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Diversification of crops and food security: the role of family farming in the COVID-19 pandemic

Diversificação de cultivos e segurança alimentar: o papel da agricultura familiar na pandemia de COVID-19

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ABSTRACT

Given the importance of family production, our aim was to characterize the productivity and importance of family production during the COVID-19 pandemic in the communities of Engano dos Rodrigues and Lagoa Seca, located in the municipality of Santana do Piauí. Data were collected by monitoring production and sales, from interviews and analysis of the strengths, weaknesses, opportunities, and threats (SWOT) matrix. The strengths of the activity lie in the diversity of food products and the continuous production of most items, in the organization into an association and the partnerships established, which were crucial at a time of crisis to guarantee the distribution and sale of agricultural products. The weak points are mainly related to the lack of technical assistance. Understanding the dynamics of agroecological family production in times of crisis highlights the importance of institutional support and continuing education for the resilience and sustainable development of rural communities. We also stress the importance of future research focusing on the impact of public policies on family farming in the semiarid region, as well as the effectiveness of different marketing and cooperation strategies among farmers.

Keywords: Semiarid; crisis; agroecology.

RESUMO

Dada a importância da produção familiar, nosso objetivo foi caracterizar a produtividade e a importância da produção familiar durante a pandemia da COVID-19 nas comunidades de Engano dos Rodrigues e Lagoa Seca, no município de Santana do Piauí. Os dados foram coletados por meio de monitoramento da produção e das vendas, entrevistas e análise da matriz força, fraquezas, oportunidades e ameaças — SWOT. Os pontos fortes da atividade estão na diversidade dos produtos alimentícios e na produção contínua da maioria dos itens, na organização em uma associação e nas parcerias estabelecidas, que foram cruciais em um momento de crise para garantir a distribuição e a venda dos produtos agrícolas. Os pontos fracos estão relacionados principalmente à falta de assistência técnica. A compreensão da dinâmica da produção familiar de base agroecológica em tempos de crise destaca a importância do apoio institucional e da educação continuada para a resiliência e o desenvolvimento sustentável das comunidades rurais. Ressaltamos ainda a importância de pesquisas futuras que enfoquem o impacto das políticas públicas na agricultura familiar no semiárido, assim como a eficácia de diferentes estratégias de comercialização e cooperação entre os agricultores.

Palavras-chave: Semiárido; crise; agroecologia.

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Introduction

Agricultural sustainability is understood as the ability of an agroecosystem to remain productive over time, even in the presence of repeated ecological constraints and socioeconomic pressures (Altieri, 1989). Therefore, these agroecosystems must be productive and rich in functional biodiversity, being integrated into a complex matrix that creates ecological barriers (Tobias and D'Angelo, 2020). Even if this is well established, the human population bases its survival on only three main crop species: wheat, rice, and corn, which provide 50% of the calories consumed globally (United Nations System Standing Committee on Nutrition – UNCSN, 2020).

In times of crisis, such as the COVID-19 pandemic, contingency measures during the early stages of the virus's circulation revealed the fragility of the global food system, which is based on industrial and predatory agriculture (Altieri and Nicholls, 2020). In Brazil, the first record of COVID-19 occurred on February 20, 2020 (Rodriguez-Morales et al., 2020) and, by March 26, 2020, the country had 2,915 confirmed cases and 77 deaths (Brasil, 2020). During this period, there was a significant increase in shortages and hunger for a large part of the human population (Ahmed et al., 2020), especially among the poorest (Zurayk, 2020).

This crisis has prompted a reflection on the consequences of the current agricultural model, which is based on extensive production (Lösch et al., 2022). For example, a global analysis of fertilizer trade networks showed that organic fertilizers were in greater demand during COVID-19 as they offered an alternative to rising costs (Gutiérrez-Moya et al., 2023). The COVID-19 pandemic was also an opportune moment to recognize the impacts of food choices on human, environmental, and planetary health (Pinheiro, 2020). Although some rapid assessments have been conducted linking the effects of COVID-19 on agricultural performance and food security, in-depth analyses of causal effects and implications within diverse socioeconomic groups are still lacking (Kansiime et al., 2021; Agamile, 2022; Samad et al., 2022).

