Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

AGROECOLOGICAL PRACTICES THAT PROMOTE AND SUPPORT SUSTAINABLE AGRICULTURE

Maria TOADER[1], Viorel ION[1], Lenuța Iuliana EPURE[1], Emil GEORGESCU[2], Adrian Gheorghe BĂȘA[1], Mirela Elena DUȘA[1], Mihaela Valentina VASILE[1], Alina Maria IONESCU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, Bucharest, Romania
[2]National Agricultural Research and Development Institute of Fundulea, 1 Nicolae Titulescu Street, Călăraşi County, Romania

Corresponding author email: mihaela.petcu@agro-bucuresti.ro

Abstract

In recent decades, sustainable agriculture has become essential in the joint effort of agricultural policies and all stakeholders against the backdrop of climate changes and concerns about natural resources conservation. This agricultural system focuses on practices that increase agricultural yields, while protecting the environment and ensuring resources for the future. These practices include, among others, soil and plant health through crops diversification and rotations, the use of organic fertilizers, water and soil conservation by new tillage methods, or the implementation of innovative technologies for crops growing and animal husbandry. On the other hand, agroecology is an innovative concept that aims to ensure sustainable agricultural production and is based on the collaboration between people, science and environment to find solutions to the major problems that agriculture is currently facing, such as: diminishing soil and crop health, pollution, climate changes, pests control, or to ensure the high quality of agri-food products. The agroecological practices could be the path to success towards a sustainable agri-food system, through the involvement and effort of all key actors, farmers, decision-makers, citizens, by co-creating an environment favorable to knowledge exchange, progress, adaptation to change, and dissemination of good results to all. In this context, this paper aims to provide an overview of some examples of agroecological practices that promote and support sustainable agriculture in Romania.

Key words*: agroecology, agroecological practices, crops health, soil health, sustainable agriculture.*

INTRODUCTION

Sustainable agriculture is an approach that seeks to minimize the negative impact of agricultural activities on the environment, while maintaining the ability to produce agrifood products in the most sustainable way possible. At the same time, according to FAO documents, agroecology involves, in an integrated approach, ecological and social concepts, principles with the aim of designing and managing agricultural and food systems in a sustainable way (FAO, 2025).

By optimizing the interactions between plants, animals, people and the environment, by including ecological, socio-cultural, technological, economic and political dimensions, from production to consumption, equitable and sustainable food systems can result that ensure food security and safety. In the realm of food security, agroecological practices play a vital role in ensuring sustainable nourishment. By bolstering soil fertility, encouraging crop diversity, and supporting local food production, agroecology acts as a buffer against the challenges posed by a changing climate (McLennon et al., 2021; Madsen et al., 2021). Consumers are increasingly interested in food products obtained through sustainable and ecological methods. This leads to an increased demand for agroecological products, stimulating the transition to more sustainable food systems (https://www.ecoruralis.ro/programe/agroecologie/).

Agroecological principles such as polyculture, crop diversity, and integrated pest control help to improve food security by increasing stability and nutrition. Agroecology encourages carbon sequestration, soil health, and greenhouse gas reductions, resulting in climate-resilient farming systems (Ranjan, 2024).

MATERIALS AND METHODS

This article presents an analysis of the specialized literature that seeks to make a connection between the importance and role of implementing agroecological practices in the approach and development of sustainable agriculture, protecting the long-term health of people, animals, landscapes and the environment, as well as the health of soil and plants.

In summary, a series of aspects related to the current global issues of the agroecological transition will be discussed through the lens of soil degradation processes and soil health management and its microbiology, emphasizing the causal relationships between factors, the dynamics of degradation processes, and the impact produced on both the soil, the environment, and human society.

Examples of agroecological practices related to improving soil fertility through nutrient management and crop rotation diversity through the use of legumes as nitrogen-fixing plants were addressed. Also, the issues of integrated pest management were addressed, which are based mainly on preventive and then curative methods.

RESULTS AND DISCUSSIONS

From the point of view of the importance of agroecology on sustainable agricultural systems, some benefits are discussed based on some general principles that refer to: soil conservation, nutrients management, crop rotation, biodiversity, energy balance of farm and environmental impact (Figure 1). The importance of each will be briefly presented below.

