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A review on the competitiveness and performance of ecological, organic and regenerative agricultural systems

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Abstract. *Over the last three decades, agricultural systems have been at the center of numerous policies designed to deliver society closer to a more sustainable future. Emergent research show agriculture as a vector of change that can significantly contribute to transforming economic models–from linearity to circularity–one of the premises of the circular economy. Turning waste into resource suggests new windows of opportunity for agriculture, as well as its potential to gain competitive advantages in relation with other economic sectors and become highly performant in this regard. Considering the new meanings of competitiveness and performance in the economics of sustainability, the objective of this research was to carry out a literature review on three types of environmentally friendly agricultural systems (ecological, organic, regenerative), and explore how the concepts of competitiveness and performance converge and/or diverge based on the different characteristics of each type of agricultural system. The literature is generally convergent towards the fact that ecological, organic, and regenerative agricultural systems are highly competitive in terms of low environmental impact, especially if compared to conventional agriculture, yet they are poorly competitive from a legislative point of view–as it is considered that those three agricultural systems are highly reliant on incentives and political support. From an economic perspective, they are also not the best-performing in terms of cost generation, yields, and income volumes. More research is still needed in order to identify pathways for the large-scale practicing of profitable, resilient, and environmentally friendly agricultural systems.*

Keywords: competitiveness, performance, ecological agriculture, organic agriculture, regenerative agriculture, economics of sustainability, circular economy, food security

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Introduction

Natural resources are critical factors in improving the economy and social development. Industrialization and urbanization have resulted in the depletion and deterioration of natural resources (Uttara et al., 2012; Antoci et al., 2018; Beia et al., 2020). Industrialization accelerated the rate of production and consumption, which was encouraged by a linear economic system. The linear production paradigm results in wasteful resource losses. However, the circular economy concept introduces a novel method to resource valuation. The concept has been defined as an economic system that is designed and intended to be restorative or regenerative; it aims to eliminate waste by integrating it into new cycles of production, designing improved materials, products, processes, and business models (Lewandowski, 2016; Michelini et al., 2017).

Climate plays a crucial role in agricultural productivity (Hertel & Rosch, 2010). Considering agriculture's significant impact on human wellbeing and the industrialization of modern agriculture, which relies on fossil fuel inputs, multinational corporations and synthetic fertilizers, insecticides, and herbicides to increase productivity (Knorr, 1984; Pimentel et al., 1991); Transitioning to a fossil-fuel-independent system capable of conserving resources for future generations and promoting sustainable development is necessary to meet the Agenda 2030 sustainable development goals.

The European Commission's Green Deal action plan incorporates the circular economy concept as the future economic paradigm (European Commission, 2019). This novel approach to economics advocates for a system of production and consumption that prioritizes reusing, reintegrating, recycling, and reconditioning existing materials and goods (Andersen, 2007; Belhadi et al., 2022; Pătărlăgeanu et al., 2021), as well as proposing innovative viable ways for extending the life cycle(s) of products through environmental-friendly practices.

In the agricultural sector, the principles of circular economy can be transposed through three models of production that are viewed as carrying for the responsible use of resources: a) Ecological Agriculture (EA); b) Organic Agriculture (OA); and c) Regenerative Agriculture (RA). Ecological farming supports biodiversity, protects soil, water, and climate, and does not harm the ecosystem with chemical inputs or genetic engineering (Garibaldi et al., 2019). The concept of ecological agriculture incorporates the characteristics of natural ecosystems to construct agroecosystems; in the linear economy, the connections between natural ecosystems were disrupted in order to increase food and fiber production to meet human needs (Magdoff, 2007). Ecological agriculture is attempting to mitigate a shift in current production models and consumption habits, through which the goal of preserving natural resources for future generations can be achieved (Andrei et al., 2021; Dorofeev et al., 2022; Kiley-Worthington, 1981).

