WCCLF 2021

II World Congress on Integrated Crop-Livestock-Forestry Systems

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WCCLF 2021 PROCEEDINGS

Embrapa

AGRICULTURAL RESEARCH AND INNOVATION ON THE 2030 AGENDA

PROCEEDINGS REFERENCE

II WORLD CONGRESS ON INTEGRATED CROP-LIVESTOCK-FORESTRY SYSTEMS

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TECHNICAL EDITORS

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PREFACE

Promoted by the Ministry of Agriculture, Livestock and Food Supply - MAPA; Brazilian Agricultural Research Corporation - Embrapa; ICLF Network Association; State Secretariat for the Environment, Economic Development, Production and Family Agriculture - SEMAGRO; Federation of Agriculture and Livestock of Mato Grosso do Sul - Famasul; and FB Eventos, the II World Congress on Integrated Crop-Livestock-Forestry Systems (WCCLF 2021) took place on the 4th and 5th May 2021 in a 100% digital format.

The objective of the Congress was to provide a forum for discussion, theoretical insights and practical applications related to technology as well as economic and environmental aspects of mixed agricultural systems that combine integrated production of crops, animals and trees in the same area, having an efficient use of inputs, all being essential for food security in the future.

ICLF is a production strategy that integrates crop, livestock, and forestry farming in the same area, in a consortium, rotated or in succession, so that there is interaction among components, generating mutual benefits.

For two days, we discussed issues related to challenges and opportunities for ICLF systems around the World; solutions and demands from Agribusiness Companies; scenarios and trends of ICLF in the World; current hot topics in ICLF; solutions and demands for ICLF from the farmer's view; Public Policies for Supporting ICLF; and innovation on ICLF systems.

The integrated agricultural production systems can be implemented combining two or three components, according to the particularities of each farm and region. They can also be adopted in small, medium, and large farms, in different biomes, using different crops, livestock and trees species. Among the many benefits of ICLF are increasing total yields of a given area, diversification of income sources, better use of inputs, improvement of soil chemical, physical and biological qualities, along with improvement of animal welfare as well as jobs and income generation. In addition, ICLF systems reduce pressure to clear new areas, it helps to recover degraded low yielding areas while mitigating greenhouse gas emissions, increasing carbon sequestration in soil and biomass. These benefits corroborate with three of the Sustainable Development Goals - SDGs:

- SDG 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- SDG 13 - Take urgent action to combat climate change and its impacts; and
- SDG 15 Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

These Proceedings report 166 scientific contributions approved by the scientific committee of the WCCLF 2021 and 18 papers from speakers that also contributed to this publication.

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Lucimara Chiari (Executive Secretary of the WCCLF 2021)

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SPATIAL AND TEMPORAL DISTRIBUTION OF GREENHOUSE GAS FLUXES FROM THE SOIL UNDER AN INTEGRATED SYSTEM IN THE SOUTHERN AMAZON

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ABSTRACT

Integrated systems have practices and alternatives aligned with the purpose of greenhouse gas (GHG) mitigation, and knowing the spatial and temporal variability of soil gas fluxes is the first step toward understanding how integrated systems mitigate GHG emissions. This work aims to assess the spatial and temporal distribution of the GHG fluxes of soils cultivated with soybean and corn in integrated systems with trees in Brazil, southern Amazonia. Soil GHG fluxes were measured using static chambers during the whole cycle of soybean and corn cultivation in the integrated system. The trees formed alleys of triple rows of eucalyptus, with 30 m intervals between the alleys. Soybean and corn were successively cultivated in the space between the alleys. The spatial and temporal distribution of the GHG fluxes showed that the nitrous oxide (N_2O) and methane (CH_4) fluxes were highly related to soil management factors, such as fertilization and soil use. As the carbon dioxide (CO_2) fluxes showed a largely similar distribution among the points within the same sampling date, another condition similar across all points (such as precipitation) could be influencing the decomposition of the soil organic matter and root respiration, which are the main processes responsible for CO_2 production in soils

Key words: Nitrous oxide; Methane; Carbon dioxide

INTRODUCTION

Soil is an important source of greenhouse gases (GHGs), which mainly consist of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (OERTEL et al., 2016). If good agricultural practices are adopted, soil can act as a sink, decreasing or avoiding GHG emissions or removing carbon (C) from the atmosphere (OERTEL et al., 2016; SMITH et al., 2008). In the humid tropics, the search for agricultural systems adapted to that specific edaphoclimatic condition has been performed considering not only high productivity but also the provision of environmental services, such as GHG mitigation.