Thus, considering the vulnerability of the global food system and the unequal impacts of the pandemic on different populations, this study sought to characterize the productivity and importance of family production during the COVID-19 pandemic in the communities of Engano dos Rodrigues and Lagoa Seca, located in the municipality of Santana do Piauí. Specifically, we sought to define the socioeconomic profile, the production calendar, and the factors that influence the vulnerability or strength of local agricultural activity. Our hypothesis is based on the idea that, although small family farmers in the semiarid region have been negatively impacted economically by COVID-19, their production has been essential to guarantee their food security and that of the community in general.

Methodology

Study area

The research was carried out in a semiarid region of Piauí, specifically the communities of Engano dos Rodrigues and Lagoa Seca, situated in the municipality of Santana do Piauí, located in the northeastern region of Brazil (6°57'03.3"S 041°28'25.01"W). The communities are located 326 km from Teresina, the state's capital. The region has a semiarid Bsh climate, characterized by high temperatures and low rainfall, with an average annual temperature of 27.2°C and annual rainfall of 684 mm, concentrated from December to April (Köppen and Geiger, 1929).

The study area is located in the xeromorphic intertropical domain, characterized by Caatinga vegetation, a complex plant formation as classified by Romariz (1996). The Caatinga is a tropical dry forest, adapted to conditions of low water availability, and features a diversity of plants with characteristics such as herbaceous annuals, succulence, aculei, and thorns, which allow them to survive in arid environments (Andrade-Lima, 1981).

The region's soils are the result of the alteration of sandstones, siltstones, and conglomerates. They are medium textured and poorly developed and vary from shallow to very shallow, often with a stony phase, which directly influences the conditions for the development of species adapted to this environment (Jacomine et al., 1986). The Department of Agriculture reports that these communities are made up of 36 farmers affiliated to the residents' and farmers' associations. All of these farmers derive their main income from agricultural activities (Department of Agriculture of the Municipality of Santana do Piauí, unpublished data, 2023).

Data collection and analysis

Three different collection methods were used. Documents provided by the Santana do Piauí municipality's Department of Agriculture were used to characterize the community's basic indicators. Information was collected on the number of farmers in the Engano dos Rodrigues and Lagoa Seca communities, as well as on the participation of these farmers in government programs aimed at marketing food. The communities were interviewed using a pre-established script with open and closed questions. Nine farmers were interviewed, representing 25% of local farmers. The questionnaire was structured in 41 items, divided into 3 sections: 1. personal identification of the farmers, 2. economic aspects, and 3. production management. The interviews lasted an average of 15–20 min and were recorded using a cell phone's recorder function. The answers were transcribed using the Reshape Transcription platform.

The information was then summarized to create a strengths, weaknesses, opportunities, and threats (SWOT) matrix. This technique was used because it makes it possible to identify, analyze, and classify farmers' characteristics in relation to internal factors (strengths and weaknesses) and external factors (opportunities and threats) (Ferrell et al., 2005). The SWOT analysis tool facilitates the formulation of strategies that optimize strengths and opportunities, mitigate weaknesses, and circumvent threats. In addition, the SWOT analysis makes it possible to identify limitations and areas that need to be overcome in order to achieve success (Kaplan and Norton, 2008).

