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SUSTAINABILITY OF ORGANIC AND CONVENTIONAL IRRIGATED SYSTEMS BASED ON FAMILY FARMING

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1 ABSTRACT

This study was conducted at two farms: Carcará Farm, certified by Associação de Certificação Instituto Biodinâmico, and at Estufa Limoeiro Farm, of conventional cultivation. They were located in Guaraciaba do Norte, Ceará, at the geographic coordinates 04°10’52” South, 40°49’41” West, and elevation of 885 m. The main objective of this research was to compare, based on economic, social and environmental indicators, two irrigated production systems, one organic one and a conventional. Data were collected through interviews with the farmers. Generation of jobs, added value, and the farmer’s income was analyzed as variables associated with the socioeconomic dimensions. For the environmental analysis, the biological activity of the soil was evaluated using the variables organic carbon (OC), microbial biomass carbon (MBC), soil basal respiration (SBR), microbial quotient (qMIC) and metabolic quotient (qCO2). The organic cultivation system provided a generation of direct jobs per unit area three times higher than the average of irrigated agriculture in the Brazilian semi-arid region, characterizing it as a system of greater social contribution compared to the conventional system, the organic farming system showed a lower risk associated with the economic dimension. The production unit with organic cultivation had higher environmental sustainability since the soil is in more satisfactory physical and chemical conditions for developing microorganisms.

Keywords: irrigation, sustainable development, generation of the job, social contribution.

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SUSTENTABILIDADE DE SISTEMAS DE CULTIVOS IRRIGADOS ORGÂNICO E CONVENCIONAL DE BASE FAMILIAR

2 RESUMO

A pesquisa foi realizada na Fazenda Carcará, certificada pela Associação de Certificação Instituto Biodinâmico, e na Fazenda Estufa Limoeiro, de cultivo convencional. As fazendas

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estão localizadas no município de Guaraciaba do Norte, Ceará, com coordenadas geográficas 04°10’52’ sul, 40°49’41’’ oeste e altitude de 885 m. Teve como objetivo avaliar comparativamente, a partir de indicadores de sustentabilidade econômica, social e ambiental, dois sistemas irrigados de produção, um orgânico e outro convencional. A geração de empregos, o valor agregado e a renda do agricultor, foram analisados como variáveis associadas às dimensões socioeconômicas. Na análise ambiental, foi avaliada a atividade biológica do solo através das variáveis: carbono orgânico (CO), carbono da biomassa microbiana (CBM), respiração basal do solo (RBS), quociente microbiano (*q*MIC) e metabólico (*q*CO_2). O sistema de cultivo orgânico proporcionou uma geração de empregos diretos por unidade de área três vezes superior à média da agricultura irrigada do semiárido brasileiro, caracterizando-o como um sistema de maior contribuição social. Um menor risco associado à dimensão econômica, comparativamente ao sistema de cultivo convencional. A unidade de produção com cultivo orgânico teve maior sustentabilidade ambiental visto que o solo se encontra em condições físicas e químicas mais satisfatórias para o desenvolvimento de microrganismos.

Palavras-chave: irrigação, desenvolvimento sustentável, geração de emprego, contribuição social.

3 INTRODUCTION

Family farming has a fundamental role in society and in global interest relations, such as environmental sustainability, food security and sovereignty, healthy eating, as well as overcoming rural poverty (ACEVEDO-OZÓRIO et al., 2018). It has been contributing to social development because, through its millions of small producers, it is a growing sector of major relevance for developing the country.

Irrigated agriculture is a strategic focus of Ceará's agricultural activity since 5% of the area cultivated with agricultural products is from irrigated agriculture, corresponding to 39% of production and 59% of the gross value of production (CEARÁ, 2020).

In the state of Ceará, the agricultural sector is a promoter of rural economic development, especially about income generation. In the Serra da Ibiapaba region, one of the main centers of vegetables and fruit production in the Northeast of the country, agriculture is characterized by the presence of family farmers, who have been essential for the economy of Ceará, with an unquestionable contribution to the development of the state.

Therefore, the strengthening of family farming is of fundamental importance for encouraging sustainable systems, both in a local and a broad view, considering that it is responsible for the cultivation and management practices that provide less environmental impact in the space and in time (BORGES et al., 2020).

Despite the current high production efficiency in agriculture, several environmental and social impacts have been observed, such as soil erosion, contamination of surface water and groundwater, reduction of biodiversity, and loss of associated traditional knowledge, economic dependence, reduction of opportunities for labor and income. For this reason, in recent times, emphasis has been given on the ecological benefits promoted by cultivating organic products. One of the benefits of the organic system is the use of organic manure, which provides increased water productivity (NUNES et al., 2017).

It is worth pointing out that the profile of consumers has been changing, increasing the demand for better quality products, due to the impacts caused in traditional cultivation with the use of pesticides. In this context, the farmer begins understanding the need to change the production bases, thus seeking a more sustainable model.

According to Popa et al. (2019), consumers have a greater concern related to possible negative health effects of foods produced with intensive agricultural methods, thus leading to a growing interest in the benefits of fruits, vegetables and animal products produced in the organic system.

Consumers of organic products consider that these products have quality assurance, free from external contamination such as chemicals, and that producers supply food in accordance with the requirements of production quality and health safety standards (DITLEVSEN; SANDOE; LASSEN, 2019).

Hence, there is an important need for comparative studies involving conventional production and organic cultivation systems. Therefore, this research aimed to analyze these two production models from indicators of economic, social, and environmental sustainability.