Integrated systems, which come in different configurations, have practices and alternatives aligned with the purpose of GHG mitigation (BEHLING et al., 2013). There are integrated systems that involve trees, which increase the C sequestration in the soil and the tree biomass. Moreover, trees in agricultural systems alter the exchanges of matter and energy compared to monocultures (BEHLING et al., 2013). These shifts are triggered by the type of spatial arrangement and the temporal succession of soil use, and they increase the number of cultures in a year (BEHLING et al., 2013). Thus, new tools must be used to understand the spatial and temporal distribution of attributes related to agricultural systems. This will lead to an understanding of these shifts, which are mainly linked to the shade of trees and the intensification of soil use. In the context of climate change, knowing the spatial and temporal variability of soil gas fluxes is the first step toward understanding how integrated systems mitigate GHG emissions.

The goal of this work was to assess the spatial and temporal distribution of the GHG fluxes of soils cultivated with soybean and corn in integrated systems with trees in Brazil, southern Amazon.

MATERIAL AND METHODS

This work was conducted in the experimental farm of the Embrapa Agrossilvipastoril, Sinop, Mato Grosso, Brazil. The Köppen climate classification of the region is Aw. The soils were classified as Hapludox (SOIL TAXONOMY, 1999) with clay textures in flat relief.

The studied integrated system was established in 2 ha in November 2011. The trees of the system are eucalyptus (*Eucalyptus urograndis* clone H13) that form triple-row alleys (3 m × 3.5 m), with intervals of 30 m between the alleys. In these spaces, soybean (*Glycine max* L.) was cultivated first, and corn (*Zea mays*) was intercropped with Marandu grass (*Urochloa brizantha* cv. Marandu) after soybean harvest. Soybean was sown on October 30, 2016 and harvested on March 3, 2017. Corn was sown on March 3, 2017 and harvested on July 21, 2017. Soybean was sown using a seeding rate to reach 10 plants m^{-1} and 0.45 m of row space, which received 90 kg ha^{-1} of K applied in the planted row and more than 90 kg ha^{-1} of K on the soil surface 30 days after sowing. Corn was sown using a seeding rate to have 3 plants m^{-1} and 0.45 m of row space in combination with the Marandu grass. Fertilization in the corn row consisted of 35 kg ha^{-1} of N, 60 kg ha^{-1} of P, and 60 kg ha^{-1} of K. The corn, in combination with the Marandu grass, also received fertilization of 67 kg ha^{-1} on the soil surface in the corn growth stages 4 and 6 (V4–V6). The whole fertilization was based on soil fertility status and crop requirements.

The GHG fluxes were measured during the whole cycle of both cultures. Fifteen samplings were performed in each cycle of the soybean and corn; each sampling started 3 days after sowing and ended during culture harvest. For this purpose, 12 chambers were distributed across 4 points of the assessed system: 7.5 m north, tree rows, 7.5 m south, and 15 m south. Each point had three replicates, and the average of each point was calculated. The GHG fluxes were evaluated using vented rectangular static chambers whose bases and tops were made of metal and polyethylene, respectively. The chamber size was 0.60 m × 0.40 m × 0.09 m (length, width, and height). The samples were collected in the top of the chamber using a 20 cm^3 syringe (PARKIN; VENTEREA, 2010). We sampled the gas weekly (between 8 and 11 am, with four samples collected within 60 min at 20 min intervals: 0, 20, 40, and 60 min) (PARKIN; VENTEREA, 2010). During gas collection, the internal temperature of the chamber was also measured using a digital thermometer. The samples in the syringes were transferred to vials subjected to a vacuum, then used to determine the N_2O, CO_2, and CH_4 concentrations in a gas chromatograph (SHIMATZU, 2014) equipped with an automatic injector, electron capture detector (ECD), and flame ionization detector (FID). The analytical curve was obtained by determining three known concentrations of standards to the three gases assessed.

Those analytical results were used to establish a linear equation between the increasing the GHG concentrations over the time of the chamber deployment (0, 20, 40, and 60 min). Equation parameters were used to calculate GHG fluxes from the soil to the atmosphere following the equation proposed by Hutchinson and Livingston (1993): Flux (μg N_2O/CH_4, mg CO_2 m^{-2} h^{-1}) = (dC/dt) x V/A x (m/Vm); where: dC/dt = change in gas concentrations within the chamber based on time; V = chamber volume (L); A = chamber area (m^2); m = molecular weight of the gas (g mol^{-1}); Vm = molar volume of the gas (m^3 mol^{-1}) corrected for the air temperature (K) of the headspace chamber.

