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SOCIOECONOMIC DEVELOPMENT OF FAMILY FARMING THROUGH SOIL MANAGEMENT TECHNIQUES AND PRODUCTIVITY

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ABSTRACT

Family farming is one of the pillars of food production in Brazil, being responsible for a large part of the food that reaches consumers' tables. Characterized by the predominant use of family labor, family management, and productive diversification, this form of agriculture is essential for food security, income generation, and preservation of the culture of rural communities. However, despite its relevance, family farmers face considerable challenges, especially with regard to soil fertility and inadequate use of agricultural inputs, factors that can directly compromise crop productivity and sustainability. The extension project reported in this work, entitled Socioeconomic development of family farming through soil management and productivity techniques, was developed with the objective of contributing to overcoming these challenges, seeking to promote free technical assistance to small producers, with the help of chemical soil analysis and personalized management recommendations. promoting at the same time a practical experience for students of the Agronomy course, integrating teaching, research and extension. The selection of producers was carried out through registrations, prioritizing properties with less access to specialized technical services. In total, 22 properties were served. Soil samples were collected in the cultivation areas, whose samples underwent complete chemical analysis, carried out by a

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Revista ARACÊ
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laboratory in the region. The parameters evaluated included pH, organic matter, cation exchange capacity (CEC), base saturation, in addition to the contents of essential macro and micronutrients. The results indicated that most of the soils in the region have a sandy texture, which limits water and nutrient retention and favors leaching processes. In addition, significant deficiencies of phosphorus (77.27% of the samples), potassium (55%) and organic matter (100%) were identified, as well as low base saturation values in 37% of the farms. These factors indicate the need for corrections, such as the application of limestone, organic and mineral fertilization, in addition to the adoption of conservation practices, such as green manure, soil cover and crop rotation. On the other hand, high levels of calcium, copper, iron and manganese have been observed, which can cause nutritional imbalances and even toxicity under certain conditions. Based on these data, the students, with the guidance of the professors, developed specific management plans for each property, due to the crops grown, the available resources and the level of technological knowledge of the farmers. In addition, during the technical visits, phytosanitary diagnoses were also carried out, which allowed the identification of pests and diseases and the proposal of specific integrated control measures for each property. In view of this, the extension project had a strong social and educational impact, contributing directly to the improvement of productivity in the properties served. This is because the farmers received qualified technical assistance in an accessible way, while the students lived an enriching practical experience, which brought them closer to the reality of the field and prepared them to act responsibly and efficiently in rural technical assistance. The data analyzed reinforce the importance of using soil analysis as an essential tool for agricultural management. The low fertility observed in most properties demonstrates the lack of specific technical actions for soil correction, which, if implemented correctly, can generate significant improvements in the production and sustainability of family crops. It is concluded that the project fulfilled its role by promoting the efficient use of inputs, adequate soil management and the strengthening of family farming. In addition, it has consolidated itself as an effective strategy for academic training, integration between university and productive sector and promotion of sustainable rural development. Initiatives like this reveal the transformative potential of university extension in building a more productive, fair, and environmentally balanced agriculture, directly contributing to the achievement of SDG 2 (Zero hunger and sustainable agriculture) of the UN 2030 Agenda.

Keywords: Technical assistance. Soil analysis. Sustainability. Profitability.

Revista ARACÊ
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INTRODUCTION

Being one of the pillars of food production in Brazil, family farming is responsible for a large part of the products that reach consumers' tables (CRESOL, 2024). This production modality is characterized by the predominant use of family labor, by retaining a maximum of four fiscal modules, by the requirement that a minimum portion of the income comes from the production unit itself, and by direct management by family members (CRESOL, 2024). The activity is recognized for the diversification of production and the strong relationship with the culture and tradition of rural communities. In addition to ensuring food and nutritional security, family farming plays an essential role in the economy, generating employment and income for millions of small producers.

This segment faces significant challenges, especially with regard to soil fertility and the use of agricultural inputs. Low soil fertility, inadequate soil management and inefficient use of agricultural inputs are some of the factors that limit crop productivity (FERREIRA, 2016). In this context, the adoption of good soil management practices and the efficient use of fertilizers and correctives are important strategies to optimize productivity and ensure the sustainability of crops.

Chemical analyses are essential tools for diagnosing the nutritional status of the soil, allowing for proper management. While the correct interpretation of the results allows the efficient use of fertilizers and correctives, optimizing the productive potential of the soil and promoting the sustainability of production systems (PREZOT *et al.,* 2007). Concomitantly, good practices such as organic fertilization, green manure, mulching, and crop rotation can contribute to improving the chemical, physical, and biological fertility of the soil, resulting in gains in productivity (OLIVEIRA, V.A.B. 2022).

Soil fertility is one of the main factors influencing the yield of agricultural crops. According to Lopes; Guilherme (2000), about 50% of the productivity gains are obtained from the correct application of fertilizers and correctives, while the rest is attributed to seed quality, pest and disease management, and other cultural practices. Despite the importance of carrying out soil analyses, many farmers still do not carry out this diagnosis systematically, which can lead to the inappropriate use of inputs.