4 MATERIAL AND METHODS

The research was conducted at Carcará Farm, which is certified by *IBD Certificações* and at Estufa Limoeiro Farm, of conventional cultivation, located in the municipality of Guaraciaba do Norte, Ceará, at the geographic coordinates 04°10’52” S, 40°49’41” W and elevation of 885 m.

Both farms adopted a localized irrigation system. The micro-sprinkler system was used in the Carcará Farm, and the drip irrigation system was used in Estufa Limoeiro Farm.

In this study, the farmers obtained financing for investment and funding from Banco do Nordeste, through Pronaf — *Mais Alimento’s* financing line. The National Program for Strengthening Family Farming (*Programa Nacional de Fortalecimento da Agricultura Familiar* - PRONAF) provides family farmers with the capacity to generate income and stimulate the use of family labor through rural agricultural and non-agricultural activities and services, giving the family farmer the ability to remain in the agricultural activity, hence ensuring social reproduction (LIMA; SILVA; IWATA, 2019).

Indicators of economic, social, and environmental sustainability were used in the analysis of the two production systems.

4.1 Economic and social indicators

The social dimension was evaluated based on the indicator generation of direct jobs and added value, while the economic dimension was evaluated through the farmer’s income indicator, which makes it possible to evaluate economic viability at the production unit level (SILVA NETO, 2005).

The direct job generation coefficient is one of the main social indicators and reveals the capacity of the production system to generate direct jobs. In this study, the generation of direct jobs was measured from information obtained directly from the farmers.

The added value indicator aims to analyze the capacity of a production unit to generate wealth for society and can be calculated according to Equation 1:

$$AV = GVP - (FC + VC + D) \quad (1)$$

Where AV is the added value (R$); GVP is the gross value of production (R$); FC is the fixed costs associated with the production system (R$); VC is the variable costs associated with the production system, except the cost of labor (R$); and D is the depreciation of equipment and facilities (R$).

The economic analysis of the production systems was based on the farmer's income indicator, which makes it possible to evaluate economic viability at the production unit level, which can be calculated by Equation 2:

$$FI=AV-(I+W+T) \qquad (2)$$

Where FI is the farmer's income (R$); AV is the added value (R$); I is the interest rate paid to banks or other financial agent (R$); W is the wages paid to the labor force (R$); and T is the taxes and tariffs paid to the State (R$).

Considering that the added value calculated for each production unit was associated with a family workforce, as well as a usable agricultural area - UAA (1.0 ha), this relationship was linearly expanded, with the added value being a function of the agricultural area. The generation of this graph made it possible to identify the social contribution (added value) of the production systems and types of farmers, considering the needs of area and fixed capital for their implementation (SILVA NETO, 2005).

We used income models to deduce the minimum UAA for the farm to remain in the agricultural activity, ensuring the farmers' social reproduction (LSR), represented by the minimum wage. Thus, the higher the fixed capital per person required to implement the production system (coefficient b) and the lower the marginal contribution in relation to the area (coefficient a), the greater the UAA per person so that each family workers can receive sufficient income for their permanence in the agricultural activity (SILVA NETO, 2005).

4.2 Biological parameters

For the environmental analysis, soil biological activity was evaluated using the parameters organic carbon (OC), microbial biomass carbon (MBC), microbial quotient (qMIC), soil basal respiration (SBR) and metabolic quotient (qCO2), which were calculated using Equations 3, 4, 5, 6 and 7, respectively (SILVA, 1999; VANCE; BROOKES; JENKINSON, 1987; MENDONÇA; MATOS, 2005; ANDERSON; DOMSCH, 1986). These parameters were evaluated in both types of systems, organic and conventional, and in a native area as the control.

$$OC = \frac{(A).(M).(0.003).(1000)}{\text{sample weight}} \qquad (3)$$

Where OC is the total soil organic carbon (mg kg^{-1} soil); A is the mohr salt and M is the molarity of Ferrous Sulfate.

$$MBC = (CF-CNF) \qquad (4)$$

Where MBC is the microbial biomass carbon (mg C kg^{-1} soil) and CF is the carbon of fumigated sample (mg C kg^{-1} soil).

$$C\text{-}CO_3 = (B-V)\times M\times 6\times \left(\frac{V_1}{V_2}\right) \qquad (5)$$

Where $C\text{-}CO_3$ is the mineralizable carbon (mg $C\text{-}CO_3$ kg^{-1} soil); B is the volume of HCl in the blank (mL); V is the volume of HCl spent in the sample (mL); M is the actual concentration of HCl (mol L^{-1}); V_1 is the total volume of NaOH used in the capture of CO_2 (mL) and V_2 is the total volume of NaOH used in the titration (mL).

$$qCO_2 = \frac{SBR}{MBC} x100 \qquad (6)$$

Where qCO_2 is the metabolic quotient (%) and SBR is the carbon from soil basal respiration (mg $C\text{-}CO_2$ kg^{-1}soil).

$$qMIC = \frac{MBC}{OC} \text{ x } 100 \qquad (7)$$

Where *q*MIC is the microbial quotient (%).

For environmental analysis, soil samples were collected in the surface layer (0 – 10 cm) in three areas: organic cultivation, conventional cultivation, and preserved area. The preserved area was evaluated to compare the microbial activity among the areas.

Organic carbon was determined through wet oxidation of organic matter, by placing a soil sample together with a sulfochromic mixture (potassium dichromate) and heating the mixture until reaching soft boiling (SILVA, 1999).

Microbial biomass carbon was determined using the fumigation-extraction methodology according to Vance, Brookes and Jenkinson (1987). This methodology is based on the difference between fumigated carbon (addition of chloroform) and non-fumigated carbon. Therefore, it is necessary to calculate this carbon separately.

