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BIBLIOMETRIC ANALYSIS OF SUSTAINABILITY AND PROFITABILITY IN CONVENTIONAL AND ECOLOGICAL AGRICULTURE

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Abstract

In the context of the growing interest in sustainable agricultural practices, this study highlights a detailed bibliometric analysis regarding the intersection between sustainability and profitability in conventional and ecological farming.While the ecological farming model clearly emerges as a frontrunner in terms of sustainability, profitability assessments present challenges due to varying regional costs, lack of standardized metrics, and short-term versus long-term value evaluations. Drawing from international sources and top-tier academic literature, the article reveals prevailing trends as well as under-researched areas in the field of agricultural research. The results indicate a clear acknowledgment of the benefits of ecological farming from a sustainability standpoint. However, the paper discusses the challenges related to assessing the profitability of these practices and identifying the most efficient strategies for supporting and expanding alternative farming systems. Thus, it underscores the imperative of a multidisciplinary perspective for deep understanding and informed action in the field.

Key words**:** *sustainability, profitability, conventional agriculture, ecological agriculture, alternative cultivation systems, bibliometric analysis*

INTRODUCTION

In recent decades, the global agricultural sector has experienced significant transformations, driven largely by the ever-increasing demand for sustainable and profitable practices [24, 31]. As the world's population continues to grow, so does the pressure on our agricultural systems to produce food in an efficient and sustainable manner [23]. This balance between sustainability – ensuring that our actions and decisions do not deplete resources or harm future generations – and profitability – ensuring that agricultural activities remain economically viable – has become a focal point of discussions, research, and policymaking [5].

Conventional farming, long celebrated for its high yields and efficiency, has come under scrutiny for its environmental implications and long-term unsustainability [11]. the other hand, ecological farming, which excludes the use of synthetic pesticides, herbicides, and genetically modified organisms, promotes a holistic approach to agriculture 4, 32]. While it is lauded for its environmental benefits, doubts persist regarding its economic viability on a large scale [2].

In this complex landscape, multidisciplinary studies emerge as very important tools, offering a more comprehensive understanding by integrating various aspects, from the natural sciences to the economic and social realms. Moreover, as the global community seeks viable solutions, alternative cultivation systems are being researched and proposed as potential paths forward [12, 18].

This paper embarks on a detailed bibliometric analysis of the existing literature, aiming to shed light on current trends, gaps, and future directions in the intertwined realms of sustainability, profitability, and farming practices. Through this exploration, we aim to

provide valuable insights for researchers, policymakers, and practitioners alike.

MATERIALS AND METHODS

Bibliometric analysis is a research method that quantitatively evaluates specialized literature based on categories of topics of interest, providing information extracted from various databases (Web of Science, Scopus, Science Direct, etc.). The method involves, on one hand, scientific mapping, which determines the structure and dynamics of the analyzed scientific fields, and on the other hand, performance analysis, which assesses the performance of authors and the institutions to which they belong [7, 30]. Another important aspect is the analysis of citations, through which scientific research is highlighted and its value recognized [29]. The results obtained from conducting a bibliometric study on citations allow for determining the number of citations as well as establishing the connections between authors, which can be identified through simultaneous citations.

RESULTS AND DISCUSSIONS

Since the current research aims to analyze studies related to conventional and ecological agricultural systems, we assessed their relevance in scientific literature using bibliometrics. In this endeavour, we extracted available information from the ISI Web of Science and Scopus databases, which are two of the most popular platforms hosting scientific publications from around the world. These are managed by Clarivate Analytics and are used as research tools. The advantages of these databases include the high scientific level of the publications, the accuracy of the information, and the relevance of the results obtained. The platforms house a significant number of scientific papers that span an extended period of research (1900 to present). The consultation of the Web of Science and Scopus databases took place on September 13, 2023. The key terms used were "conventional agriculture" and "ecological agriculture," resulting in 1,486 articles. Subsequently, we refined the search to select only publications containing comparative studies between the two agricultural systems, yielding 62 articles. By adding the term "sustainability," we arrived at a total of 15 articles. Using the period of 2000-2023 as a filter, 1,392 articles were identified, of which 95.61% are written in English. In Figure 1, both the number of publications and citations are illustrated.