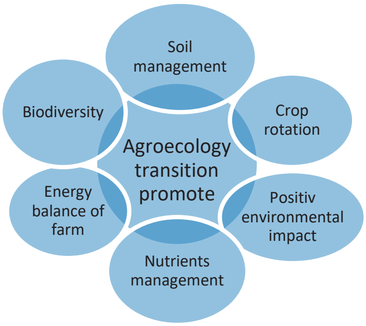

Figure 1. Agroecology practices to support sustainable agriculture

Soil health management. Broad sustainable soil development is only available it if includes forms of conservation and sustainability within the processes of soil management. Of the 4.40 billion ha of agricultural land on worldwide, 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050 (FAO and ITPS, 2015; IPBES, 2023). Soil erosion and land degradation pose a major threat to global food security and to the achievement of the Sustainable Development Goals (SDGs) – compromising the well-being of at least 3.2 billion people around the world (FAO, 2025).

The loss of fertile arable land is accelerating annually with a rate of around 24 million ha and 23 ha per minute and economic losses amounting to 10% of the global GDP annually (Gebremedhin et al., 2022). Because 95% of the food comes from the soil, soil erosion is critical for protecting the soil while ensuring a sustainable and food security in the world (https://www.weforum.org/stories/2023/02/soil-degradation-biodiversity-planet/).

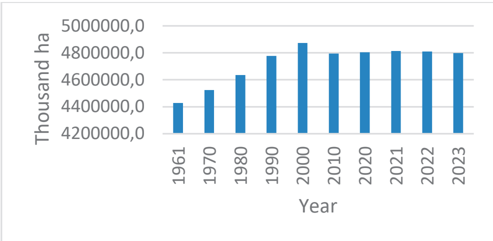

Figure 2. Evolution of agricultural land in the world in the period 1961-2023 (FAOSTAT, 2023)

According to Alderman et al. (1990), on the global basis, the soil degradation is caused primarily by overgrazing (35%), agricultural activities (28%), deforestation (30%), over exploitation of land to produce fuelwood (7%), and industrialization (4%). In Europe, according to the same authors, the soil degradation is caused primarily by agricultural activities (38%), deforestation (29%), overgrazing (44%) and industrialization (9%). Romania's agricultural area impacted by critical levels of singular processes, highlighting the degradative pathways of soil compaction (40%), aridity (24%), tillage erosion (22%), soil nutrient imbalances (22%) and water erosion (20%) as the greatest threats to

agricultural landscapes countrywide (Prăvălie et al., 2025).
Under no-till conditions the earthworm populations are much more abundant than in those where plowing is applied (Amuza and Ilie, 2024).

Table 1. Soil organism functions and agronomic consequences

Soil organisms	Functions	Agronomic consequences
Earthworm burrows	Consume dead plant material (roots, residues) make galleries, redistribute organic matter and nutrients from the topsoil layer, secrete a plant growth stimulant	Soil aeration, water infiltration, root penetration, nutrient recycling, plant growth stimulation
Arthropods	Consume plant and animal residue	Nutrient recycling
Bacteria	Descompose organic matter wastes, realease plant growth hormones, fix atmosferic nitrogen, transform nitrogen to ammonium to nitrites and viceversa, secretae the polysaccharides	Provision of available nutrients (N, P, Al), plant grow stimulation, improvement of the soil structure, root diseases resistance
Fungi	Decompose organic matter, release plant hormones and antibiotics	Nutrient recycling, plant stimulation
Mychorhizae (fungi)	Extend the reach of roothairs, release plant hormons and antibiontics	Increase in water and nutrient (p) intake, plant diseases resistance, root growth stimulant
Actinomicetes	Descopose organic matter, release antibiotics	Nutrient recycling, root disease resistance
Algae	Photosynthesize, secrete organic substance	Improvement in soil structure
Protozoa	Consume bacteria and other microbes	Increase in the rate of nutriet cycling
Nematodes	Eat decaying organic matter and microorganisms (bacteria, fungi, algae, protozoa, nematodes	Increase in the rate of nutrient cycling

