Long-term no-fire conservation agriculture diversifies production on a sandy Acrisol in Acre state, southwestern Brazilian Amazon

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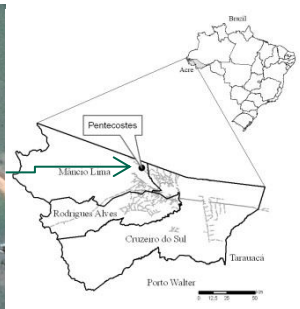
Introduction

The conservation agriculture (CA) needs "no-fire" (no-fire CA) in Brazilian Amazon, where slash-and-burn agriculture (SBA) is still common, which decrease soil organic matter (SOM) and increase greenhouse gases emissions and decrease crops production. Soil tillage to smallholders do not is actually a common practice nowadays. But this scenario is changing by the regional agribusiness. In the Juruá region of Acre State, where this study was carried out, predominate sandy soils. Cassava (*Manihot esculeta*, Crantz) is the main crop and almost monoculture in smallholder farming. But cultivation of cassava is SBA-based, i.e. a low technological system. Soil tillage associated to soil sandy features and total annual precipitation in Juruá can increase erosion because cassava cultivation starting is coincident to begin of rainfall regional station. This corolarium indicate to a decreasing productivity of cassava and likewise to others agricultural crops. The hypothesis of this study is that no-fire CA to smallholder farming is part of the solution of scenario presented. To test this hypothesis no-fire CA models were evaluated in comparison to SBA. Economic and environmental results are presented.

Methods

The study was carried out in a ongoing 15-year long-term experiment located at the rural area of Pentecostes, Mâncio Lima municipality (7°28' S, 72°56' W, 190 m asl), Acre State, Brazilian Amazon, stablished in a smallholder farming partnership on a Acrisol with 134, 77 and 786 g kg^{-1} of clay, silt and sand respectively in the 0–20 cm layer (Picture 1). The regional climate is Af according to Köppen classification with 2005-2019 mean annual precipitation and temperature of 2,151 mm 25.6°C, respectively.

Picture 1. Orthophotograph of experimental plots in 2014 from Mâncio Lima, Acre, Brazilian Amazon. Google Earth, 2021.



The experiment is a split-plot design in a randomized complete blocks with three repetitions for no-till (NT) and conventional tillage (CT – plow harrow) (main plots), employing cassava/green manure/maize/cowpea; subplots were (1) Control SBA (2) green manures (*Mucuna aterrima, Canavalia ensiformes, Sorghum bicolor, Cajanus cajan, Pennisetum glaucum*) as soil cover crops - SCC (3) SCC + P-fertilizer (4) SCC + liming, and (5) SCC + P-fertilizer + liming. CT and NT in combination with subplots 2 to 5 are considerate in this order technological evolutions of no-fire CA systems. This study is concern to comparisons between SBA and no-fire CA boths with CT5 and NT5, named CT and NT, respectively. The economic analysis integrated cassava and maize crops results from 2015 to 2019. Costs and economic indicators were calculated. The CO_2e costs of agricultural operation and biomass burning were calculated with NT-SBA meaning avoided emissions of plow harrow operation and biomass burning and NT-CT meaning avoided emissions of plow harrow operation.

Results

The economic (Table 1) and environmental results of no-fire CA were positive compared to SBA. The total cost, with no-fire CA being ~50% in average NT-CT greater than SBA, was offset by increases in no-fire CA in NT and CT compared with SBA also in NT and CT in total income from the activity (327% NT and 204% CT), in the remuneration of labor (347% NT and 202% CT), in the daily rate paid to the smallholder (430% NT and 217% CT), and in the total productivity of the factors of production (181% NT and 100% CT) (Table 1). The net income was positive only in the no-fire CA in NT (R$31.36) *versus* SBA (R$-1,434.60), demonstrating its economic viability. The associated average productivity (cassava + maize from 2006 to 2019) at SBA was 7.6 t ha^{-1}, while for no-fire CA it was 21 t ha^{-1} (NT) and 20 t ha^{-1} (CT) (Figure 1), as a result of increasing technology input of 178% (NT) and 165% (CT).

Table 1. Economic analyses of the slash-and-burn agriculture (SBA) and no-fire conservation agriculture (no-fire CA) models in conventional tillage (CT) and no-tillage (NT). Mâncio Lima municipality, Acre State, Brazilian Amazon. Results are in Brazilian Real (R$1.00).

	-------SBA-------		-----no-fire CA-----	
Economic parameter	CT	NT	CT	NT
Total cost	2,377.77	2,242.00	3,584.41	3,412.73
Total income	1,083.60	807.38	3,296.60	3,444.10
Remuneration of labor	530.77	392.23	1,602.60	1,753.82
Daily rate paid to the small farmer	21.01	14.68	66.60	77,75
Total productivity of the factors (dimensionless)	0.46	0.36	0.92	1.01

NT avoided the emission of 1,536 t ha^{-1} of CO_2e in 13 years due to the absence of fire and soil preparation in comparison to SBA-CT. The avoided emission of NT-CT both in no-fire CA due only soil tillage was 1,470 t ha^{-1} of CO_2e in 13 years (Figure 2).

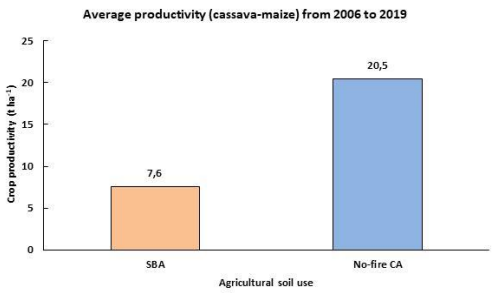


Figure 1. Average productivity (cassava-maize), 2006-2019.

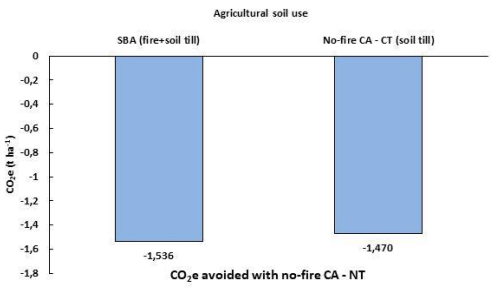


Figure 2. CO2e avoided with no-fire CA-NT in 13 years.

Conclusions

No-fire CA is a suite of technologies with proven agronomic and economic feasibility and low carbon emission. From easy learning, no-fire CA in NT technology can be transferred to farmers, technical assistance and rural extension professionals and students. The results hereby generated can support public policies to strengthen smallholder farming. Smallholder farmers from Juruá, especially residents of areas with sandy soils, are the target for this technological solution. Nevertheless, this technology is also applicable to other scales of production in Acre and other states in the Brazilian Amazon. Insofar practices of the conservation agriculture (no-till, permanent soil cover and crops diversity in schemes of successions, rotations or consortia) are full adopted in the fields, the smallholder agribusiness can be a profitable agriculture and food security, i.e. a win-win strategy.