The third method involved analyzing the food production and sales records of 15 farmers (41.6% of all local farmers) over a 21-month period (2020/2021). These data were obtained through a partnership with the project "Free fair in the university space: bringing family/campesino agriculture closer to the academic environment" (Open fair in the university space: bringing family/peasant farming closer to the academic environment) at the Federal University of Piauí, Senador Helvídio Nunes de Barros *campus*, Picos, state of Piauí. The project provided access to detailed data on the production and marketing of food produced in the communities of Lagoa Seca and Engano dos Rodrigues. The information was made available in Excel tables and was analyzed with an emphasis on the seasonality of production, food sales values, and sales potential. The data were analyzed to determine the production calendar and the production and financial impact of the COVID-19 pandemic on farmers. The images were made in Canva and the RStudio program using the ggplot2 package (Wickham, 2017).

This research study was submitted to and approved by the Ethics Committee of the Federal University of Paraíba, Protocol No. 5.432.561 (CE/CCS/UFPB), through Plataforma Brasil, Certificate of Presentation for Ethical Appreciation (CAAE) No. 58670122.5.0000.5188.

Results and Discussion

The age range of the interviewees varies from 35 to 73 years, with an average of 45 years, which is consistent with the majority of Brazilian family farmers, both men and women (IBGE, 2017a). Of the nine interviewees, seven were women (77.8%), who not only sell their products at fairs but are also responsible for managing the farming, and the logistics and marketing of the food. This finding underscores the importance of the role of women in family farming (Loli et al., 2022).

The number of family farming establishments in Brazil managed by women increased by 18.6%, i.e., there are approximately one million women involved in food production (IBGE, 2017b). The families studied consisted of two to five people, with an average of four per household, and all members were involved in food production or sales. Four farmers (44%) work on rented land, while five (56%) own the land on which they produce. All use well water for consumption and crop irrigation. In addition, they all have access to the health center, which provides medical assistance once a week.

From an educational point of view, there has been a change in the provision of education in rural communities. While older people (around 42–72 years old) have only basic or incomplete education due to the lack of educational conditions in the past, this reality has changed with public policies aimed at improving rural education. The internalization of public universities, which began in 2003, has led to significant social improvements in municipalities considered to be on the periphery of Brazil (Bizerril, 2020). This trend of greater access to education at the beginning of the 21st century is also observed in other agricultural areas of the world (Charlton et al., 2020).

Organization and support from government or civil society projects are important differentiating factors for the development of activities such as family farming (Freitas et al., 2019). The interviewees' participation in the residents' association shows this. Despite the difficulties, associations and cooperatives strengthen the marketing and distribution of food. In this process, public policies such as the Food Acquisition Program (PAA) and the National School Feeding Program (PNAE) are fundamental, especially during the pandemic, to maintain production, avoid losses, and guarantee farmers' income (Nogueira and Marcelino, 2021).

According to information from the Secretariat of Agriculture, all farmers in the studied communities have also benefited from public policies from the Federal Government through associations (PAA and PNAE). This public policy was an alternative to reduce socioeconomic impacts, providing access to food quantity and quality for populations in a state of vulnerability, and could guarantee better social and economic conditions for family farmers (Sambuichi et al., 2020).

Investments in public policies aimed at the most vulnerable farmers are important to eliminate problems with the market (Alves and Souza, 2015). In addition to public policies, organizations in groups such as associations and cooperatives can also be an alternative to various restrictions in the market production chain (Charles et al., 2019) as they favor the improvement of productive infrastructure and services in rural communities (Silva et al., 2007).

In this way, the organized farmers of the Lagoa Seca and Engano dos Rodrigues communities have been given the stimulus and basic structure they need to structure and strengthen their activity. The farmers also had the support of the university, which was decisive for the sale of food during the pandemic. They are all linked to the extension project "Free fair in the university space" at the Federal University of Piauí Senator Helvídio Nunes de Barros *campus*, located in Picos, Piauí. This project was essential during the most critical period of COVID-19 as it made it possible to market practically all agricultural production. Thus, the university stands out as an ally in the development of extension actions, guiding farmers in socio-productive organization and cooperation, and encouraging collective and entrepreneurial behavior, in addition to promoting the trade of healthy products in fairs (Pasin et al., 2018).