Soil basal respiration (SBR) was determined by the methodology described by Mendonça and Matos (2005), through the evolution and quantification of the C-CO_2 released in the microbial respiration process during eight days of incubation under controlled conditions of light and temperature.

The metabolic quotient was evaluated according to the procedure described by Anderson and Domsch (1989), and this analysis was used as an indicator of the efficiency of the microbial community in incorporating carbon into its biomass.

The statistical analysis was performed using the program "ASSISTAT 7.5 BETA". The data were subjected to analysis of variance (ANOVA). When the F test was significant, the means were compared using Tukey's test with 95% probability ($p \leq 0.05$).

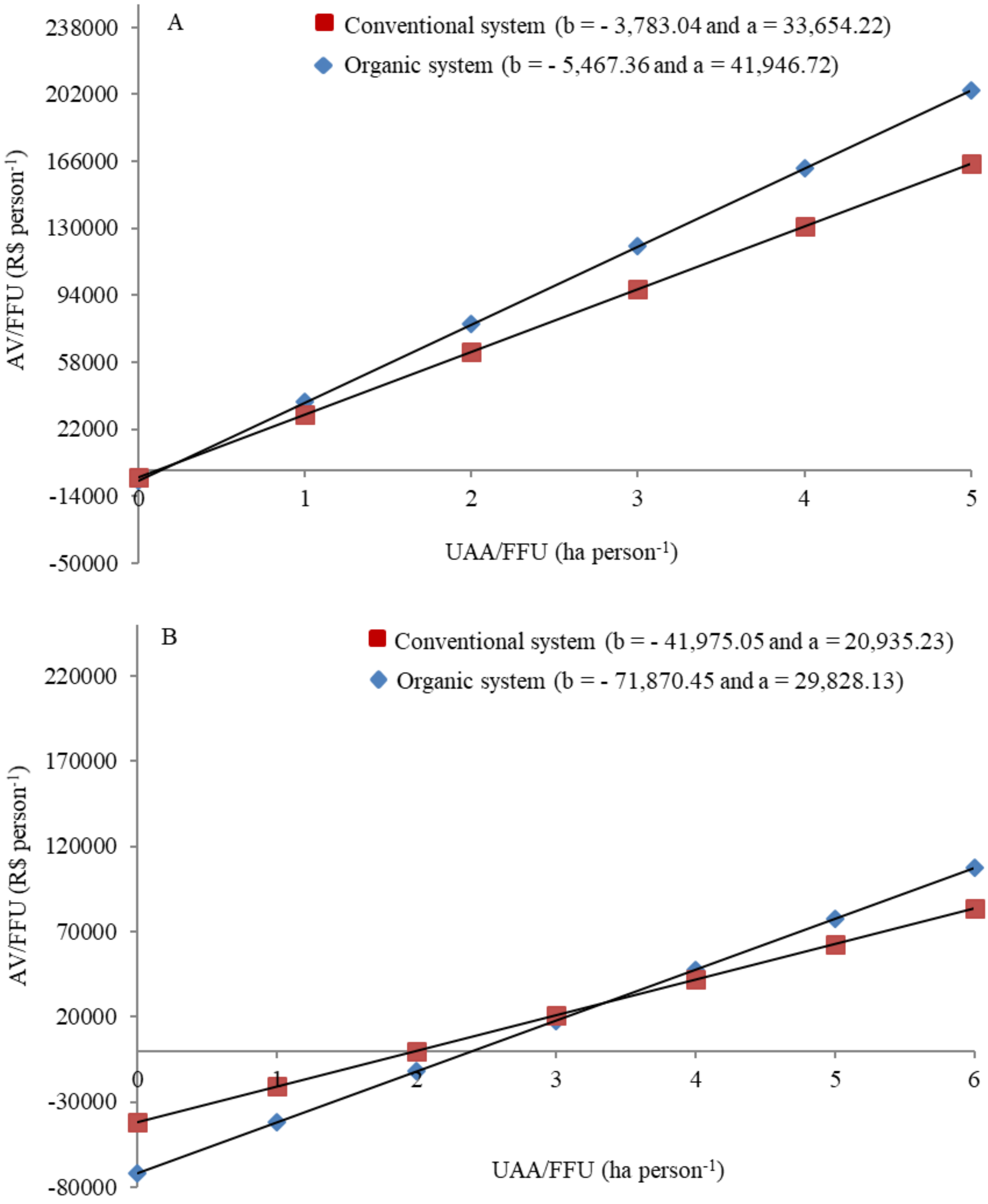
5 RESULTS AND DISCUSSION

Estufa Limoeiro Farm has 4.5 ha in production, which employs six permanent workers during the year, generating 1.33 jobs for each hectare in production. Carcará Farm has 1.16 ha in production and generates 3.45 jobs for each hectare in production, considering that it has four permanent workers and two eventual workers. The higher number of jobs generated by Carcará Farm can be explained by the greater diversification in the production system.

5.1 Economic and social indicators

The added values of production as a function of the UAA for the two production systems with and without financing from PRONAF are shown in Figure 1A and Figure 1B, respectively. The organic system requires a higher fixed cost (R$ 5,467.36) necessary for the implementation of the enterprise, but has a higher marginal contribution (R$ 41,946.72) and, consequently, higher added value for each hectare in production, being more intensive than the conventional system unit, considering that both systems have PRONAF financing.

Figure 1. Added value of production (AV) at Estufa Limoeiro Farm (conventional system) and Carcará Farm (organic system) with (A) and without (B) financing from PRONAF *Mais Alimento*



Both production systems need at least 1.0 ha to cover the fixed production costs (Figure 1A). However, the organic system is more intensive since its marginal contribution is greater, thanks to the highest gross value of one-hectare production, resulting from the greater diversity of crops. This enables the system to be less affected by market price variation, maintaining a gross value of production throughout the year.