The average of the GHG fluxes of each point (spatial) in the integrated system was distributed as a function of the time (temporal - days after sowing) of the soybean and corn stages, in which were applied the Spline method of interpolation using the ArcMap® software.

RESULTS AND DISCUSSIONS

Overall, N_2O fluxes were lower in the soil under the alley of trees in the integrated system (Figure 1a), with values between 5 and 25 µg N_2O-N m^{-2} h^{-1} throughout the cycle of the soybean. The highest fluxes were observed in the soil with soybean, with values between 5 and 120 µg N_2O-N m^{-2} h^{-1}. At the point 15 m south in the beginning of the culture cycle was observed high values of fluxes, what can be related to the soil changes in the sowing line, once it just received K fertilization in this period of the culture. The N_2O fluxes increased again 92 days after sowing, with the highest flux at the point 7.5 m north. In this period of the soybean occurs the dead of the nodule responsible for N_2 fixation and the senescent leaves fall in the soil surface, increasing soil temperature, what favor the N_2O formation (NASCIMENTO et al., 2021). Besides, when tree shade was more projected to the north, at the end of the soybean cycle, was observed the highest fluxes at the point 7.5 north, and, at the beginning of the culture, when the tree shade was projected to the south (MAGALHÃES et al., 2018), this point had the highest fluxes. All these may evidence the role of the temperature on the processes related to the N_2O formation (BUTTERBACH-BAHL et al., 2013).

The CO_2 fluxes were between 50 and 300 mg CO_2-C m^{-2} h^{-1} (Figure 1 b). Such as to the N_2O, the highest fluxes occurred in the soil with soybean, however, CO_2 fluxes seemed to have less influence of the soil management once the soil under the alley of tress and soybean had similar fluxes, forming more vertical zones of the same color. In this case, the rainfall, that is similar to the all points, could help to explain these similar fluxes, even on the influence of the shade.

In general, all the point assessed in the integrated system showed soil with CH_4 influxes during the soybean cycle (Figure 1c), with values mostly between 0 to less than -4 µg CH_4-C m^{-2} h^{-1}. When fluxes were observed they occurred in the soil cultivated with soybean. The homogeneous color zones more distributed in the horizontal can be an evidence of more influence of the soil management on the CH_4 formation in the integrated system.