With regard to the support received by the communities studied, it should be noted that good publicity, presentation, and support in the commercialization process made a big difference to the success of the activity. In this scenario, the partnership with the university was key as it provided support for both the advertising and sales platforms, as well as a space for a weekly agroecological fair on its premises. Having specific spaces dedicated to the sale of these products facilitates reaching consumers, as can be seen in the organic fairs held in Curitiba, southern Brazil, from 2015 to 2017, which were democratic, offered healthy foods, and promoted sovereignty and food and nutritional security (Carvalho et al., 2022).

Agriculture in the communities of Lagoa Seca and Engano dos Rodrigues has more positive than negative points (more strengths and opportunities than weaknesses and threats). A very important point is diversification of the foods produced and the continuous annual production of most of them (Table 1). Family farming is recognized for its diversity in food production (Deimling et al., 2015), enabling a greater range of opportunities and, consequently, greater possibilities for generating income (Simonetti et al., 2013).

An important strength factor that needs to be highlighted is that all production is used, including what is not sold. All interviewees stated that leftovers are used to feed animals, two (22%) reported donating to the community, and seven (78%) said they produce fruit pulp, sweets, and sauces.

A similar system was observed in Amazonian communities in Brazil, where diversified production, aimed mainly at self-consumption by family farmers, proved to be a way of guaranteeing the maintenance of these farmers by allowing basic food availability (Soares et al., 2018). Strengthening production for self-consumption on family properties stimulates family groups by internally generating food security in production units (Gazolla, 2006).

The management and production strategies adopted by producers in both communities are fundamental to the activity. Farmers avoid using chemical substances to manage insects and diseases, keeping the production system in line with agroecological principles. The weaknesses identified are associated with social issues, such as health problems, lack of leisure opportunities, and insufficient technical training for the efficient management of plant pests and diseases. According to IBGE (2017c), 94% of farmers in the northeast of Brazil do not receive technical assistance, which exacerbates these challenges. Another weakness observed was a lack of financial control over spending on the property, food production, and leftovers from the fair. It is therefore important for farmers to have financial control of their activities, which can help measure the performance of rural activities as a mechanism for improving production planning and control. With planning, it is possible to set medium- and long-term goals, taking market variables into account for the financial planning of activities (Marion, 2014).

Among the external factors identified as a threat is the dependence on government funding (Chart 1). While this is seen as a strength because it guarantees extra financial support and greater peace of mind when dealing with variations in farming, on the contrary, benefits are subject to instability and changes in government (with the exception of retirement benefits, which are guaranteed by law). Therefore, farmers should not rely solely on this resource in their plans.

In general, the restrictive measures imposed by the COVID-19 pandemic have led to changes in the production, communication, and marketing dynamics of family farmers. There have been delays in transportation, roadblocks, closure of markets, and fairs, among others, which have caused the accumulation of production and a loss of quality, especially in perishable items, due to restrictive measures aimed at reducing the spread of the virus (HLPE, 2020).

In the case of the farmers surveyed, these difficulties could be overcome by the partnerships they had (and have) with each other and with other institutions, such as the higher education institution mentioned above. Therefore, this was a crucial moment to demonstrate their ability to recreate themselves and invest in other production, dissemination, and marketing strategies. Large and small farmers had to adapt to keep the country's supply chain going and ensure the continuity and maintenance of agriculture in the face of the coronavirus crisis (Vieira Filho, 2020).

With the closure of the market, the farmers had to close their points of sale at the fair. The reach in sales at the height of the pandemic was only possible because the farmers embraced the use of digital platforms such as Instagram and WhatsApp and had the support of the university to create a website to sell their food. In this sense, digital tools such as social media, websites, and messaging apps are considered a good opportunity to advertise the sale of food, which are used as an instrument of communication, articulation, and mediation between the different actors that participate directly in family farming (Zuñiga et al., 2020). On the contrary, not all family farmers in Brazil have access to or the ability to operate these technologies. Digital exclusion or backwardness, which is unfortunately a reality in our country, is a reflection of extreme economic, social, and educational inequality (Costa and Gonçalves Neto, 2023).

