and SF systems, which showed lower values of GWP, indicating less disturbed systems (Figure 7).

5. CONCLUSIONS

•GHG fluxes showed a seasonal behavior, with higher emissions during the rainy season.
•Quesungual (QSMAS) and secondary forest (SF) systems were net methane sinks. On the other hand, slash and burn (SB) system was the net source of methane; methane emission being a good parameter to evaluate appropriate soil and cover management.
•QSMAS has a small value of GWP, compared to SB, and its behavior is comparable to SF.
•The region of Southern Lempira in Honduras is not affecting regional balances of GHG, due to current use of more environmentally friendly systems, such as SF and QSMAS.
•QSMAS is a sustainable system, broadly favoring the use of renewable and local resources, while SB traditional system is affecting the resources and presenting a low value of sustainability index.
•In general, QSMAS showed more environmental benefits and advantages than SB traditional system.

6. ACKNOWLEDGMENTS

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7. REFERENCES CITED

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