Agroecological practices that support technological progress, as well as better tillage systems, supporting biodiversity through crop rotation, balanced fertilization plans, and controlling weeds, pests, and diseases, can offset the negative effects of soil degradation (Al-Musavi et al., 2025).
Organic matter is anessential component of soil. Among its several properties, it supplies carbon, energy and nutrients, stabilizes soil aggregates, improves storage characteristics and water flow in soil, acts as a sourse of nutrients, has a great capacity of cationic exchange, reduces the soil apparent density while minimizing the effect of compression, makes soil much more friable an less adherent, thus easier to till, reduces negative effects of pesticides, heavy metals and other polluters. The quantity of organic material in soil at a given moment is determined by the equilibrum between the addition of material and its loss and decomposition.
Nutrients management. Balanced fertilization refers to the optimal supply of nutrients necessary for plants for healthy and vigorous growth, without excesses or deficiencies. Such a balance involves the adequate supply of nitrogen (N), phosphorus (P) and potassium (K), as well as other minor elements, depending on the specific needs of the plant and the soil. The Code of Good Agricultural Practices (CBPA) formulates several principles to ensure efficient and non-polluting fertilization. Rational fertilization and the preservation of soil quality are interdependent. The principles it is based on include application of fertilizers only during the active vegetation period, because during periods of vegetative rest, significant losses of nutrients occur in surface waters and groundwater and implicitly pollution with nitrates.
The mechanisms of involvement and participation of nutrients in physiological processes in plants are the same, regardless of their origin (from natural sources or from chemical fertilizers). At the same time, the quantitative requirements of nutrients vary with the crop, the expected harvest and the climatic conditions. The fertility level of a soil can be degraded if the cultivation technologies are incorrect or, on the contrary, it can increase if it is cultivated in a manner that improves its chemical, physical and biological properties (Furey and Tilman, 2021).

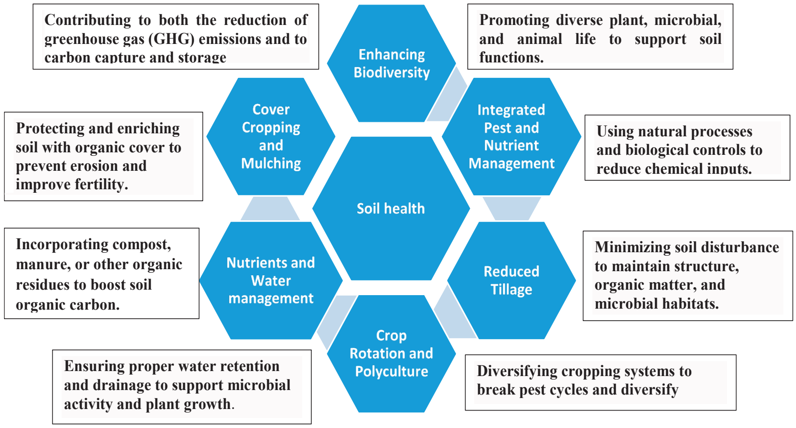

Figure 3. Benefits of soil health to agroecology transition

A soil with good natural fertility can become productive by correcting the limiting factors that prevent the normal growth and development of plants (acidity, excess or deficiency of nutrients) or it can depreciate by impoverishing in one or more nutrients, by degrading some properties or it can be completely destroyed by erosion phenomena (Karlen, 2004).

In recent decades, sustainable agriculture has become essential in the joint effort of agricultural policies and all stakeholders against the backdrop of climate change and concerns about resource conservation. This agricultural system focuses on practices that increase agricultural yields, while protecting the environment and ensuring resources for the future. These practices include soil and plant health through crop diversification and rotation, the use of organic fertilizers, water and soil conservation, or the implementation of innovative technologies in plant cultivation and animal husbandry. On the other hand, agroecology is an innovative concept that aims to ensure sustainable agricultural production and is based on the collaboration between man, science and the environment to find solutions to the major problems that agriculture is currently facing, such as: diminishing soil and crop health, pollution, climate change, or the need to ensure the quality of agri-food products (Chable et al., 2020). The agroecological transition could be the path to success towards a sustainable agrifood system, through the involvement and effort of all key actors, farmers, decision-makers, citizens, by co-creating an environment favorable to knowledge exchange, progress, adaptation to change, which would help to popularize, accelerate the transition and implementation of agroecological practices.

In this context, as examples of agroecological practices that promote and support sustainable agriculture are the cultivating of plants that can be grown for green manuring are those that yield relatively much green mass under the farms climatic and soil conditions. In addition, nitrogen-fixing plants are advantageous. The effect of green manure depends not only on the crop ploughed in but also on the soil. In sandy soil poor in nitrogen, the bacteria within root nodules fix more nitrogen. In spite of this, the yield increasing effect of green manuring is higher in latter because, together with decomposition of ploughed in green manure, the decomposition of the soils organic substances accelerates too, so that more nutrients available to the plant are produced.

