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THE IMPACT OF SUSTAINABLE AGRICULTURAL TECHNOLOGIES ON THE CO_2 EMISSIONS FROM CARANI AND JAMU MARE

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Abstract: *This paper analyzes the impact of sustainable agricultural technologies on CO_2 emissions in the rural areas of Carani and Jamu Mare. The study focuses on the adoption of environmentally friendly practices such as precision agriculture, reduced tillage systems, efficient irrigation technologies, and the use of renewable energy sources in agricultural operations. By comparing emission levels before and after the implementation of these technologies, the research highlights their role in reducing greenhouse gas emissions and improving resource efficiency. The research analyzed the main components of the natural environment – relief, lithology, hydrography, climate and vegetation – in correlation with the physicochemical properties of the soils and the applied technological practices. Soil samples were taken from representative soil profiles and analyzed in the laboratory to determine the soil reaction (pH), humus, phosphorus, potassium and nitrogen content, as well as to estimate the carbon sequestration capacity. Data were collected through field measurements, farmer surveys, and analysis of agricultural inputs and outputs. The results indicate a significant decrease in CO_2 emissions, primarily due to reduced fuel consumption, optimized fertilizer use, and enhanced soil carbon sequestration. The results obtained highlight that the adoption of sustainable agricultural technologies, such as crop rotation, organic fertilization and reduction of mechanical works, contributes significantly to reducing the carbon footprint and increasing the soil's capacity to store organic carbon. By integrating these practices, agriculture can become a key factor in mitigating climate change and promoting sustainable management of natural resources. Furthermore, the findings emphasize the importance of local conditions and policy support in accelerating the transition toward sustainable agriculture.*

Keywords: *ecopedological, sustainable, CO_2, soils, technologies*

INTRODUCTION

In the context of global climate change, agriculture has a dual role – being both an important source of greenhouse gas emissions and a potential solution to reduce them. Sustainable agricultural practices can significantly contribute to reducing CO_2 emissions by increasing the capacity of soils to store organic carbon.

Agriculture has a key role to play in ensuring food security, maintaining rural livelihoods and managing environmental sustainability. However, growing concerns about soil degradation, biodiversity loss and greenhouse gas emissions have intensified the debate between conventional and organic farming systems. In this context, assessing and comparing these two agricultural models can provide valuable insights into their long-term sustainability and environmental impact.

Romania's 2.9 million farmland owners are increasingly adopting innovative practices aimed at improving the efficiency and sustainability of production. These include smart agricultural technologies, land conservation techniques, chemical mapping, and variable seeding densities adapted to soil structure and nutrient availability. Overall, Romania's agricultural sector is not only vital to its national economy, but also holds a distinct and influential position in the broader European agricultural landscape.

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Conventional agriculture, also referred to as industrial or modern agriculture, relies heavily on chemical interventions and large-scale mechanized operations. It typically uses genetically selected seeds, synthetic fertilizers, pesticides, and herbicides to maximize yields. This system often focuses on monoculture – growing a single crop over large areas – and concentrates animals in closed facilities. While this pattern has significantly boosted global food production (the World Bank estimates that 70-90% of recent increases are due to conventional methods), it has also triggered serious social and environmental consequences.

In contrast, organic farming, known in Romania and the European Union as "organic farming," emphasizes sustainability, environmental protection, and the health of consumers and ecosystems. This approach avoids synthetic inputs, relying instead on natural processes, crop rotation, biodiversity and soil regeneration techniques. Organic farms often integrate livestock production and crops to maintain ecological balance.

The paper comparatively analyzes two representative areas in western Romania, Carani and Jamu Mare, highlighting the link between ecopedological particularities and the efficiency of ecological agricultural technologies in reducing carbon emissions. The conventional farm in Carani follows intensive agricultural practices characterized by synthetic inputs such as chemical fertilizers and pesticides, mechanized operations, and monoculture cultivation systems. Instead, the organic farm in Jamu Mare adheres to organic principles, minimizing external inputs, increasing biodiversity, and focusing on soil health through natural amendments and crop rotation.

MATERIALS AND METHODS

These paper investigates several key indicators of agricultural sustainability, including soil composition and fertility, crop production levels, pesticide use and carbon sequestration capacity. These factors are not only essential for the productivity and profitability of farms, but also for their environmental footprint and their role in mitigating climate change.