The added value of production without financing for the cost of the enterprise shows, in Figure 1B, that only 1.0

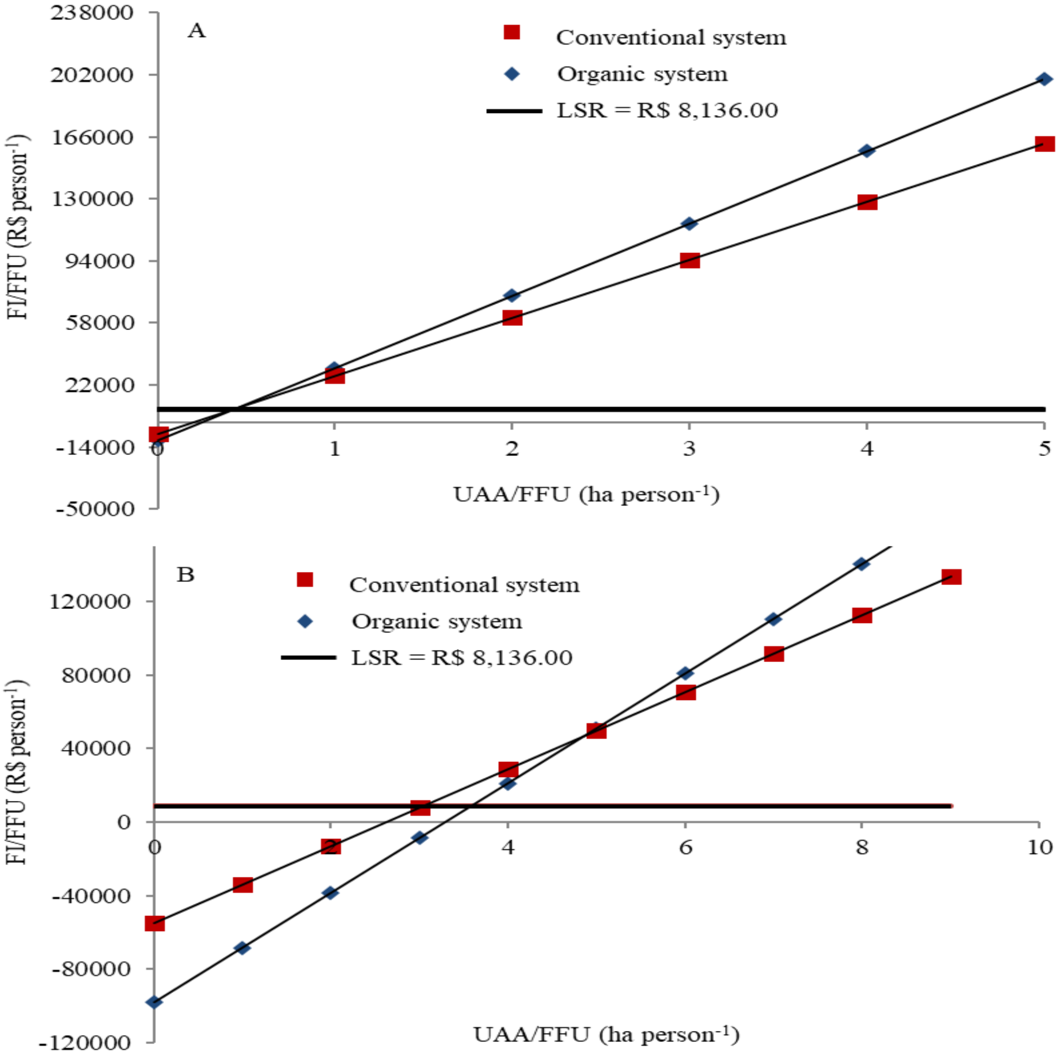
ha of production is not sufficient for the units studied to make a production system feasible in a scenario that does not contemplate financing.

Production systems pay investment from 3.0 ha, when the added value is equal to R$ 17,613.94 in the organic system and R$ 20,839.64 in the conventional system. Compared to the organic system, the higher value estimated to the conventional system is due to the lower initial fixed cost of the organic system (R$ 41,975.05) to implement the production unit. However, from 4.0 ha of production, the organic system has a higher added value due to its greater marginal contribution (R$ 29,828.13), which implies greater intensity of the activity and consequently greater generation of wealth for society.

According to Lima, Silva and Iwata (2019), more than 70% of the food that supplies the Brazilian population comes from family farming, a production system that is considered intensive.

A linear relationship was established between the previously calculated added value, when analyzing the social contribution of each production unit to a UAA of up to 5.0 ha, and the farmer’s income, represented in Figure 2A and Figure 2B, with financing to pay their investment and without financing, respectively.

Figure 2. Farmer's income (FI) at Estufa Limoeiro Farm (conventional system) and Carcará Farm (organic system) with (A) and without (B) financing from PRONAF *Mais Alimento*



The level of social reproduction (LSR) is related to the income necessary for social reproduction based on the minimum wage. Here, the LSR value represented in the chart refers to the annual salary.

The income of the PRONAF financed farmer (Figure 2A) shows that both Estufa Limoeiro and Carcará Farms can surpass the LSR with approximately 0.5 ha in production. However, from 1.0 ha, the organic system has a higher LSR than the conventional one, guaranteeing a better quality of life for the farmer's family.