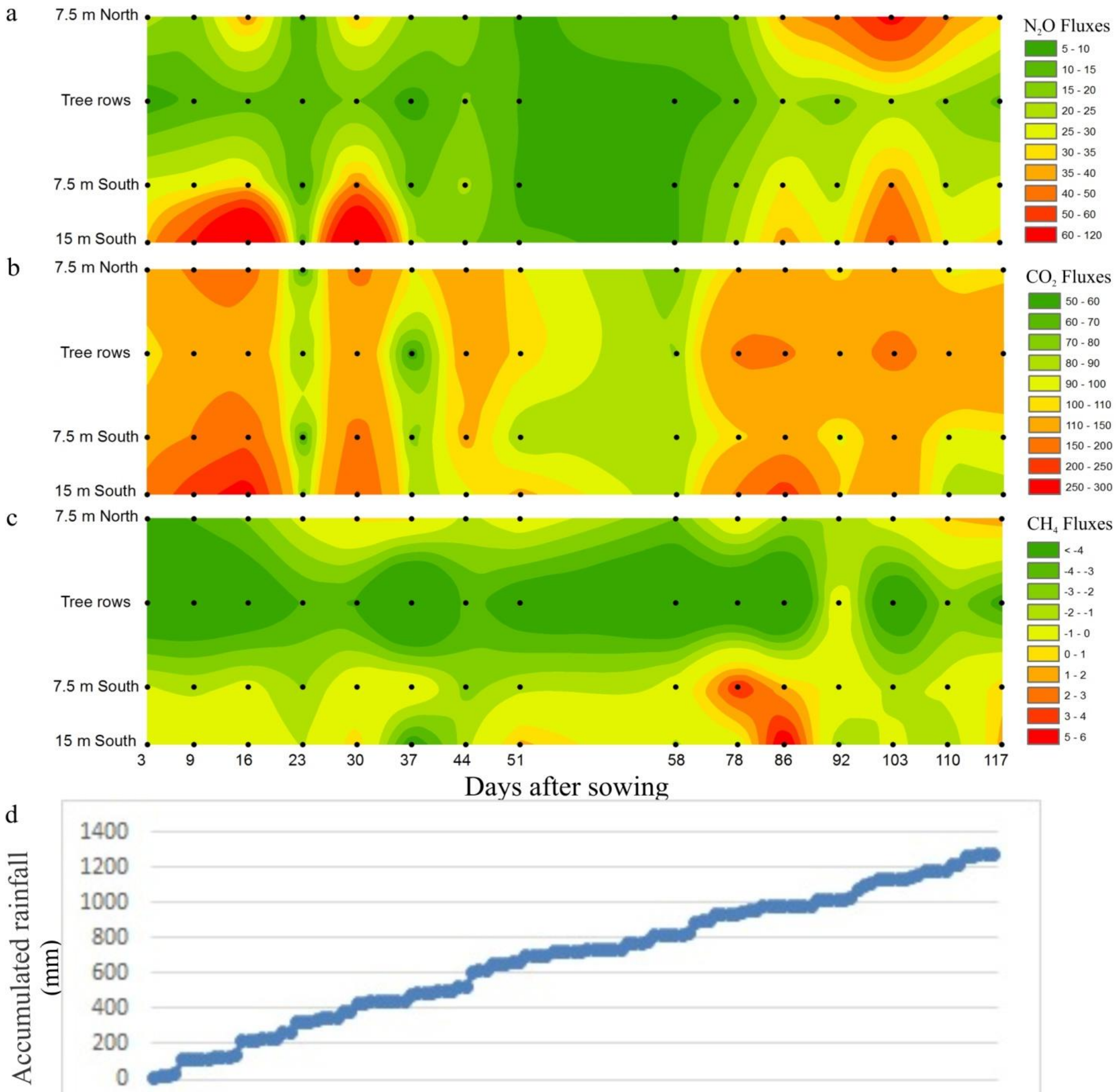

Figure 1. Spatial and temporal distribution of the fluxes of N_2O (µg N_2O-N m^{-2} h^{-1}) (a), CO_2 (mg CO_2-C m^{-2} h^{-1}) (b), and CH_4 (µg CH_4-C m^{-2} h^{-1}) (c) from the soil and accumulated rainfall (d) throughout the soybean cycle in intergraded system with trees in the Southern Amazon – Brazil.

Such as to the soybean, soil cultivated with corn showed higher N_2O fluxes than under the trees (Figure 2a). The highest N_2O fluxes occurred after N fertilization on the soil surface 24 to 30 days after sowing, with values between 50 and 120 µg N_2O-N m^{-2} h^{-1}. Increasing the N availability in soils with the fertilization, added the period of rainfall, triggered the formation of N_2O in the soil with corn (BUTTERBACH-BAHL et al., 2013). Even with high fluxes in the soil with corn, the soil under the trees showed fluxes below 25 µg N_2O-N m^{-2} h^{-1} at the same period.

Around 80 days after sowing, when there was no more rainfall, all the points and dates had N_2O fluxes below 20 µg N_2O-N m^{-2} h^{-1}.

Until 24 days after sowing, the highest CO_2 fluxes occurred in the soil under the trees (Figure 2b). From this period, homogeneous color zones in the vertical appeared with more frequency, showing likely more influence of the water availability than the soil management on the processes related to the oxidation of soil organic matter and the root respiration. Such as to the N_2O, the CO_2 fluxes decreased a lot 80 days after sowing, further highlighting the role of the rainfall on this gas.

The CH_4 fluxes were in general below zero throughout the corn cycle (Figure 2c). The higher values of influx occurred in the soil with trees, with values below -20 µg CH_4-C m^{-2} h^{-1} 24 day after sowing. In general, it was observed a trend of form homogeneous color zones in the horizontal, showing the role of the soil management on the formation of this gas.

Taken into account the both cultures, the soil under the alley trees showed more methanotrophy than the soil with soybean or corn, corroborating Oertel et al. (2016), who claim that forest soils have more methanotrophic potential and showed similar results that those shown here.

An important point to highlight during the soybean and corn cycles is the facts that on the dates when there was an increase in N_2O fluxes occurred an increase in CO_2 fluxes in the same points. What differentiates the two is the fact that the increases in N_2O occurred only in the points that underwent some management intervention, whereas the increases in CO_2 fluxes also occurred in the points without interference of these managements.