Regenerative agriculture (RA) is a holistic approach to farming that highlights the connection between farming systems and the broader ecological system (Francis et al., 1986; Sherwood & Uphoff, 2000). The concept is defined as a practice-based assessment that focuses on farming systems that strictly adhere to five highly acknowledged principles: cover the soil, avoid soil disturbance, increase crop diversification, maintain living roots in the earth year-round, and incorporate livestock (Giller et al., 2021). The objective of regenerative farming is to improve the soil quality and biodiversity of farms while profitably generating nutritious farm products. Regenerative farming approaches eliminate tillage and eliminate spatio-temporal occurrences associated with bare soil, while promoting plant diversity and integrating animal and food production on the land (LaCanne & Lundgren, 2018).

Organic agriculture (OA) is a holistic approach of agricultural management that maintains and increases the health of the soil, including biological cycles. This is accomplished by the

application of agronomic, biological, and mechanical techniques, rather than through the use of synthetic materials to perform specific functions within the system (FAO/WHO Codex Alimentarius Commission, 1999). An additional meaning of the word "organic" lies in the fact that it refers to products that have been produced and handled in accordance with the organic standards (FAO 2000).

Regenerative agriculture (RA) is a model that entails expanding the connections and interactions within an ecosystem while integrating livestock into conventional crop farming in order to become self-sufficient in terms of fertilizer inputs (Gosnell et al., 2019; Luján Soto et al., 2020). Organic agriculture (OA) includes adhering to the following regulations: no chemical pesticides, no synthetic fertilizers, no genetically modified crops, and responsible use of energy and natural resources. While ecological farming is similar to organic farming, it goes further by considering the entire ecosystem and operating exclusively in accordance with the natural life cycle. Ecological agriculture (EA) entails minimizing waste generation, recycling all waste generated (organic waste is composted), or putting vegetation around crops that benefit pollinators and woodland birds (Lynch et al., 2014; Marco et al., 2020; Sandhu et al., 2010).

The action plan: European Green Deal, certifies the complexity of the environmental situation, was designed as an instrument to assist the EU-27 alliance in mitigating the detrimental effects of climate change. Climate change, soil degradation, and environmental degradation all pose significant threats to Europe. Globalization can have a detrimental influence on sustainable development in some situations, particularly in the absence of specific instruments and systems.

The European Union aspires to be a resource-efficient and competitive structure. Simultaneously, with the adoption of this action plan, the following objectives were established: (a) by 2050, the EU-27 should become carbon neutral; (b) economic growth will be decoupled from resource usage, and (c) no person or place will be left behind.

Considering the EU's objectives and strategies for accomplishing the goal of decoupling resource consumption from economic growth, the notions of performance and competitiveness should be considered in the context of sustainable development (Osaulenko et al., 2020). A modern approach to competitiveness is one that refers to achieving competitive advantage at the level of the Sustainable Development Goals (Alonso-Almeida et al., 2020; United Nations, 2015; Pătărlăgeanu et al., 2020). When evaluating competitiveness and performance in regard to the three agricultural models, it is essential to take into consideration the critical nature of proactive adaptation to changing business and technical environments (Li et al., 2021; Cepoi et al., 2020).

The objective of this research was to study the multidimensional facets of competitiveness and performance in relation with three types of agricultural systems: ecological (EO), organic (OA), and regenerative agriculture (RA). Thus, this paper brings its contribution to the literature with an extensive overview on how three environmentally friendly agricultural systems were approached by other scholars in their work dedicated to the study of the competitiveness or performance of those agricultural systems or particular components of the systems.

Methodology

The review process of the papers on the topics of ecological, organic and regenerative agricultural systems followed multiple steps: (a) resorting to a research string pattern to identify relevant scientific papers in the Web of Science (WoS) database; (b) perform an initial screening on the identified studies by title, abstract and keywords, and decide whether they are eligible to be further assessed (full-text assessment) in accordance with the objective of this paper; and (c) conduct a qualitative synthesis of selected papers, based on the previous rounds of eligibility assessment.