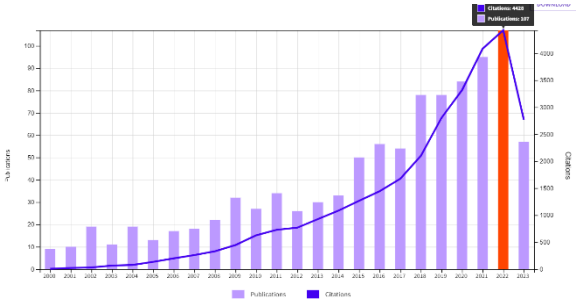

Fig. 1. Evolution of citations and scientific research articles from the period 2000-2023
Source: own representation, WOS.

Thus, we observe that the interest in studying both conventional and ecological agriculture has been on a rising trend from 2000-2023, with the highest number of articles, totalling 107, recorded in 2022. Regarding the number of citations, the highest count was also registered in 2022, amounting to 4,428.
Table 1 presents the overview of the main authors who have shown interest in the comparative analysis between conventional and ecological agriculture. The authors are listed in descending order based on the number of citations found in the specialized literature. The criterion applied in this case was a minimum of 25 citations per article.
After determining the sample of scientific papers, we conducted the actual bibliometric analysis using the mapping methodology and the VOS viewer software (Centre for Science and Technology Studies, Leiden University, Netherlands, 2020). This software allows the construction and visualization of bibliometric networks.
We first examined the collaboration network between authors from the perspective of their countries of origin to identify researchers' interest in the comparative analysis of the two agricultural systems.

Table 1. Citation overview for scientific articles, by authors, for the period 2000-2023

Authors	Citations
Koch, M.S., Ward, J.M., Levine, S.L., Baum, J.A., Vicini, J.L., Hammond, B.G. [14]	**140**
Agostinho, F., Diniz, G., Siche, R., Ortega, E. [1]	**105**
Parra-López, C., Calatrava-Requena, J., De-Haro-Giménez, T. [20]	**84**
Loeser, M.R.R., Sisk, T.D., Crews, T.E. [16]	**81**
Smolik, J.D., Dobbs, T.L., Rickerl D.H. [26]	**77**
Wilson A.L., Watts R.J., Stevens, M.M. [34]	**52**
MacRae, R.J., Frick, B., Martin, R.C. [17]	**44**
González-Pérez, J.A., González-Vila, F.J., González-Vázquez, R., Arias, M.E., Rodríguez, J., Knicker, H. [10]	**39**
Xu, Q., Ling, N., Chen, H., Duan, Y., Wang, S., Shen, Q., Vandenkoornhuyse, P. [35]	**38**
Marx, H., Gedek, B., Kollarczik, B. [19]	**37**
Watson, C.A., Walker, R.L., Stockdale, E.A. [32]	**35**
Singh, U., Choudhary, A.K., Sharma, S. [25]	**34**
Flores, C.C., Sarandón, S.J. [8]	**29**
Jennings, N., Pocock, M.J.O. [13]	**28**

Source: own representation, WOS.

We set a minimum threshold of 25 papers published in the same country, resulting in a total of 127 countries. By adding a minimum number of 25 citations per country, the number of countries reduced to 19. It appears that the USA has the highest interest in this subject, with a total of 319 scientific papers that accumulated 16,320 citations, establishing 128 links. It is followed by China, with 224 studies, 4,668 citations, and 70 links, and Germany, with 126 studies, 4,810 citations, and 92 established links. In Romania, 26 studies were published, cited 145 times, with 5 established links.

The research from these 19 countries is grouped into 4 clusters, with a total of 118 links and a combined link strength of 434.