Estufa Limoeiro Farm has five people who depend on the income of its production. The production of 1.0 ha is insufficient to pay a minimum wage to each dependent, considering that one-hectare annual income is R$ 27,457.16. This corresponds to R$ 2,288.10 monthly income, resulting in R$ 457.62/person, which represents 63.2% of the minimum wage.

The Carcará Farm with only 1.0 ha in production can pay from its income to each dependent the amount of R$ 666.15 per month, since the annual income for one hectare is R$ 31,975.24 and four people depend on this income. It is also noticed that in this production system, with only 1.0 ha in production, the wage that each person receives per month represents 92% of the minimum wage of the year under study.

According to Silva Neto (2005), the models of the systems represented by graphs of the farmer's income make it possible to identify the types of farmers with greater difficulties to remain in the agricultural activity and their perspectives according to the accumulation dynamics of the agricultural system, by easily deducing the minimum UAA so that the production unit can remain in the agricultural activity, ensuring social reproduction (LSR) of the type of farmer under analysis.

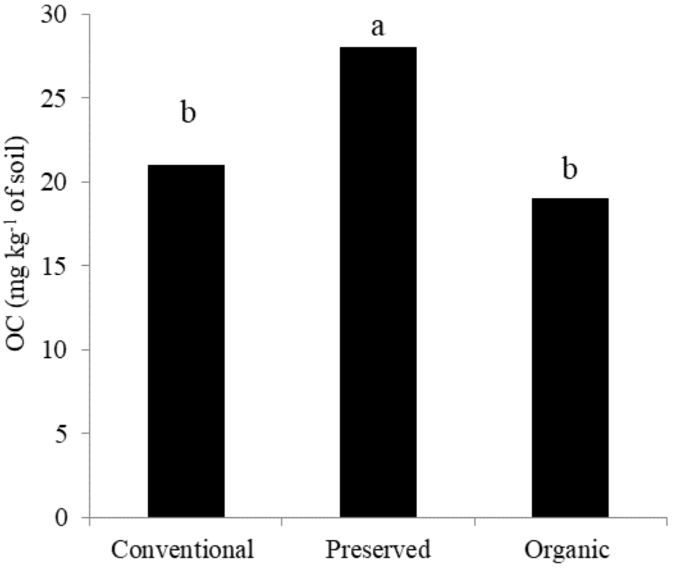
Figure 2B shows the behavior of the farmer's income, considering a scenario such that he would not obtain financing to start his enterprise. In this model, it is possible to observe the difficulty that both farmers must generate an income higher than the minimum income necessary to ensure social reproduction.

The farmer's income would only exceed the LSR if his UAA was 4.0 ha, and in this scenario, the conventional system becomes more viable than the organic system because with 4.0 ha it produces an income of R$ 28,783.65, while the organic system obtains an income of R$ 21,095.87. The respective incomes represent for each dependent of the family the amounts of R$ 479.73 and R$ 439.50 in the conventional and organic systems, respectively.

5.2 Biological parameters

The total soil organic carbon content virtually did not vary between the organic and the conventional systems but showed much lower values compared to the preserved area, whose value was 28.03 mg kg^{-1} of soil (Figure 3).

Figure 3. Total soil organic carbon (OC) contents in the dry period (October) in the municipality of Guaraciaba do Norte-CE, Brazil. Means followed by the same letter did not differ significantly (Tukey test, p>0.05)



The organic carbon content was higher in the preserved area's soil, indicating greater incorporation of organic matter in this agroecosystem, compared to the soil of the organic and conventional areas. The differences correspond to 25.16% and 32.14% to the conventional and organic system soil, respectively.

Troian et al. (2020) obtained lower levels and total organic carbon stock in the soil of managed areas compared to the preserved area, and the latter has a greater potential for carbon accumulation in the soil.

The greater amount of soil organic carbon in the preserved area is due to the constant and permanent addition of plant residues in the soil under the canopy of plants, promoting greater uniformity of moisture and temperature, thus increasing the decomposition of the residues and consequently the addition of organic carbon to the soil.

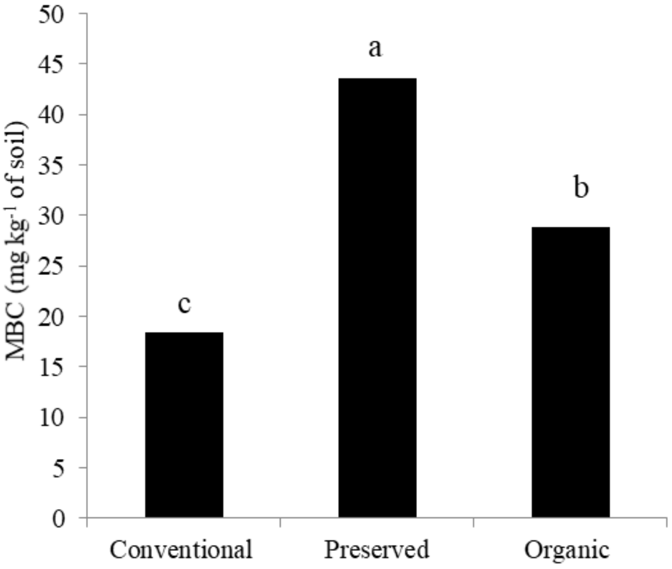
Loss et al. (2015), evaluating agroecological no-tillage and conventional systems, found higher contents of organic carbon in secondary forests than in the production systems being studied.

Several studies indicate higher contents of organic carbon in areas of natural vegetation. In the natural environment, the higher contents of organic carbon in the soil are due to the greater input of plant residues and absence of disturbance in the system, which explains the higher contents of organic carbon found in native vegetation soils compared to cultivated and reforested areas (FREITAS et al., 2018).