The following WoS search strings were applied: (1) ALL=("ecological agriculture" competitiveness); (2) ALL=("ecological agriculture" performance); (3) ALL=("organic agriculture" competitiveness); (4) ALL=("organic agriculture" performance); (5) ALL= ("regenerative agriculture" competitiveness); (6) ALL=("regenerative agriculture" performance). The numbers of scientific publications identified based on those research queries and more methodological background were included in Figure 1.

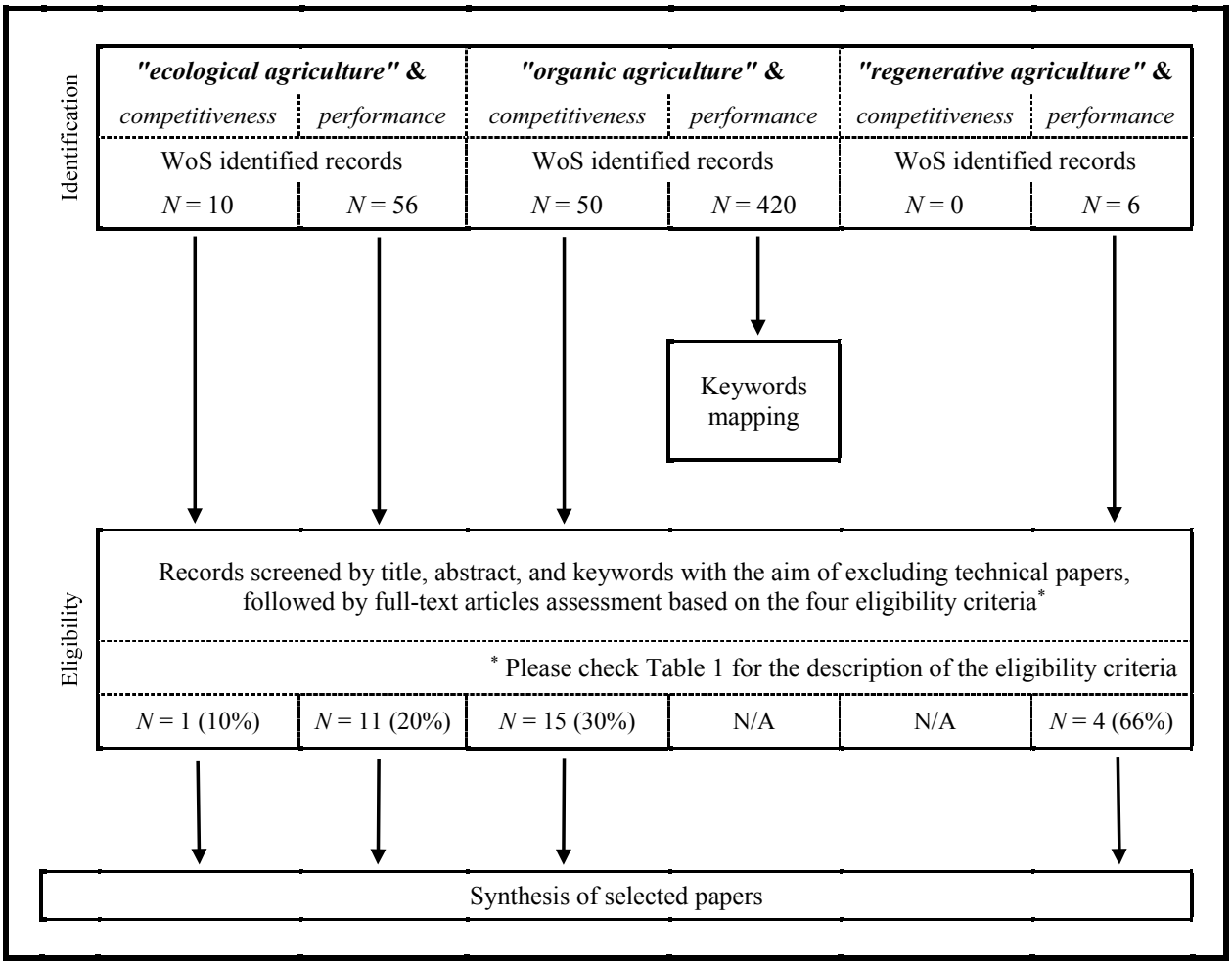


Figure 1. The methodological foundation of the review

Source: Authors' own design.