The study was carried out in two representative localities: Carani, located in Vinga Plain, and Jamu Mare, located in the contact area between the Gătaia Plain and the West Hills. The analysis included the characterization of relief, lithology, hydrography, climatic conditions and soil types, according to the methodology of ICPA (1987) and the Romanian Soil Taxonomy System (SRTS, 2012).

The object of study is the agricultural land belonging to the administrative territorial units of Jamu Mare (organic farm) and Carani (conventional farm), with emphasis on the characteristics of the soils used in the two farming systems.

The research of the ecopedological conditions was carried out in accordance with technological sheets from both farms.

Within each plot, representative soil profiles were opened, from which soil samples were collected on pedogenetic horizons, both in natural (unmodified) and in modified settlement:

In the natural settlement, the samples for determining the physical and hydrophysical characteristics were collected in metal cylinders of known volume, at the momentary humidity of the soil, and in special cardboard boxes for micromorphological analysis;

In the modified settlement, the samples were collected in labeled bags, separated by genetic horizons, for the physicochemical and partially biological characterization of the soils.

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RESULTS AND DISCUSSIONS

The localities of Carani and Jamu Mare, located in the south-western part of Romania, in Timiș county, respectively Caraș-Severin county, are located in a geographical and climatic context specific to the Western Plain, respectively to the contact area with the Banat Hills. The village of Carani is located 18 km north of Timișoara, on the county road DJ692. Jamu Mare is the village of the commune of the same name in the southern extremity of Timiş County, on the border with Serbia.

The relief of the Banat region, where the localities of Carani and Jamu Mare are located, is predominantly plain, with slight undulations. Carani is located in the Vingăi Plain, part of the Western Plain, with average altitudes around 90–100 m. The Western Plain is located in the western part of the country being bounded by:

- east - Northern Group of the Eastern Carpathians, Zarand Mountains and Western Hills
- west - border with Hungary
- north - border with Ukraine
- south - border with Serbia

The altitudes vary between 75 and 190 meters, and the predominant relief units are the low and high plains. The slope of the land is very low, oriented in the east-west direction, which favors the stagnation of water and has determined, in the past, the frequent occurrence of floods in the lowlands.

Jamu Mare is located in a transition zone between the Gătaia Plain and the Oravița Hills, part of the Western Hills, with altitudes that can exceed 130 m. The Western Hills are a hilly geographical unit located in the western part of the Western Carpathians. The flat terrain favours intensive agricultural land use, but in some areas there are tendencies of settlement or superficial erosion, especially in the case of intensive agricultural work.

Hydrography is poorly represented in both localities. In Carani, the Bega River crosses the area to the northwest, but at a considerable distance from the village. The system of dewatering canals is well developed, characteristic of the Banat Plain. Jamu Mare is located in a more hilly area, where water is collected in seasonal streams and small valleys that drain to the Moravița River. From a hydrogeological point of view, both localities are located above shallow water aquifers, used for domestic water supply and irrigation.

The air temperature directly determines the intensity of physiological and biochemical processes and acts indirectly on them, through the influence it has on the thermal regime of the soil, as well as on evapotranspiration.

The average annual temperature is 10.9^0 C. Under the influence of the Mediterranean and oceanic air, winters are shorter and milder.

The multiannual average of precipitation oscillates between 605.5-725.9 mm

From a phytogeographical point of view, the perimeter belongs to the Central European botanical province, strongly influenced by the vicinity of the Southern European geobotanical province.

Human activity has profoundly influenced the natural setting in both localities. In Carani, intensive farming, the use of chemical fertilizers and pesticides has led to the gradual degradation of soil quality and soil compaction. Jamu Mare, although less affected by intensive agriculture, is influenced by monoculture and the lack of crop rotation. In both localities there is a reduction in biodiversity, an alteration of the natural hydrological regime and an increased risk of groundwater pollution.

This paper presents the technologies of wheat cultivation in a conventional and organic system within two different farms.