Despite being cultivated under organic management for 17 years, the area with an organic system prior to this period was subjected to intensive land use under conventional system for 16 years.

There was a higher microbial biomass carbon content in the preserved area (43.65 mg C kg^{-1} soil), intermediate content in the area of the organic system (28.80 mg C kg^{-1} soil) and lower content in the area of conventional system (18.45 mg C kg^{-1} soil), differing by 34.02% and 42.26% from those of the preserved area, respectively (Figure 4).

Figure 4. Microbial biomass carbon (MBC) content in the dry period (October) in the municipality of Guaraciaba do Norte-CE, Brazil. Means followed by the same letter did not differ significantly (Tukey test, p>0.05)



The preserved area showed higher contents of soil organic carbon, and the positive correlation between organic matter and soil microbial biomass, commonly reported, proves to be a close relationship. In this context, the higher contents of biomass carbon in the preserved area can be explained by the fact that this area has a greater input of organic material in the soil (PROMMER et al., 2019).

In the conventional system analyzed, the area is prepared intensively with plowing and harrowing operations in each cultivation cycle. Thus, the low contents of microbial biomass carbon observed in the conventional system may have been affected by these physical disturbances.

According to Hoffmann et al. (2018), cultivation systems associated with greater plant diversity and less soil management favor the accumulation of MBC, probably due to the greater availability of organic matter. Santana et al. (2017) found that areas of forest and conservation cultivation have higher MBC contents in the soil.

Most of the soil tillage in the organic system area is performed manually, reducing the degradation of soil physical structure to the minimum. However, the organic system area has organic carbon content equal to those found in the conventional system, which could influence microbial biomass at the same intensity, but this was not observed because the amount of microbial biomass carbon in the organic area was significantly higher than that of the conventional system area (Figure 4).

This fact can be explained by the management adopted in soil tillage of the area analyzed, once the turning of the soil surface layer is reduced due to the manual management, compared to the mechanized management used in the conventional system area.

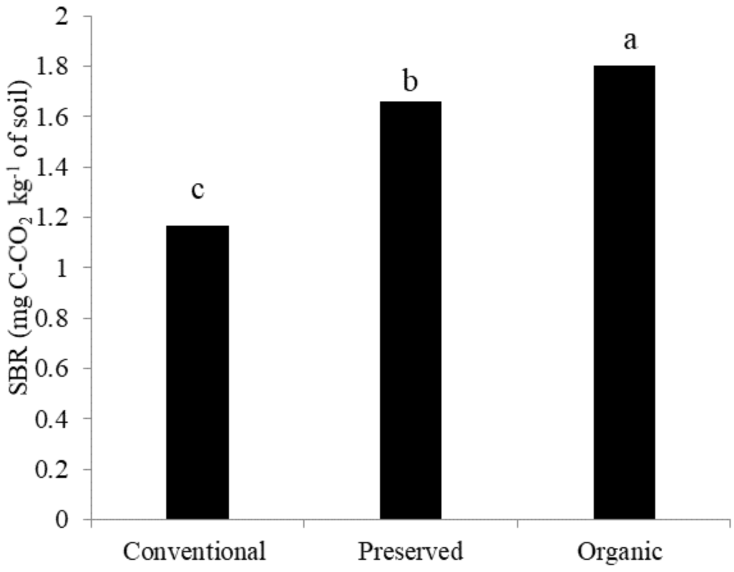
Similarly, Mazzetto et al. (2016), comparing agricultural production systems with native vegetation, verified higher contents of carbon immobilized in microbial biomass in areas of native vegetation. Among the probable factors responsible for more favorable conditions for microbial development in the preserved area, the absence of soil tillage and the greater floristic diversity of this area deserve to be highlighted.

The removal of primary forest for cultivation of native species reduces the contents of organic carbon, MBC and humic substances (humic and fulvic acids and humin) of the soil, so the natural alteration of the soil for the cultivation of a given specie alters its microbiota (ZANINETTI; MOREIRA; MORAES, 2016).

The labile fractions of soil organic carbon are affected by the type of land use, with a 50% reduction in soil MBC content in areas of short-cycle agricultural cultivation and with intensive use of plowing and harrowing practices compared to native forest areas; thus, indicating the advantage of the substitution of conventional practices by agroecological practices that minimize soil turning, prioritizing the vegetation cover of the soil (LOUREIRO et al., 2016).

The organic system area showed the highest amount of CO_2 released by the respiration of microorganisms, representing an average of 1.80254 mg kg^{-1} of soil (Figure 5). The conventional system area had the lowest amount of CO_2 released (1.16410 mg kg^{-1} of soil), which represents a 35.41% reduction compared to the organic system area.

Figure 5. Soil basal respiration (SBR) contents in the dry period (October) in the municipality of Guaraciaba do Norte-CE, Brazil. Means followed by the same letter did not differ significantly (Tukey test, p>0.05)