Technical assistance and rural extension are fundamental tools for the dissemination of knowledge and for increasing the productive efficiency of rural properties. According to Redin (2013), many producers, even performing soil analyses, are sometimes unable to

Revista ARACÊ
ISSN: 2358-2472

interpret the results adequately, either due to lack of training or financial difficulties in hiring specialized consultancies.

In view of this scenario, the extension project developed aimed to analyze the soil fertility of municipalities in Adamantina and region and meet some of the demands of family farming, through recommendations for correctives and fertilizers and the development of efficient management strategies with the help of chemical soil analysis.

The project aimed to optimize the productivity and profitability of crops. In addition, it sought to provide students of the Agronomy course with the opportunity to apply in practice the knowledge acquired in the classroom, contributing to the training of professionals trained to work in the area of rural technical assistance, since "(...) the connection of the triad of teaching, research and extension is fundamental to ensure the transformative character of the interaction between higher education and civil society" (HAYAKAWA; BUENO; GUIMARÃES, 2024, p.20).

Last but not least, it should be noted that the work developed directly contributed to the achievement of Target 2.3 of SDG 2 of the UN 2030 Agenda, a goal that aims to double agricultural productivity and the income of small food producers, including family farmers, by 2030, through access to productive resources and inputs. knowledge, services and opportunities to add value, among other actions (IPEA, 2024).

METHODOLOGY

LOCATION AND DESCRIPTION

The present study was developed in the municipalities of Adamantina and region, with the purpose of providing free technical assistance services to family farmers, promoting integration between farmers, students and professors of the University Center of Adamantina. In addition to technical assistance, the project included a detailed study on the fertility of the soils in the region, based on the results of laboratory analyses of samples collected on rural properties.

DISSEMINATION AND SELECTION OF FAMILY PRODUCERS

The dissemination of the project was carried out through digital materials, such as folders, banners and posters through social networks and the University Center of Adamantina. Interested producers were registered through a registration form, based on this registration, twenty-two (22) family rural properties were selected, prioritizing those

Revista ARACÊ
ISSN: 2358-2472

with limited resources for the hiring of specialized technical services. After the selection of producers, technical visits were made to the properties in order to present the proposal for technical assistance and carry out soil sampling collections.

SOIL ANALYSIS AND FERTILITY STUDY

The soil samples collected were sent to a laboratory in the region, selected based on criteria of analytical quality and economic feasibility. In the laboratory, complete chemical analyses were conducted, aiming at the characterization of the nutritional profile of the soils of the properties served. The parameters analyzed included macronutrient and essential micronutrient contents, organic matter, pH, cation exchange capacity (CEC) and base saturation. Based on these data, a study was prepared on the fertility of the soils of the participating municipalities, identifying patterns and possible nutritional limitations that could impact the agricultural productivity of the region.

RECOMMENDATIONS AND TECHNICAL ASSISTANCE

The results of the laboratory analyses were interpreted by the students based on the knowledge obtained in the classroom, considering the specificities of each property and the nutritional requirements of the crops implanted. Management plans were prepared, including suggestions for fertilization and soil correction, always taking into account the technological level of the properties, the economic viability of the inputs and the accessibility of the producers to the recommended fertilizers and correctives (figures 01 and 02). In addition, phytosanitary diagnoses were carried out during the technical visits, enabling the detection of pests and diseases and the proposition of integrated control strategies (figures 03 and 04).

Revista ARACÊ
ISSN: 2358-2472

Figure 01. Technical assistance in pineapple cultivation / soil management.

Source: Authors.

Figure 02. Technical assistance in pineapple cultivation / planting techniques.

Source: Authors.

Figure 03. Technical assistance in guava culture / diagnosis of diseases (girdling).

Source: Authors.

Figure 04. Technical assistance in persimmon cultivation / pest diagnosis (fruit fly).

Source: Authors.

RESULTS

The methodological approach adopted in the project not only provided direct improvements in the productivity of the properties served, but also enabled an in-depth analysis of the soil fertility conditions in the region. The information generated served as a basis for decision-making by farmers, contributing to the optimization of the use of inputs and the promotion of the sustainability of production systems.

The study of soil analyses revealed nutritional deficiencies that negatively impacted crops, demonstrating the need for corrective actions to increase the efficiency of cropping systems. Showing that most of the soils analyzed, in addition to being sandy, had inadequate levels for phosphorus, potassium, organic matter, calcium, copper, iron and manganese.

Revista ARACÊ
ISSN: 2358-2472

The extension project is a valuable opportunity for practical learning for the students involved, promoting their technical training through direct experience with the productive sector. The interaction between students, teachers and family farmers fostered an enriching exchange of knowledge, reinforcing the importance of the junction between theory and practice in the training of future qualified professionals to work in the area of agricultural (or rural) technical assistance.

In this way, in addition to meeting the specific demands of family farming, the project also contributed to the strengthening of the Teaching, Research and Extension actions of the University Center of Adamantina, consolidating itself as a model of integration between the university and the productive sector.