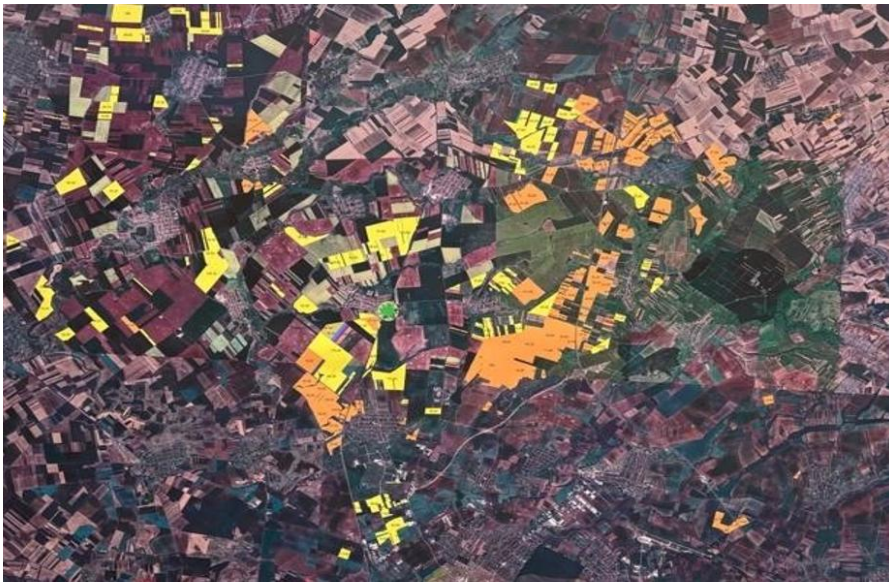

Figure 1. The location of plots from conventional farms

In the conventional system, the agricultural farm on the perimeter of Carani was studied. Following the taking of soil samples from the wheat crop in the organic system and the

Regarding the main physical and hydrophysical properties of the analyzed soil, it has an average argillaceous -clay texture (TT) between 0-200 cm .

The bulk density (DA, expressed in g/cm³) registers medium values between 0-17 and very low values between 17-120.

The reaction of the analyzed soil (pH) varies on the profile, being moderately acidic between 0-17 cm, weakly acidic between 17-47cm, neutral between 47-90 cm and weakly alkaline between 90-200 cm;

The current study contains elements of soil characterization that can be used for the rational and efficient use of fertilizers and soil amendments.

Developing a fertilization plan is essential to compensate for nutrient deficiencies in the soil, which involves the use of chemical fertilizers.

Within the farm on the study soils, a short rotation system is used, wheat and corn.

The soil in the plot cultivated with wheat shows a weak acidic reaction, which led to the beginning of the phosphorus blocking process. Although potassium levels are currently high, soil acidification is accentuated as calcium reserves are depleted, especially from the surface horizon. This phenomenon is also favored by the predominant use of fertilizers with an acidifying effect.

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The determination of the amount of carbon dioxide taken from the atmosphere and stored in biomass is carried out on the basis of the ratio of the molar masses of the component elements.

Given that the atomic mass of carbon is 12.0107 g/mol and the molar mass of carbon dioxide is 44.010 g/mol, it follows that carbon dioxide is about 3.6642 times heavier than elemental carbon.

For every gram of carbon fixed in biomass, plants take up about 3.6642 grams of carbon dioxide from the atmosphere.

The carbon footprint, also called the CO_2 footprint, represents the total greenhouse gas emissions associated with the activities of a person, product, event or organization, in a specific time frame.

A liter of diesel, with a density of 0.85 kg/l, generates about 2.6 kg of carbon dioxide after combustion.

The table below highlights the fuel consumption and the amount of carbon dioxide emitted during the cultivation of wheat by conventional methods.