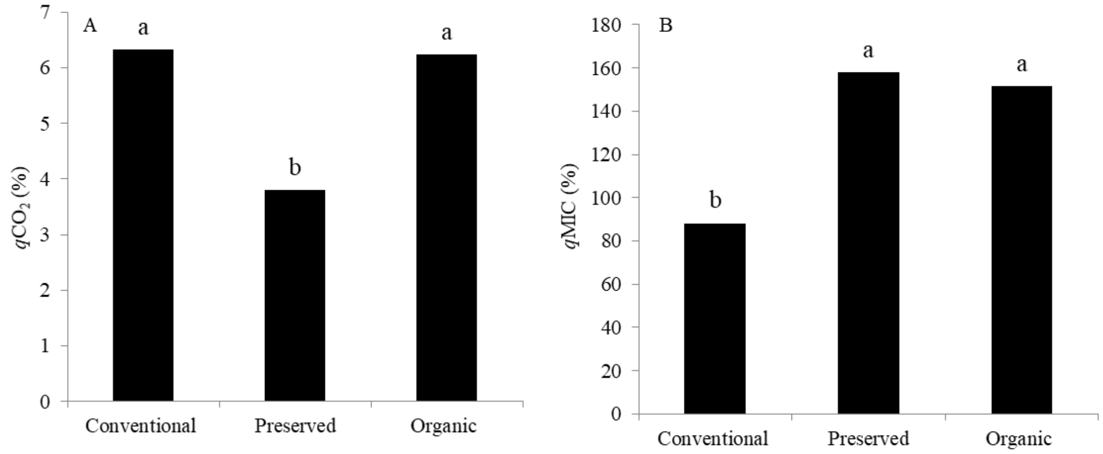


The pH influences the availability and toxicity of mineral nutrients such as Fe, Mn and Al, so it may harm soil microbiota because of the possibility of reaching toxic levels due to pH values lower than 5.0. Soil acidity can alter the availability of nutrients to plants and it may increase aluminum content and saturation (BAMBOLIM et al., 2015).

According to the analysis of soil chemical attributes, it is verified that the soil pH values of the conventional system area (pH = 4.5) and preserved area (pH = 4.5) are low, indicating soil acidity and consequently greater availability of toxic nutrients such as Al since the Al contents in these areas are high, 0.65 and 0.75 cmolc kg^{-1}, respectively. Thus, it is denoted that the lower level of soil basal respiration in these two areas (conventional and preserved) is influenced by soil acidity.

The areas with conventional and organic cultivation did not differ in terms of metabolic quotient (qCO_2), represented by 6.32% and 6.24%, respectively. The preserved area had a value of 3.80% for the respective variables (Figure 6A).

Figure 6. (A) Metabolic quotient (qCO_2) and (B) microbial quotient (*q*MIC) in the dry period (October) in the municipality of Guaraciaba do Norte-CE, Brazil. Means followed by the same letter did not differ significantly (Tukey test, p>0.05)



The area of conventional system had the lowest microbial quotient, compared to the values observed in the preserved area and in the organic system area (Figure 6B).

Colodel et al. (2018), analyzing the effect of different management systems on soil biological attributes, found lower levels of qCO_2 in native vegetation areas compared to cultivated areas of intensive land use.

According to Souza et al. (2013), areas of native vegetation have lower values of qCO_2 because they are environments that have the most stable chemical, physical and biological attributes, indicating a more balanced ecosystem in these areas.

The higher values of *q*MIC observed in the preserved area and organic cultivation area indicate that a large amount of organic carbon is immobilized in microbial biomass. This result may be associated with a higher rate of organic matter mineralization by microorganisms in these soils.

The higher microbial quotient suggests that organic carbon in these areas is available to soil microbiota, since the relationship between microbial biomass carbon and total soil organic carbon is an indicator of the availability of organic matter to microorganisms (ANDERSON; DOMSCH, 1989).

6 CONCLUSIONS

The organic farming system promoted a generation of direct jobs per unit area three times higher than the average of the irrigated agriculture in the Brazilian semi-arid region.

Compared to the conventional system, the organic cultivation system showed a lower economic risk, being more intensive, but the current usable agricultural areas of the two production units ensure the social reproduction of farmers in a scenario with financing from PRONAF.

The production unit with organic cultivation had higher environmental sustainability compared to the conventional system since the soil is in more satisfactory physical and chemical conditions for developing microorganisms.

7 REFERENCES

ACEVEDO-OZÓRIO, A.; SANTOVO-SÁNCHEZ, J. S.; PEDRO, G.; JIMÉNEZ-REINALES, N. Family farming facing the extractive model of rural development in Colombia. **Gestión y Ambiente**, Bogota, v. 21, n. 2, p. 144-154, 2018.

ANDERSON, T. H.; DOMSCH, K. H. Ratio of microbial biomass carbon to total organic carbon in arable soils. **Soil Biology and Biochemistry**, Elmsford, v. 21, n. 4, p. 471-479, 1989.

BAMBOLIM, A.; CAIONE, G.; SOUZA, N. F.; SEBEN JUNIOR, G. F.; FERBONINK, G. F. Calcário líquido e calcário convencional na correção da acidez do solo. **Revista de Agricultura Neotropical**, Cassilândia, v. 2, n. 3, p. 34-38, 2015.

BORGES, M. S. B.; ALMEIDA, R. L. J.; LIMA, C. A. O.; FERNANDES, A. C. G.; GOMES, R. M.; OLIVEIRA, S. P.; OLIVEIRA, L. P.; SILVA, M. E. G.; ARAÚJO, W. S.; SIMÕES, A. R. Análise de sustentabilidade da agricultura familiar em um sistema agroflorestal em Alagoa Nova. **Pesquisa, Sociedade e Desenvolvimento**, Itabira, v. 9, n. 6, p. 1-14, 2020.

CEARÁ. Secretária do Desenvolvimento Econômico e Trabalho do Ceará. **Agronegócio**. Fortaleza: SEDET, 2020. Disponível em: https://www.sedet.ce.gov.br/negocios/agronegocio/. Acesso em: 1 jun. 2020.

COLODEL, J. R.; PIERANGELI, M. A. P.; SOUZA, M. F. P.; CARVALHO, M. A. C.; DALCHIAVON, F. C. Atributos físicos e biológicos de Argissolo Vermelho-Amarelo Amazónico sob diferentes sistemas de uso e manejo. **Revista de Ciências Agrárias**, Lisboa, v. 41, n. 2, p. 287-297, 2018.