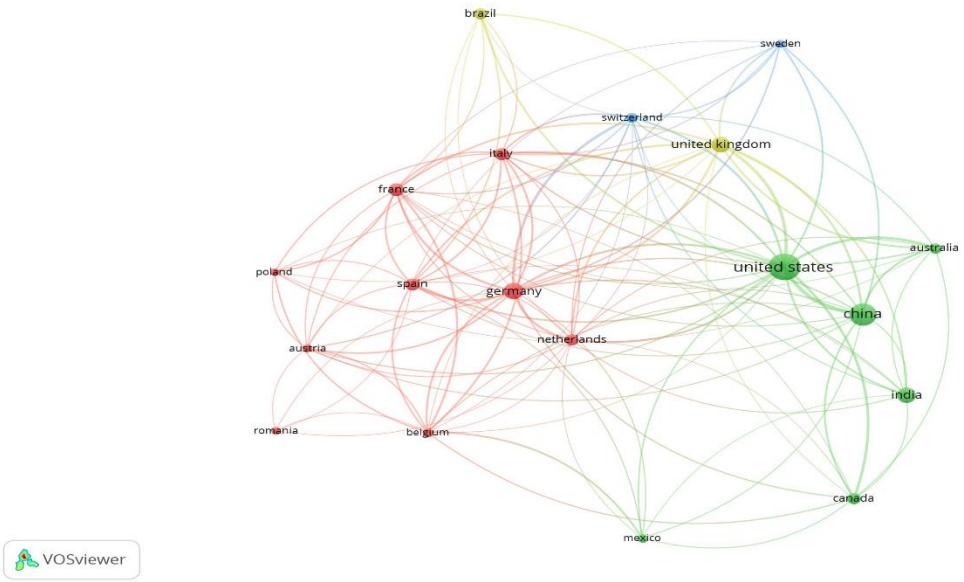

Fig. 2. The network of links between authors and their countries of origin
Source: own representation, WOS.

The size of the nodes corresponding to each country reflects its significance in research on conventional and ecological agriculture. The thickness of the lines and the distance between nodes indicate the collaboration links between authors. The graphical representation identifies four groups of countries, each coloured differently, sharing scientific

collaborations related to conventional and ecological agriculture (groups are formed based on collaboration intensity).

The red group, which includes Romania, comprises 9 countries: Germany, France, Italy, Spain, Netherlands, Poland, Austria, Belgium, and Romania. The most significant country in terms of international collaboration is the United States, which appears in the green group, alongside China, India, Australia, Canada, and Mexico. American authors collaborated with authors from all 19 countries, having stronger ties with countries such as China, India, and England. The third group consists of England and Brazil (yellow), and the fourth of Sweden and Switzerland (blue). England is also one of the countries with noteworthy studies in this field. Romanian authors collaborated with researchers from Germany, France, Italy, Spain, Poland, the Netherlands, Belgium, and Austria. Subsequently, we analyzed the distribution of the most used keywords in the published research to determine their connections. We set a minimum threshold of 25 simultaneous appearances. Out of the 1,392 scientific papers, 9,972 keywords were identified, of which 883 surpassed the minimum threshold. We selected the top 25 keywords with the strongest connections to other keywords, resulting in a total of 122 keywords grouped into 3 clusters with 5,872 links and a combined link strength of 28,832.

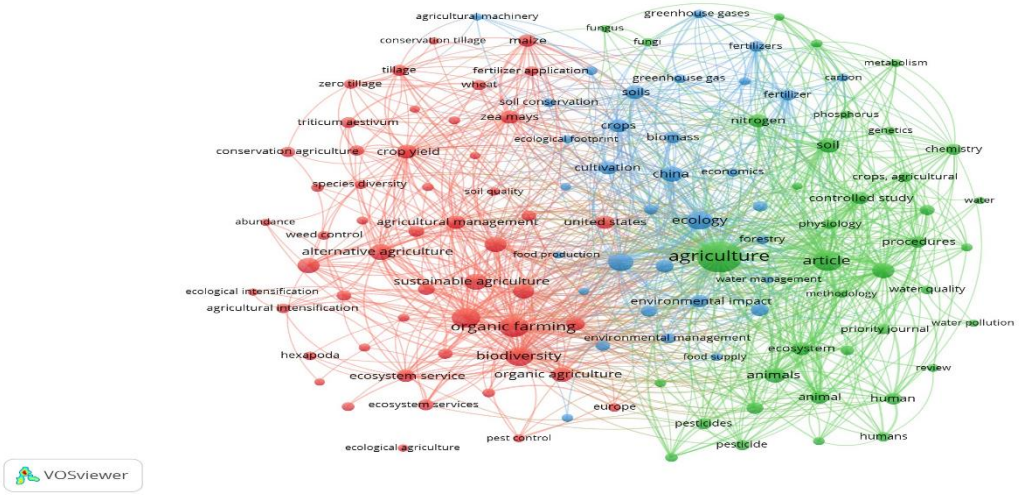

Fig. 3. The network of links between authors and keywords
Source: own representation, WOS.