Since the objective of this paper was oriented towards exploring environmental, socio-economic and governmental aspects specific to each type of agricultural system, the scientific papers which had a profound technical component were excluded from this review. Besides this exclusion, the review was also based on four eligibility criteria that were considered optimal considering this paper's objective. The eligibility criteria were explained in Table 1.

Moreover, this research is complemented by a keyword-level analysis of the papers identified based on the ALL= ("organic agriculture" performance) search string. Since there were hundreds of papers (420) identified in WoS indexed on the topics of organic agriculture and performance, a quantitative approach was considered suitable in order to cover all the existing literature. The above-mentioned bibliometric analysis was conducted using the VOSviewer

software, dedicated to such empirical avenues (van Eck and Waltman, 2010). As a practical matter, the WoS database provides essential materials for the efficient development of bibliometrics analysis of works focused on the issue of organic agriculture and performance. Therefore, the Web of Science database was queried in the following manner: *ALL=("organic agriculture" performance); Timespan: All years*. In February 2022, based on the results of this particular query performed on the WoS database, 420 indexed papers were identified, papers which contained both the word(s) "organic agriculture" and "performance" in their title, abstract, or keywords.

Table 1. Eligibility criteria description

Eligibility Criteria for Paper Screening (in order to be considered, screened papers had to answer to at least one of the following questions)	Classification of Ecological / Organic / Regenerative Agriculture
Does the research support the fact that ecological/organic/regenerative agriculture bring significantly more environmental externalities than conventional agriculture? Is ecological/organic/regenerative agriculture much more efficient in terms of natural capital damage mitigation than conventional agriculture?	Highly competitive in terms of low environmental impact from agricultural activities
Was the research focused on explaining the reasons why ecological/organic/regenerative agriculture requires political support in order to become largely embraced? Did the paper include information regarding legislative gaps and possible solutions meant to encourage farms to transition to ecological/organic/regenerative agriculture? Did the authors approach the importance of providing incentives for farmers that practice sustainable forms of agriculture?	Poorly competitive from a legislative point of view, as it is considered reliant on incentives, political support etc.
Were there economic analyses carried out that justify increased volumes of cost for farmers that practice ecological/organic/regenerative agriculture? Did the authors suggest that conventional agriculture is more cost-efficient?	Poorly competitive in terms of cost generation
The research included economic implications of practicing ecological/organic/regenerative agriculture and results converged towards the conclusion that conventional agriculture records better yield productivity and income levels for farmers.	Poorly competitive in terms of yields / income generation

Source: Authors' own research design.

Results and discussions

When evaluating the competitiveness and performance of the three agricultural models (EA, OA, and RA), it is critical to recognize the fundamental importance of proactive adaptation that the agricultural sector must adopt in this era of continuous change in commercial and technical environments. Performance and competitiveness should be examined within the foreground of long-term growth and sustainability. The simplified version of the review of the eligible scientific papers (based on the criteria from Table 1) on the topics of the performance and competitiveness of EO, OA, and RA was elaborated in Table 2.

Table 2. Overview on the eligible scientific papers

Author(s)	Highly competitive in terms of low environmental impact from agricultural activities	Poorly competitive from a legislative point of view, as it is considered reliant on incentives, political support etc.	Poorly competitive in terms of cost generation	Poorly competitive in terms of yields / income generation
WoS search string ALL=("ecological agriculture" performance)				
(Liu et al., 2021)				
(Ardila Galvis et al., 2020)				
(Chen & Diao, 2022)				
(Agostinho et al., 2008)				
(Kamphues, 1998)				
(Xie, 2021)				
WoS search string ALL=("ecological agriculture" competitiveness)				
(Skryl et al., 2019)				
WoS search string ALL=("organic agriculture" competitiveness)				
(Krause & Spicka, 2017)*				
(Ursu & Petre, 2020)*				
(Fang et al., 2017)*				
(Josef & Ondrej, 2018)*				
(Burja, 2009)*				
(Aceleanu, 2016)				
(Kovalenko et al., 2017)				
(Simin et al., 2021)				
(Crowder & Reganold, 2015)				
(Shen et al., 2020)				
(Voronkova & Vysotskaya, 2019)				
(Offermann, 2003)				
(Kułyk & Kowalewicz, 2017)				
(Rota et al., 2021)				
(Rodrigues & Zimmermann, 1998)				
(Tomic et al., 2011)				
(Defrancesco & Rossetto, 2007)				
(Zander et al., 2008)				
(Vilpoux et al., 2021)				
(Plotto & Narciso, 2006)				