DITLEVSEN, K.; SANDOE, P.; LASSEN, J. Healthy food is nutritious, but organic food is healthy because it is pure: The negotiation of healthy food choices by Danish consumers of organic food. **Food Quality and Preference**, Barking, v. 71, n. 1, p. 46-53, 2019.

FREITAS, L.; OLIVEIRA, I. A.; CASAGRANDE, J. C.; SILVA, L. S.; CAMPOS, M. C. C. Estoque de carbono de Latossolos em sistemas de manejo natural e alterado. **Ciência Florestal**, Santa Maria, v. 28, n. 1, p. 228-239, 2018.

HOFFMANN, R. B.; MOREIRA, E. E. A.; HOFFMANN, G. S. S.; ARAÚJO, N. S. F. Efeito do manejo do solo no carbono da biomassa microbiana. **Brazilian Journal of Animal and Environmental Research**, Curitiba, v. 1, n. 1, p. 168-178, 2018.

LIMA, A. F.; SILVA, E. G. A.; IWATA, B. F. Agriculturas e agricultura familiar no Brasil: uma revisão de literatura. **Retrato de Assentamentos**, Araraquara, v. 22, n. 4, p. 50-68, 2019.

LOSS, A.; BASSO, A.; OLIVEIRA, B. S.; KOUCHER, L. P.; OLIVEIRA, R. A.; KURTZ, C.; LOVATO, P. E.; CURMI, P.; BRUNETTO, G.; COMIN, J. J. Carbono orgânico total e agregação do solo em sistemas de plantio direto agroecológico e plantio convencional de cebola. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 39, n. 4, p. 1212-1224, 2015.

LOUREIRO, D. C.; DE-POLLI, H.; AQUINO, A. M.; SÁ, M. M. F.; GUERRA, J. G. M. Influência do uso do solo sobre a conservação de carbono na biomassa microbiana em sistemas orgânicos de produção. **Revista Brasileira de Agroecologia**, Dois Vizinhos, v. 1, n. 1, p. 1-10, 2016.

MAZZETTO, A. M.; CERRI, C. E. P.; FEIGL, B. J.; CERRI, C. C. Activity of soil microbial biomass altered by land use in the southwestern Amazon. **Bragantia**, Campinas, v. 75, n. 1, p. 79-86, 2016.

MENDONÇA, E. S; MATOS, E. S. **Matéria orgânica do solo**: métodos de análises. Viçosa: UFV, 2005.

NUNES, K. G.; COSTA, R. N. T.; CAVALCANTE JÚNIOR, J. A. H.; ARAÚJO, D. F. Comportamento da alface-americana sob diferentes doses de composto orgânico e lâminas de irrigação. **Irriga**, Botucatu, v. 22, n. 1, p. 167-176, 2017.

POPA, M. E.; MITELUT, A. C.; POPA, E. E.; STAN, A.; POPA, V. I. Organic foods contribution to nutritional quality and value. **Trends in Food Science & Technology**, Cambridge, v. 84, n. 1, p. 15-18, 2019.

PROMMER, J.; WALKER, T. W. N.; WANEK, W.; BRAUN, J.; DAVID, Z.; HU, Y.; HOFHANSL, F.; RICHTER, A. Aumento do crescimento microbiano, biomassa e renovação impulsionam o acúmulo de carbono orgânico no solo em maior diversidade de plantas. **Global Change Biolo苏ly**, Urbana-Champaign, v. 26, n. 2, p. 669-681, 2019.

SANTANA, A. S.; CHAVES, J. S.; SANTANA, A. S.; RODRÍGUEZ, C. A.; MORAES, E. R. Biomassa microbiana em diferentes sistemas de manejo do solo no Sul do Estado de Roraima. **Revista Brasileira de Ciências da Amazônia**, Rolim de Moura, v. 1, n. 1, p. 44-50, 2017.

SILVA NETO, B. Objetivos e Aspectos Metodológicos dos Estudos Municipais. *In*: SILVA NETO, B.; BASSO, D. (org.). **Sistemas agrários do Rio Grande do Sul**: análise e recomendações políticas. Ijuí: Editora Unijuí, 2005. p. 159-163.

SILVA, F. C. **Manual de análises químicas de solos, plantas e fertilizantes**. Brasília, DF: Embrapa, 1999.

SOUZA, M. F. P.; SILVA, M. P.; ARF, O.; CASSIOLATO, A. M. R. Chemical and biological properties of phosphorus-fertilized soil under legume and grass cover (Cerrado region, Brasil). **Revista Brasileira de Ciência do Solo**, Viçosa, v. 37, n. 6, p. 1492-1501, 2013.

TROIAN, D.; ROSSET, J. S.; MARTINS, L. F. B. N.; OZÓRIO, J. M. B.; CASTILHO, S. C. P.; MARRA, L. M. Carbono orgânico e estoque de carbono do solo em diferentes sistemas de manejo. **Revista em Agronegócios e Meio Ambiente**, Maringá, v. 13, n. 4, p. 1447-1469, 2020.

VANCE, E. D.; BROOKES, P. C.; JENKINSON, D. S. An extraction method for measuring soil microbial biomass C. **Soil Biology and Biochemistry**, Elmsford, v. 19, n. 6, p. 703-707, 1987.

ZANINETTI, R. A.; MOREIRA, A.; MORAES, L. A. C. Atributos físicos, químicos e biológicos de Latossolo Amarelo na conversão de floresta primária para seringais na Amazônia. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v. 51, n. 9, p. 1061-1068, 2016.