Crops rotation and legumes crops. Crop rotation is a sustainable agricultural practice that involves systematically changing the types of crops grown in a particular area across different seasons or years. This method helps improve soil health, breaking pest and disease cycles, and decrease the reliance on chemical inputs. Key benefits of crop rotation in organic farming include: enhancing soil fertility by alternating crops with different nutrient needs; breaking pest and disease cycles by disrupting their habitats; reducing weed problems through diverse planting patterns; promoting beneficial soil organisms. Common crop rotation strategies often include the use of legumes (such as beans or peas) to fix nitrogen in the soil, followed by crops that consume more nutrients (like grains or vegetables), and then cover crops or green manure to restore soil organic matter. Legumes have a positive impact on soil fertility due to their ability to fix atmospheric nitrogen in the soil through symbiotic bacteria such as those of the genus *Rhizobium*. This process helps increase the level of nitrogen available to other plants, reducing the need for chemical fertilization.

The benefits of these plants include: improving the nutrient content of the soil, especially nitrogen, improving soil structure and water retention capacity; reducing soil erosion; increasing microbiological biodiversity in the soil. In addition, legume crop rotation helps prevent nutrient depletion and reduce soil diseases, thus helping to maintain and improve soil fertility in the long term (Țopa at al., 2024).

Plant protection. Plant protection according to agroecology principles focuses on maintaining healthy crops by minimizing the impact of pests, diseases, and weeds using natural and sustainable methods. This approach emphasizes preventing problems through proactive measures and fostering a balanced ecosystem rather than relying on synthetic pesticides (Zhou et al., 2024). Unlike conventional agriculture, these methods rely on ecological principles and preventive techniques, such as crop rotation and biodiversity management, to control pests, diseases, and weeds, rather than chemical inputs. Specific techniques include the use of organic substances like compost and manure for fertilization, mechanical methods such as barriers and water sprays for pest removal, and biological controls utilizing natural predators or biopesticides. Also often incorporates IPM principles, which involve monitoring pest populations, identifying thresholds for intervention, and using a combination of preventative and direct control methods. Deguine et al. (2022) defined Agroecological Crop Protection (ACP) as the reduction of pest impacts through the reorganization of cropping practices and the improvement of agroecosystem sustainability by harnessing its ecological functions. The stimulation of ecological processes such as natural pest regulation through improved soil health and improved interactions between plant and animal communities, is a rich source of innovative crop protection models (Brévault and Clouvel, 2019). Key principles are presented in the next table (Table 2).

Table 2. Key principles and practices of plant protection according to agroecology principles (own processing)

Key principles	Practices
Biodiversity	• Promoting a diverse ecosystem helps to naturally control of pests and diseases; • Including crop rotation, intercropping, and maintaining habitats for beneficial organisms.
Soil Health	• Healthy soil is fundamental for plant health; • Practices like composting, cover cropping, and reduced tillage improve soil structure, fertility, and microbiome diversity, which in turn enhances plant resistance to pests.
Cultural Practices	• Techniques such as intercropping, crop rotation, and timed planting can reduce pest pressures and improve crop resilience; • Planting pest-resistant varieties also plays a significant role.
Biological Control	• Utilizing natural predators and parasitoids to manage pests is a standard practice in ecological farming; • Introducing or conserving beneficial insects (like ladybugs or parasitoid wasps).
Mechanical and Physical Controls	• Practices such as mulching, row covers, and traps can physically restrict pests and weed growth without chemicals.
Monitoring and Thresholds	• Regularly monitoring pest populations and understanding economic thresholds helps farmers make informed decisions about when intervention is necessary, reducing unnecessary pesticide use.
Natural Inputs	• Using of natural substances (such as neem oil, insecticidal soaps, or diatomaceous earth) that are less harmful to the environment compared to synthetic options.
Education and Knowledge Sharing	• Farmer education and participation in cooperative learning can enhance knowledge of sustainable practices and pest management strategies.

Plant protection seeks to create a balance between maintaining productive agriculture systems and conserving biodiversity.
By implementing a combination of biological, cultural, physical, and, when necessary, natural control measures, farmers can effectively manage pests while promoting environmental sustainability.

CONCLUSIONS

Agroecology applies ecological principles to design sustainable food systems that work with nature, to reduce environmental impact and promote ecological renewal.
By emphasizing biodiversity, closed nutrient cycles, and natural processes, it minimizes reliance on synthetic inputs, enhances ecosystem services like soil fertility and natural pest control, and contributes to more resilient, equitable, and sustainable food production systems.