Author(s)	Highly competitive in terms of low environmental impact from agricultural activities	Poorly competitive from a legislative point of view, as it is considered reliant on incentives, political support etc.	Poorly competitive in terms of cost generation	Poorly competitive in terms of yields / income generation
WoS search string ALL=("regenerative agriculture" performance)				
(Colley et al., 2020)				
(Luján Soto et al., 2020)				
(Le et al., 2021)				
(Velasco-Muñoz et al., 2021)				

*was identified based on "ecological agriculture" search string, but the paper is dedicated to organic agriculture

Source: Authors' own review of eligible papers.

The literature is consistent in the sense that most authors argue for the importance of delivering environmental protection in the context of the global mission to shift paradigms regarding agricultural systems. Although in most cases crop yields are generally lower in the case of environmentally-friendly agricultural systems than in the conventional system, environmental externalities can sometimes be deemed more valuable than income volume, profit, or other financial indicators. Taking into account the desirable circular model of agricultural system, maintaining and upgrading ecosystem's services, regenerative agriculture has a lot of untapped potential. With the purpose of encouraging farmers to consider such agricultural practices, decision makers should create an optimal legislative framework and incentive systems, as they play an essential role in the economics of farmers who practice eco-friendly agriculture, and, as a result, are more prone to registering higher cost volumes than farmers who practice conventional agriculture. Additionally, a keywords network analysis was carried out on the concept of Organic Agriculture (OA) through the lens of performance by utilizing VOSviewer software and Figure 2 was designed.