Table 1 – Analysis of the strengths, weaknesses, opportunities, and threats of family farming in the Lagoa Seca and Engano dos Rodrigues communities based on a synthesis of the information obtained through interviews with farmers. Santana do Piauí-PI, Brazil, during the COVID-19 pandemic, 2020/2021.

Strengths	Weaknesses
Facilitating access to education Medical assistance Participation in social organizations Management of pests and diseases without pesticides Using surplus food Diversity of production throughout the year	Health problems (postural) Little diversity of leisure Little knowledge about pest and disease management No financial control regarding expenses on the property
Opportunities	**Threats**
Participation in projects that help sell production Food sales at fairs and at the university Diversification of distribution channels through WhatsApp and own website Short production circuits	Dependence on government resources, subject to instability Risk of diseases and pests that can affect crops Difficulty selling food production during crises, such as COVID-19

Another element identified as an opportunity for regional agriculture in the communities of Lagoa Seca and Engano dos Rodrigues is related to the promotion of short production circuits in the sale of food at the university. Farmers in the study area stated that they do not use intermediaries in the sale and marketing of food, managing these spaces directly, which can contribute to improvements in employment and increased profitability, following studies carried out by Sievers et al. (2013) and Ramos (2020a). This type of sale provides a close relationship between farmers and small-scale operators in rural areas (Antúnez Saiz and Ferrer Castañedo, 2016). Furthermore, it can facilitate direct communication with consumers about food production and its nutritional benefits, contributing to food security (Franco Crespo et al., 2023).

Short-production circuits allow closer interactions based on trust and the offer of healthy food at a fair price for consumers and farmers (Contreras et al., 2017), providing an opportunity to change consumption practices, promote sustainability, and democratize access to food of agroecological origin, creating a more stable and sustainable market (Ramos, 2020b).

In this context, research carried out with family farmers in the northeastern semiarid region of Brazil found that, despite facing technical and productive difficulties, they were prone to innovation and experimentation with new agricultural practices, especially those based on agroecology (Nunes et al., 2018). Based on this assumption, farmers in these communities also demonstrated that they are prone to changes in the way they sell and distribute food during periods of crisis such as COVID-19.

Production calendar: production diversification

The production calendar of the studied communities indicates a stable production throughout the year. Even amid the COVID-19 crisis, farmers maintained their production process (Figure 1). Of the 65 crops, 46 (71%) are produced over at least 10 months and only 19 (29%) are produced at spe-

Figure 1 – Production calendar for vegetable and leafy vegetable crops in the Lagoa Seca and Engano dos Rodrigues communities, located in the municipality of Santana do Piauí, Piauí, Brazil.

cific periods of the year. The production calendar is an interesting strategy to guarantee rational and efficient planting times in farmers' crop planning. With climate change, the concept of production calendar was improved to study the productivity of agricultural crops, especially in areas with unstable environments and unfavorable climatic conditions (Kotera et al., 2014; Yegbemey et al., 2014), characteristics of the semiarid region in which the communities are located.

From this perspective, adjusting planting times and applying cultivation technologies based on a production calendar can reduce the risks of productivity losses due to climate variability (Apriyana et al., 2021). In the communities studied, it was possible to identify some crops that are not cultivated in the period with the greatest rainfall intensity (January, February, March) or have reduced production, e.g., parsley and spinach, with the best planting time spanning from April to June, as indicated by the Brazilian Agricultural Research Company (Amaro et al., 2007).