ACKNOWLEDGEMENTS

This article was financed by the Faculty of Agriculture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, within "SUNRISE - Supporting the Agroecological Transition Through Living Labs Networks" project, in response to the 1st Agroecology Partnerships co-funded call, as part of Program 5.8. - European and international cooperation, Subprogram 5.8.1. - Horizon Europe and Framework Programme for Research and Innovation and Executive Unit for Financing Higher Education, Research, Development and Innovation in Romania (UEFISCDI), contract no 106/01.04.2025.

REFERENCES

Amuza, A.C., Ilie, L. (2024). Research on earthworm community in maize crop in Borcea, Călărași. *Scientific Papers. Series A. Agronomy, Vol. LXVII, Issue 2*, pp. 13–18.

Alderman, D., Holdich, D., Reeve, I. (1990). Signal crayfish as vectors in crayfish plague in Britain. *Aquaculture, 86*(1). 3–6.

Al-Musavi, Kh.Z., Vona, V., Kulmány, I.M. (2025). Utilizing Different Crop Rotation Systems for Agricultural and Environmental Sustainability: A Review. *Agronomy, 15*(8). 1966.

Brévault, T., Clouvel, P. (2019). Pest management: Reconciling farming practices and natural regulations. *Crop Protection, 115*. 1-6.

Chable, V., Nuijten, E., Costanzo, A., Goldringer, I., Bocci, R., Oehen, B. (2020). Embedding cultivated diversity in society for agro-ecological transition. *Sustainability, 12*. 784.

Deguine, J., Aubertot, J., Bellon, S., Côte, F., Lauri, P., Lescourret, F., Ratnadass, A., Scopel, E., Andrieu, N., Bàrberi, P., Becker, N., Bouyer, J., Brévault, T., Cerdan, C., Cortesero, A., Dangles, O., Delatte, H., Dinh, P.T.Y., Dreyer, H., Lamichhane, J.R. (2022). Agroecological crop protection for sustainable agriculture. *Advances in Agronomy, 178*. 1–59.

Gebremedhin, M., Coyne, M. S., Sistani, K.R. (2022). How Much Margin Is Left for Degrading Agricultural Soils? The Coming Soil Crises. *Soil Systems, 6*(1). 22.

FAO, 2025. One Health and agroecology for agrifood system transformation. https://www.fao.org/one-health/highlights/one-health-and-agroecology/en.

FAO and ITPS. 2015. Status of the World's Soil Resources (SWSR) – Main Report. *Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils*, Rome, Italy.

Furey, G.N., Tilman, D. (2021). Plant biodiversity and the regeneration of soil fertility. *Proceedings of the National Academy of Sciences, 118*. e2111321118.

Karlen, D. (2004). Productivity. *Encyclopedia of Soils in the Environment*, pp 330–336.

IPBES (2023). Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., Pauchard, A., Stoett, P., and Renard Truong, T. (eds.). *IPBES secretariat*, Bonn, Germany.

McLennon, E., Dari, B., Jha, G., Sihi, D., Kankarla, V. (2021). Regenerative agriculture and integrative permaculture for sustainable and technology driven global food production and security. *Agron. J.,* 113. 4541–4559.

Madsen, S., Bezner Kerr, R., Shumba, L., Dakishoni, L. (2021). Agroecological practices of legume residue management and crop diversification for improved smallholder food security, dietary diversity and sustainable land use in Malawi. *Agroecol. Sustain. Food Syst., 45*. 197–224.

Prăvălie, R., Necula, N., Borrelli, P., Tişcovschi, A., Săvulescu, I. (2025). A complex spatial inventory of land degradation and desertification in Romania. *Ecological Indicators, 176*. 113671.

Ranjan, R. (2024). Agroecological approaches to sustainable development. *Frontiers in Sustainable Food Systems, 8*. 1405409.

Țopa, D., Căpșună, S., Calistru, A., & Ailincăi, C. (2024). Sustainable Practices for Enhancing Soil Health and Crop Quality in Modern Agriculture: A Review. *Agriculture, 15*(9). 998.

Zhou, W., Arcot, Y., Medina, R.F., Bernal, J., Cisneros-Zevallos, L., S Akbulut, M.E. (2024). Integrated Pest Management: An Update on the Sustainability Approach to Crop Protection. *ACS Omega*, *9*(40). 41130.

***https://www.ecoruralis.ro/programe/agroecologie/.

***https://www.iaea.org/topics/improving-soil-fertility # :~:text=Soil%20fertility%20can%20be%20further,nitrogen%20fixation;%20by%20micro%2Ddose.

***https://www.weforum.org/stories/2023/02/soil-degradation- biodiversity-planet/.