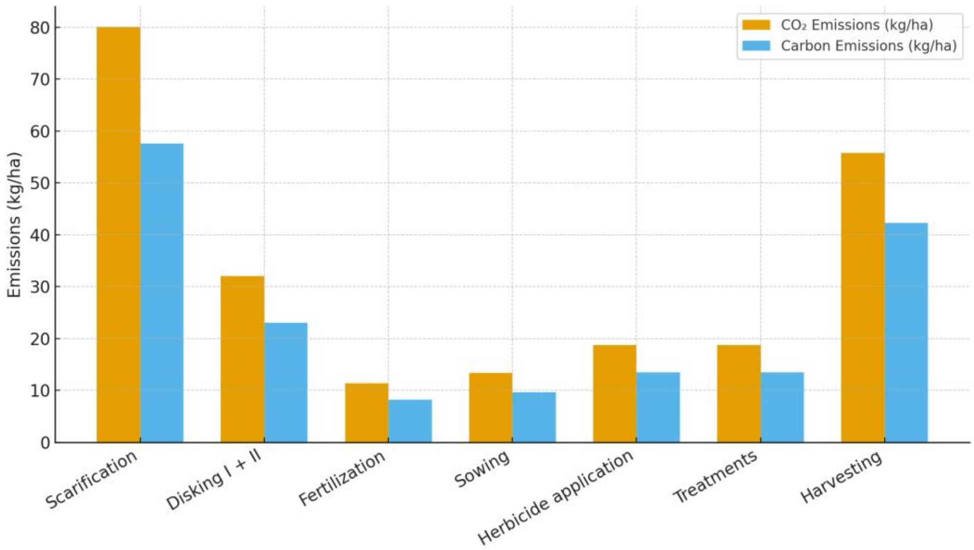

Figure 2. Energy consumption and carbon emissions in the conventional system

Through the conventional tillage system, we consume 78 liters of diesel/ha, resulting in emissions of 229.87 kg CO2/ha.

The organic farm has 450 organic hectares and 50 hectares of conversion. They use the rotation system with legume crops that fix nitrogen.

In the Jamu Mare area, a soil unit was identified, a Vertic preluvosoil, medium clay / medium clay .

Figure 3. Location of plots from organic farms

Regarding the main physical and hydrophysical properties of the analyzed soil, it has a medium clay texture (TT) between 0-18cm, clay (TP) between 18-29cm, medium clay (TT) between 29-200cm.

The humus reserve in the first 50cm shows low values. The content in P assimilable in the AP shows a good state of supply. The content in K, assimilable in Ap, has a medium supply state.

The reaction of the soil is moderately acidic between 0-18cm, weakly acidic between 18-71cm, moderately acidic between 71-100cm.

Two types of wheat are grown on the farm to make bread. The wheat crop "Rebelde" is located on a total area estimated at 180 ha. The complete biological cycle of the wheat crop took place at the beginning of September. For the establishment of wheat crops, we started with the crop rotation plan for the previous winter/spring.

Soil works such as disc work (I, II) were carried out in early September - mid-September with performance machinery.

Organic fertilization processes begin 2–4 weeks before sowing with: manure from a sheep farm in the commune of Clopdia, Amino acids and covering the soil with plant debris. The wheat crop "Rebelde" was sown in late September - mid-October. Ecological foliar fertilization was carried out several times, in October, April and May. No weed control substances are used, a high sowing density is used to control them.

To combat diseases and pests, crop rotation is taken into account, resistant species are introduced, Italian wheat "Rebelde" has sharp ears, which animals do not like.

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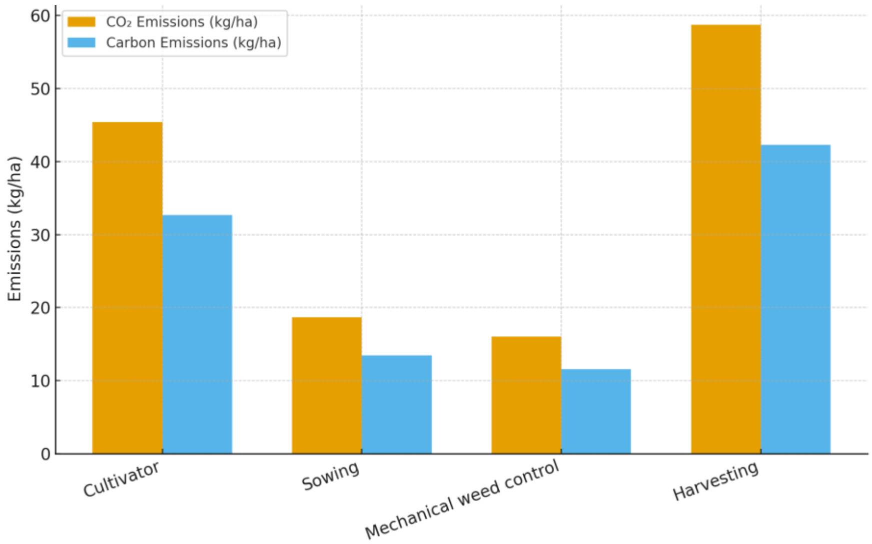

Figure 4. Energy consumption and carbon emissions in the ecological system

The amount of carbon emissions resulting from organic soil tillage in the organic system is 138.4 kg/ha, and from the intensive system 229.67 kg/ha. Carbon emissions from soil fertilization with chemical fertilizers are much higher, respectively by 385.2 kg/ha.