One example of a species whose production is affected by seasonality is the tomato, primarily due to two main reasons: the possibility of disease and the management techniques adopted. In the communities studied, tomatoes are usually planted in March, as observed in the coastal tablelands in Piauí, Brazil, where they concluded that the best time to grow tomatoes would be to start sowing in March and harvest in July, to avoid the period of highest rainfall (Souza, 1992), with excess water in the soil (Lopes and Santos, 1994) and the increase in insects and diseases associated with the crop (Silva et al., 1990).

Therefore, as chemical control substances are not used, it is preferable to wait until the months with the highest incidence of insects have passed before planting the crop. This logic goes against the concepts and principles of agroecology, which emphasizes the development of a methodology that values the participation of farmers, the use of traditional knowledge, and the adaptation of farms to local needs and socioeconomic conditions (Altieri, 2002). This diversification is also considered an adaptation and risk reduction strategy for family farming (Simonetti et al., 2013), poverty reduction (Michler and Josephson, 2017), and improving farmers' food security (Waha et al., 2018).

At the height of the COVID-19 pandemic, all farmers kept their food prices flat, offering food to approximately 300 consumers. This attitude proved to be a different approach to marketing, "avoiding the elitization of the consumption of these foods" (Meirelles, 2004), and incorporating one of the objectives of agroecology, which "does not only seek to contribute to more sustainable production but is also not limited to finding vacancies in the markets for 'green' products within the framework of globalization-ecological policies" (Leff, 2003). In addition, this strategy can alleviate impacts related to food insecurity and problems linked to the health of the population (Leddy et al., 2020), as well as poverty and social exclusion (Adhikari et al., 2021).

Brazil (Brasil, 2010) has a Food and Nutritional Security Policy (Decree No. 7,272/2010), which highlights the relevance of family farming as a strategy for the development of food and nutritional security, with the aim of developing a sustainable, equitable, and inclusive economy by encouraging diversified cultivation, expanding the capacity of consumption of food and other goods by rural families, and commercialization (CONSEA, 2014). The scenario studied in the Lagoa Seca and Engano dos Rodrigues communities in Piauí reveals that small family producers can play an important role in this process, ensuring quality food and reinventing themselves to guarantee the distribution of their production.

Food production, sales, and farmers' production potential during the COVID-19 pandemic

The communities studied had a stable production in 2020 but saw a decrease in average production and an increase in average sales in 2021 (32.98%), suggesting an improvement in sales performance, although with greater monthly fluctuation. This variation may be related to a period of adaptation by farmers to the new method of selling food (Figure 2A).