The coauthor ship analysis aims to identify collaboration ties between researchers, organizations, countries, or regions. To discern these connections, we set certain criteria: a document may mention up to 25 organizations, an organization should have at least 10 papers, and garner a minimum of 50 citations. From these criteria, 125 countries were identified, of which 36 matched our standards.

These countries were then segmented into six clusters based on the intensity of coauthor collaborations. The USA, China, and Germany notably emerge with the most robust coauthor networks.

The first cluster highlights European collaborations, including countries such as Austria, Czech Republic, Denmark, Germany, Hungary, Netherlands, Norway, Romania, Portugal, and Spain. In contrast, the second cluster amalgamates countries from various regions, like Argentina, Italy, Kenya, South Africa, Sweden, Switzerland, the UK, and Zimbabwe. The third cluster focuses on Asia and the Pacific, including Australia, China, Malaysia, New Zealand, and Pakistan.

Cluster 4 groups authors from Belgium, Canada, India, Japan, and Mexico, hinting at a mix of transatlantic and transpacific collaborations. Cluster 5 represents strategic

links between countries like Iran, Poland, Turkey, and the USA. Lastly, cluster 6 underscores intense collaboration between Brazil and France.

Notably, the strongest ties are established between authors from the USA, China, and Australia, underscoring these nations' influence in the research field.

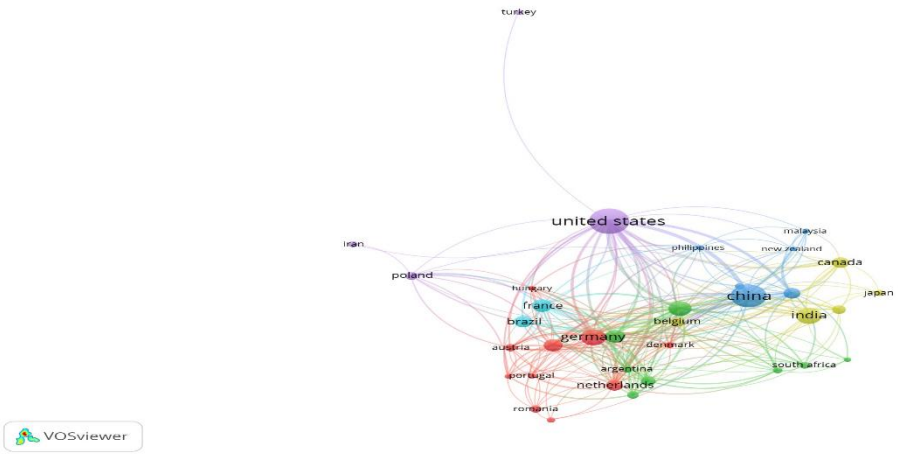

Fig. 4. Details the network of collaborations between coauthors and their respective countries of origin
Source: own processing based on Scopus data

In the process of identifying information related to ecological and conventional agriculture, as well as their comparison, we deemed co-occurrences with keyword groups essential, meaning those words that simultaneously appear in the same article or study. Figure 5 illustrates the relevance of keywords. By imposing a restriction of a minimum of 25 keywords, a total of 9,972 words resulted, of which 122 met the restrictions. Three clusters were identified, establishing 5,872 connections between them. Among the most significant keywords identified are agriculture, conventional agriculture, ecological agriculture, ecological farm, biodiversity, alternative agriculture, ecology, agroecology, and management.