In the case of traditional tilling, diesel consumption is about 81 liters per hectare, which generates emissions of about 2106 kg CO_2/ha. By applying a minimum processing system, consumption decreases to 52 liters/ha, equivalent to 1352 kg CO_2/ha.

Carbon conversion results.

As regards the distribution of energy inputs, the largest amount of emissions is recorded in the case of the use of nitrogen fertilisers.

Based on the total biomass production (primary + secondary) and knowing the straw ratio, we can calculate the amount of carbon stored per hectare.

To determine the straw production, we multiplied the grain yield per hectare by the coefficient of 0.59.

For wheat cultivation, with a biomass production of 11 tons per hectare, we have 4.5 tons of grains + 6.5 tons of straw. In addition, underground, we have 3.2 tons of roots.

Plant residues are represented by 6.5 tons of straw x 0.44 = 2.86 tons of carbon.

3.2 tons of roots x 0.43 = 138 tons of carbon

Total: 9.5 tonnes of residual biomass, containing 4.24 tonnes of carbon

30% of this carbon (1.46 tons) is released into the atmosphere through respiratory processes and other losses:

$4.24 - (0.30 \times 4.86) = 4.24 – 14.6 = 2.78$ tons of carbon.

1 tonne of carbon = 0.34 tonnes of soil organic carbon (COS).

As a result, 1 hectare of wheat brings a net amount of 2.78 tons of carbon x 0.34 = 0.95 tons of humus C (COS).

The beans contain about 45% carbon → 45 tons of beans x 0.45 = 2.02 tons of carbon.

As for the primary production of grains, it will be exported from agricultural fields, which means that this amount of carbon will be fed back into the system.

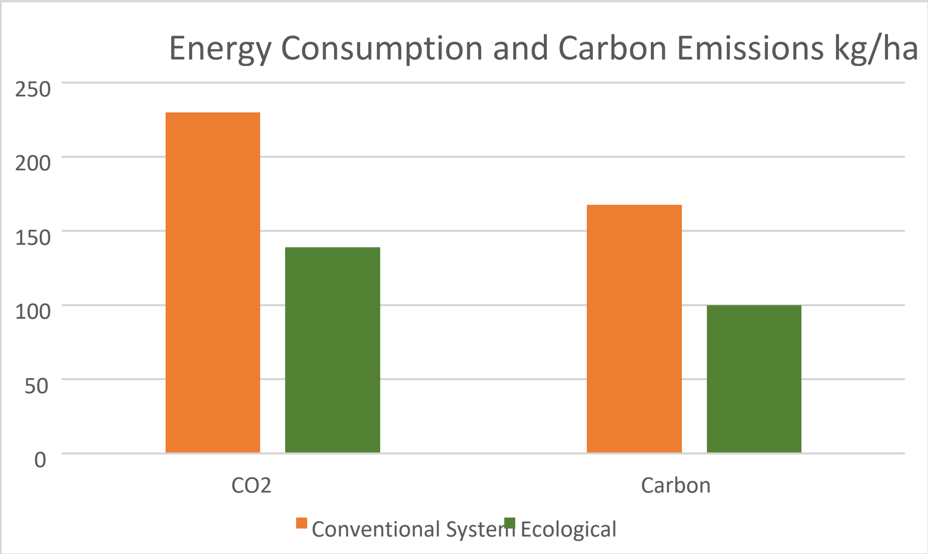

Figure 5. Energy consumption and carbon emissions kg/ha for the conventional system and the ecological system

CONCLUSIONS

Alternative solutions have been identified to increase energy efficiency and reduce carbon dioxide emissions. Fixing carbon dioxide from the atmosphere in soil and biomass, together with the use of alternative technologies to reduce CO_2 emissions, are key directions in protecting the environment and managing climate change globally. Also, the accumulation of carbon in the soil helps to improve its properties and stimulates the activity of microorganisms in the soil ecosystem. Limiting the intensity of tillage leads to a decrease in the volume of emissions produced.

The application of synthetic substances in agriculture involves high energy consumption, which is responsible for most of the emissions, especially in the case of nitrogen fertilisers. An effective alternative is to introduce legumes into crop rotations, which contribute significantly to the natural nitrogen input to the soil and considerably reduce CO_2 emissions.

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