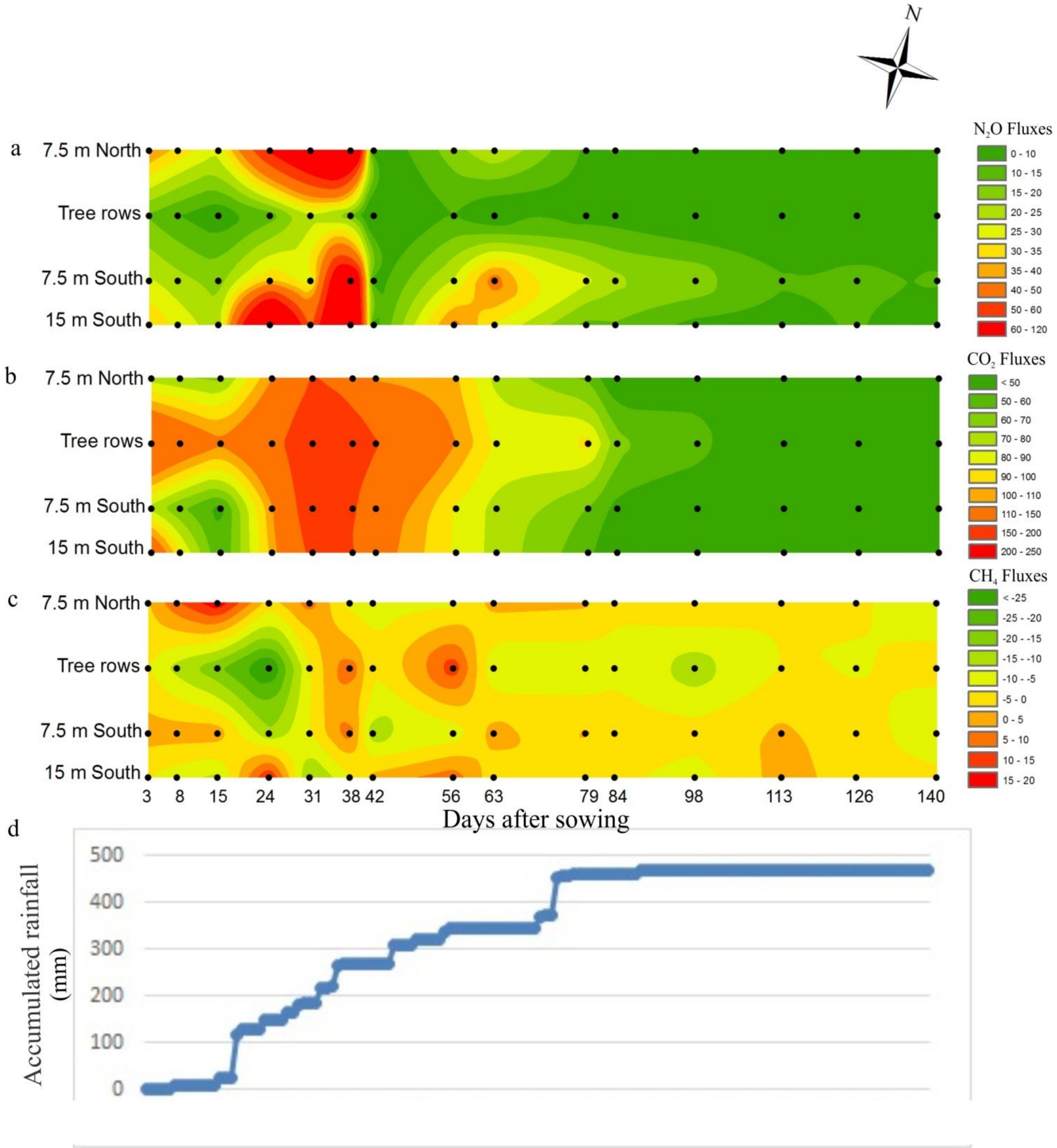

Figure 2. Spatial and temporal distribution of the fluxes of N_2O (µg N_2O-N m^{-2} h^{-1}) (a), CO_2 (mg CO_2-C m^{-2} h^{-1}) (b), and CH_4 (µg CH_4-C m^{-2} h^{-1}) (c) from the soil and accumulated rainfall (d) throughout the corn cycle in intergraded system with trees in the Southern Amazon – Brazil.

CONCLUSIONS

For the edaphoclimatic conditions of the Southern Amazon, the spatial and temporal distribution of the GHG fluxes of the soil cultivated with soybean and corn in intergraded system showed that N_2O and CH_4 fluxes are more related to the soil management, such as fertilization and soil use (tree, soybean, corn). As CO_2 fluxes showed more similar distribution among the points within the same sampling date, it seems that another condition, such as precipitation, similar to all points, could be a factor influencing the decomposition of the soil organic matter and root respiration, the main processes responsible by the CO_2 production in soils.

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