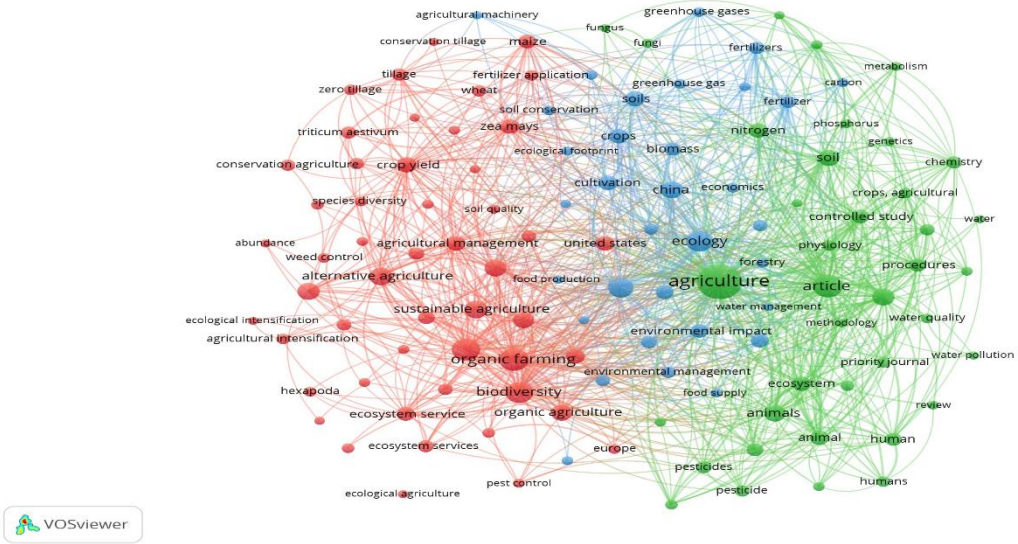

Fig. 5. The network of connections between co-occurrence and the keyword group
Source: own processing based on Scopus data.

To identify, on one hand, research gaps and, on the other hand, to harness the results of conducted studies, we analyzed the most relevant scientific papers. The results were synthesized in Table 2. In achieving this objective, we used the Scopus database, selecting research from the period 2000-2023. Additionally, we incorporated an extra criterion: the evaluation of the sustainability of the practiced agricultural systems. The search and filtering yielded a total of 14 articles. These were reviewed based on their authors, publication, year of release, title, number of citations, and the results obtained.

Table 2. Scientific research in the field of sustainability and profitability of conventional and ecological agriculture

Authors	Year of public.	Publication name	Title	Results obtained	Citations
Bai, X., Wen, Z., An, S., Li, B. [3]	2015	PLoS ONE, 10 (3)	Evaluating sustainability of cropland use in Yuanzhou County of the Loess Plateau, China using an emergy-based ecological footprint	Starting from the fact that assessing the sustainability of cropland use is essential for ensuring food security and sustainable agricultural development, the study conducted in the Loess Plateau region of China evaluates its sustainability based on an ecological footprint model that integrates emergy analysis, enhancing the ecological footprint method. The new method considered both the surface energy of the soil and the net loss of topsoil for human consumption. The paper assesses the overuse or sustainable management of farmland from 1981-2009	14
Gómez Betancur, L.M., Márquez Girón, S.M., Restrepo Betancur, L.F. [9]	2018	Idesia, 36 (1), pp. 123 - 131	The milpa as a agricultural conversion alternative of conventional agroecological systems of bean (Phaseolus vulgaris), in the municipality of Carmen viboral, Colombia	The study is participatory, based on the application of ecological principles, transferred from one farmer to another. Its purpose was the development and implementation of an agro-ecological project within a farm that, based on the multidimensional variance analysis and the dimensional descriptive process, established the arithmetic mean, standard deviation, and variation coefficient for the experiment conducted on zucchini and bean crops, grown after corn.	8
Flores, C.C., Sarandón, S.J. [8]	2004	Journal of Sustainable Agriculture, 24 (2), pp. 77 - 91	Limitations of neoclassical economics for evaluating sustainability of agricultural systems: Comparing ecological and conventional systems	The study highlights weaknesses in the application of both ecological and conventional agriculture, based on research conducted in La Plata, Argentina, which examined ecological, productive, and social aspects using a set of sustainability indicators. The cost-benefit analysis showed that the ecological farm was more profitable only when the prices of ecological products reached 340% compared to conventional ones. The agro-ecological analysis indicated that the ecological system achieved sustainability goals more efficiently than the conventional one. At the same time, it highlighted the fact that some aspects cannot be quantified through cost-benefit analysis, necessitating a new holistic approach that should be incorporated into agricultural education institutions	29
Redlichová, R., Bečvářová, V., Pociovălișteanu, D.M., Vinohradský, K., Zdráhal, I. [22]	2018	World Sustainability Series, pp. 319 - 341	Green-growth policies and economic effects: lessons learnt from ecological	The paper analyzes the findings of research that investigates the comparative economic performance of ecological and conventional farms in the Czech Republic. The ecological farming system has expanded, driven by the granting of subsidies. During the analyzed period, 2001-2012, ecological	0