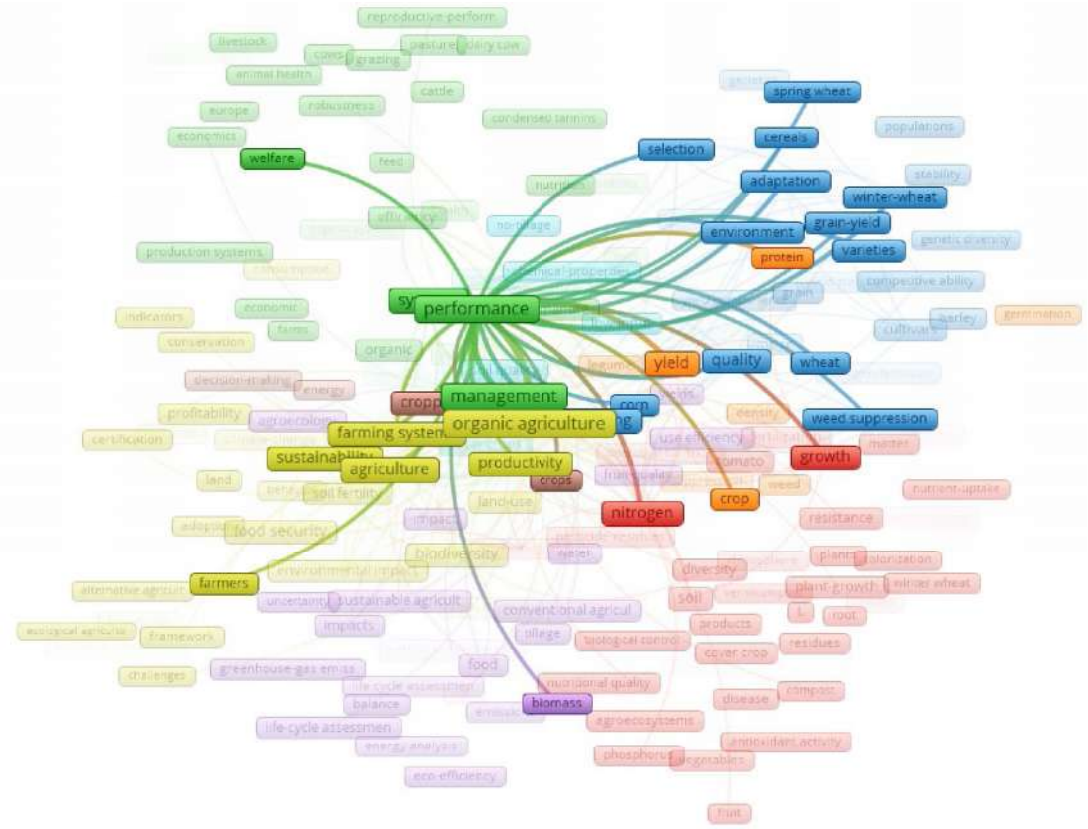


Figure 2. Cluster analysis keyword and keyword structures associated to publications concerning the topics of "Organic Agriculture" and "performance"

Source Authors' processing in VOSviewer 1.16.18.

The scientific community was interested in the OA's model performance, prior to the release of the 2030 Agenda for Sustainable Development (1992-2015), 152 documents were published and identified when using the query (36.19% from the total of 420 papers). After 2015, scientific interest increased and switched toward the critical need to address the performance of organic agriculture. Considering the large number of papers identified (420) and indexed in WoS on the topics of organic agriculture and performance, this type of quantitative approach was deemed appropriate to encompass all available research. As in Figure 2, the keyword analysis performed in VOSviewer reviled the OA is seen as a new type of farming management that incorporates nitrogen (N) fertilization and that OA practices such as: use of catch crops, and residue management can all have a significant effect on crop yields and soil nitrogen cycling (Bhattacharjee & Dey, 2014; Doltra et al., 2019; Hertel & Rosch, 2010).

Additionally, by approaching the concept of OA through the lens of "welfare" and "sustainability" keywords, this linkage emphasizes the establishment of a market for organic products, that also becomes an influential force for change due to the increased environmental awareness and responsibility of producers and consumers (Allen & Kovach, 2000; Reganold & Wachter, 2016). OA is considered to mitigate the harmful external consequences associated with traditional high-input agriculture. On the other hand, organic agriculture practices are associated with much lower yields per unit of land area. (Ponisio et al., 2015) One of the reasons the keyword "yields" appears frequently (35 occurrences) is that the research community shows interest in studying the performance of the OA system in a traditional economic benefit-focused approach.

Conclusion

Holistic perspectives are critical and extremely valuable for successfully reshaping and adapting agricultural production systems to a more sustainable path. In the European Union, the Common Agricultural Policy is instilling the spirit of transitioning to a cleaner agricultural system among farmers, which are encouraged to practice ecological, organic, and regenerative agriculture.

Together with the European Green Deal, the new socio-economic and agricultural paradigm is centered on the environmentally friendly aspects of reusing, reintegrating, recycling, and reconditioning existing materials and goods in the economy. By examining the multiple facets of competitiveness and performance in the case of three distinct agricultural systems: ecological (EA), organic (OA), and regenerative agriculture (RA), findings suggest that the scientific literature is consistent and that the majority of scholars argue for the critical of environmental protection in the context of the global mission to shift agricultural system paradigms towards sustainability.

This review on the competitiveness and performance of ecological, regenerative, and organic agriculture showed that the large-scale practicing of those environmentally friendly types of agriculture brings a lot of environmental benefits, but more research is required in order to find solutions to minimize the cost volumes and incentives, as well as maximize yields, farmers' income.

The main limitation of this review is that technical papers were not included in the analysis of the competitiveness and performance of the ecological, regenerative, and organic agricultural systems. A possible future research avenue could be focused on developing a narrative review on the large number of papers identified on the topic of the performance of organic agriculture.

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