DISCUSSION

The results of the project highlighted the importance of using soil analysis as a tool for diagnosing and managing soil fertility. The identification of nutritional deficiencies and chemical imbalances reinforces the need for strategic interventions, such as liming, fertilization, and soil conservation practices, to improve agricultural productivity and ensure the sustainability of production systems. From the results obtained after the chemical analyses of soils, some discussions were raised, showing that most of the rural properties had inadequate values for base saturation, the contents of some macro and micronutrients, and the levels of organic matter.

Of the twenty-two properties studied, twenty-one properties indicated sandy soils, and only one property presented soils of medium texture, showing that most of the soils in the region have high levels of sand. It is true that the predominance of sandy soils is a relevant factor. Because they have particles with greater particle size and less amount of electrical charges, sandy soils tend to have a low water and nutrient retention capacity, in addition to having high acidity and susceptibility to erosion (DUARTE, 2020). These soils require specific management, such as fractional fertilization and use of organic matter, to minimize losses due to leaching.

In addition, base saturation (V%) reflects the availability of essential basic cations, such as calcium (Ca), magnesium (Mg), potassium (K) and some regions, usually arid or semi-arid the element sodium (Na), in relation to the cation exchange capacity (CEC) of the soil. Soils with V% below 50% tend to have high acidity, which can inhibit the absorption of some nutrients and negatively affect plant growth (SOBRAL *et al.,* 2015). In the present

Revista ARACÊ
ISSN: 2358-2472

study, 37% of the soils analyzed presented V% below this limit, indicating the need for correction with limestone to neutralize toxic aluminum (Al^{3+}) and increase the availability of essential cations. Liming is fundamental to correct acidity and increase base saturation. This process improves the efficiency of fertilization and provides better conditions for the root development of plants.

Furthermore, phosphorus (P) is one of the most limiting nutrients for agricultural productivity, as it is directly involved in photosynthesis, energy storage and transfer (ATP), and plant root development (BARROS, 2020). In the study in question, 77.27% of the soil samples showed a deficiency of this nutrient, which can result in estimated losses of 10% to 20% on productivity. The low availability of phosphorus can result from several factors, including: lack of replacement of the nutrient, phosphorus fixation by iron and aluminum oxides, acidic soils and compacted soils (MENDES; JÚNIOR, 2003).

In turn, potassium (K) showed inadequate levels in 55% of the samples analyzed. According to Tonini *et al.* (2022) this nutrient plays a key role in osmotic regulation, opening and closing of stomata, protein synthesis, and enzymatic activation of plants. Soils with potassium deficiency can result in lower water use efficiency and greater susceptibility to abiotic stresses, such as drought and sudden temperature variations. In addition, the lack of potassium compromises the resistance of plants to pests and diseases, making crops more vulnerable.

According to Leite (2004), organic matter (OM) plays a crucial role in soil fertility, as it directly influences its water and nutrient retention capacity, in addition to improving its structure and biological activity. In the present study, 100% of the samples analyzed presented organic matter contents below the ideal, bringing values below 17 g/dm^3, which can compromise the development of plants and the sustainability of production systems. The incorporation of organic matter into the soil can be promoted by the use of green manures, organic fertilizers, composting, and crop rotation, practices that contribute to increasing the fertility and stability of agricultural systems, directly contributing to the achievement of sustainability (OLIVEIRA, 2022).

The contents of calcium (Ca), copper (Cu), iron (Fe) and manganese (Mn) were found at levels above the ideal in most of the samples analyzed. Excess calcium can reduce the availability of magnesium and potassium, impairing the nutritional balance of plants (BARROS, 2020). Copper and iron, when in excess, can generate toxicity for plants, reducing root growth and interfering with the absorption of other micronutrients (BARROS, 2020). Manganese, in turn, can reach phytotoxic levels in acidic soils, impairing plant photosynthesis and metabolism, in addition, it can interfere with the absorption of other nutrients such as calcium, iron and magnesium (VELOSO, 2025).

In view of these findings, the technical recommendations prepared by the students included the application of fertilizers, soil correctives and the adoption of conservation practices to improve soil structure and ensure an adequate supply of nutrients to plants. The positive impacts observed on crops and producers' income demonstrate that the adoption of practices based on technical diagnostics can result in significant benefits for family farming.

The strengthening of rural extension resulting from the integration between the university and the productive sector is important to promote greater sustainability and profitability in family farms. In addition to the agronomic benefits, the project provided positive impacts in the social and academic spheres. Family farmers received qualified technical assistance, while the students involved were able to experience the reality of the field and apply the knowledge acquired in the classroom in a practical way.

CONCLUSION

The project demonstrated that a relevant percentage of rural properties do not receive adequate soil management, highlighting that nutritional deficiencies compromise the productivity and sustainability of crops.

Thus, the adoption of corrective practices, such as liming, gypsum, and the correct use of fertilizers, can promote greater production efficiency and increase farmers' profitability, contributing to the achievement of sustainability.

In addition to the direct benefits for farmers, the project strengthened the academic training of students, providing practical experiences and expanding their understanding of the challenges faced by family farming.

Strengthening technical assistance and rural extension proved essential to ensure that the recommendations are implemented effectively, promoting the sustainable development of the sector.

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Revista ARACÊ
ISSN: 2358-2472

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