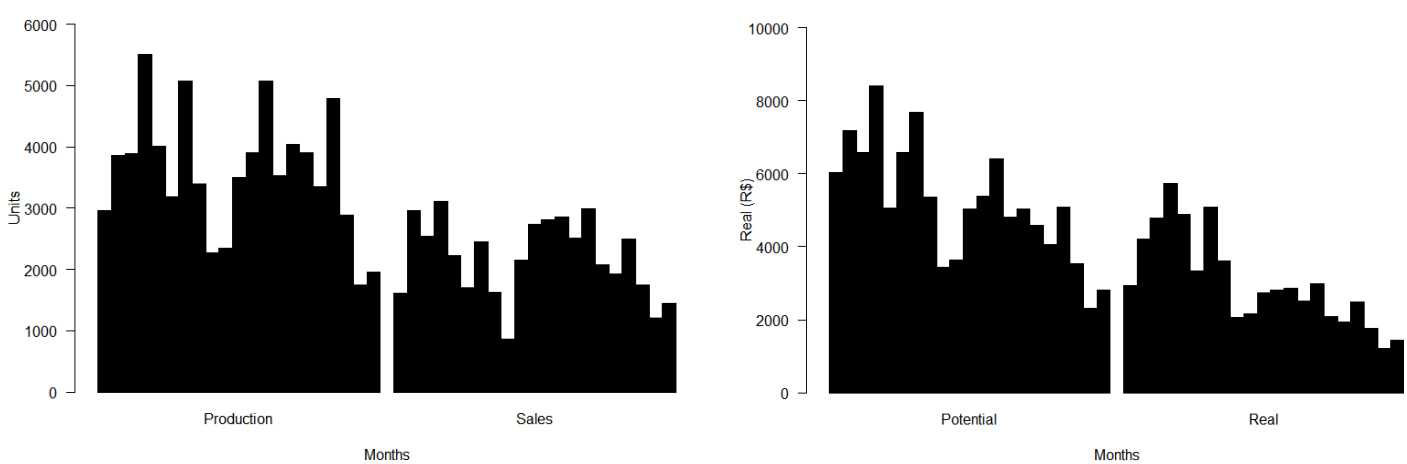

Figure 2 – (A) Production and sale of food and income considering the production and (B) potential of farmers in the communities of Lagoa Seca and Engano dos Rodrigues, located in the municipality of Santana do Piauí, state of Piauí, Brazil, during the COVID-19 pandemic.

The farmers have a sales potential that still needs to be explored (Figure 2B). Our data indicates that, in both years, they did not reach their full sales potential (69.6% in 2020 and 66.3% in 2021). However, although this potential is not explored in the form of sales, it is important to highlight that all the food that is produced is part of the family's diet, thus contributing to improving the quality of life and food security of these families, with the rest being transformed into pulp, sweets, sauces, and animal feed.

Although farmers self-consume and use what has not been sold, the sales potential could have been greater. However, due to the closure of markets and problems in food distribution, this potential was not reached. Several studies indicate that, during the COVID-19 pandemic, there was a large loss of fresh food due to the inability of farmers and agricultural entities to carry out the logistics of this food (Aldaco et al., 2020; Naughton, 2020), consequently reducing the means of subsistence of family farmers as well as the production and availability of food for the population (HLP, 2020).

Conclusion

Based on the results obtained, the relevance of family production during the COVID-19 pandemic in family-based crops in the city of Santana do Piauí, state of Piauí, semiarid northeastern Brazil, is evident. The points highlighted emphasize the importance of the farmers' organization into an association and the partnerships they established, which were crucial in such a moment of crisis by guaranteeing the distribution and sale of their agricultural products. In addition, the urgent need for education and training was emphasized so as to prepare farmers to face new episodes of crisis with resilience and adaptability.

The importance of continuous agroecological production was also highlighted as it has ensured the income and self-consumption of farming families, strengthened community relations, and promoted food security locally and in the surrounding areas. These results offer significant contributions to understanding the dynamics of family agricultural production in times of crisis, reinforcing the importance of institutional support, continuing education, and valuing agroecological-based systems as fundamental pillars for the resilience and sustainable development of rural communities. In this way, our hypothesis was partially corroborated because family farmers were not negatively impacted, in economic terms, by COVID-19.

This was because they had the support of governmental and non-governmental bodies and embraced new technologies for sale. In this sense, future research that focuses on the impact of public policies on family farming in the semiarid region, as well as on the effectiveness of different marketing strategies and cooperation between farmers, can shed light on more detailed questions related to the structuring of this system and ensure that it is a good model for other communities.

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Authors' contributions

Vaz, M.A.: conceptualization; formal analysis; methodology; investigation; writing – original draft; writing – review & editing. **Vitorino**, H.S.: investigation; methodology; visualization. **Evaristo**, A.M.: data curation; project administration; supervision. **Pereira**, D.R.A.S.: data curation; project administration; supervision. **Silva**, E.L.: data curation; project administration; supervision. **Costa,** F.L.: data curation; project administration; supervision. **Pinheiro**, T.G.: data curation; project administration; supervision visualization; writing – original draft; writing – review & editing. **Cruz**, D.D.: conceptualization; data curation; formal analysis; investigation; methodology; supervision; visualization; writing – original draft; writing – review & editing.

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