			farming in the Czech Republic	farms achieved an agricultural production value per hectare of 30-40% of the value produced in conventional agriculture. The research also explains the concept of the "ecological paradox," showing how ecological farms create an ecological footprint per capita that is 1.5 times greater than in the case of conventional farms. The analysis of economic indicators raises the issue of the economic sustainability of ecological farms.	
Herrero, A., Wickson, F., Binimelis, R. [11]	2015	Sustainability (Switzerland), 7 (8), pp. 11321 - 11344	Seeing GMOs from a systems perspective: The need for comparative cartographies of agri/cultures for sustainability assessment	Starting from the fact that agricultural biotechnologies cannot be assessed as isolated technological entities, but must be in the context of the socio-ecological system, the paper explores, compares, and contrasts some of the available methodological tools for promoting this system-based perspective. The work has made a significant theoretical and methodological contribution by promoting a system-based approach to conceptualizing and evaluating genetically modified organisms (GMOs) and proposing a methodology for mapping the networks of relationships between different crops	9
Le, Q.V., Cowal, S., Jovanovic, G., Le, D.-T. [15]	2021	Frontiers in Sustainable Food Systems, 5, art. no. 712733	A Study of Regenerative Farming Practices and Sustainable Coffee of Ethnic Minorities Farmers in the Central Highlands of Vietnam	The study aims to highlight the benefits of regenerative agriculture, which plays a crucial role in adapting to and mitigating the effects of climate change. The research conducted by the authors, aiming to pinpoint the pros and cons of both conventional and ecological farming systems, suggests that regenerative farming practices boost biodiversity. However, these practices also create microclimates that foster the growth of the Roya fungus. The economic analysis concerning production costs and net profitability shows that regenerative farming practices lead to reduced reliance on external inputs. This reduction is a result of diversified crop systems and integrated production (both animal and plant-based), enhancing overall productivity and economic profitability while preserving ecological and environmental integrity.	1
Speiser, B., Stolze, M., Oehen, B., Gessler, C., Weibel, F.P., Bravin, E., Kilchenmann, A., Widmer, A., Charles, R., Lang, A., Stamm, C., Triloff, P., Tamm, L. [27]	2013	Agronomy for Sustainable Development, 33 (1), pp. 21 - 61	Sustainability assessment of GM crops in a Swiss agricultural context	The purpose of this study conducted in Switzerland was to assess the sustainability of genetically modified (GM) crops, highlighting: the gaps concerning the risks and benefits of production systems used for rotating field crops, and orchards; the socio-economic impact of agricultural systems for GM crops. The study involved the creation of new agricultural practice scenarios associated with the use of GM crops in conventional, integrated, and ecological farming systems, drawing from the United Kingdom's experience in this field.	12
Parra-López, C., Calatrava-Requena, J., de-Haro-Giménez, T. [20]	2008	Ecological Economics, 64 (4), pp. 820 - 834	A systemic comparative assessment of the multifunctional performance of alternative olive systems in Spain within an AHP-extended framework	The paper had three objectives: to present a methodology for the comparative assessment of the multifunctional performances of various agricultural systems; to expand the methods for improving decision-making processes regarding the choice of cropping systems; and to compare the performances obtained in different	84

				alternative cropping systems based on a study conducted for an olive plantation in Andalusia, Spain. The study tested the sustainability of ecological agriculture compared to conventional farming, highlighting a higher overall performance of ecological and integrated agriculture, thus providing a scientific basis for the promotion and implementation of these farming techniques. However, some conflicting issues were identified, especially in areas related to environmental performance, leaving room for further research.	
Pergner, I., Lippert, C. [21]	2023	Agronomy for Sustainable Development, 43 (2), art. no. 24	On the effects that motivate pesticide use in perspective of designing a cropping system without pesticides but with mineral fertilizer—a review	The paper proposes a complementary cropping system to conventional and ecological farming, called the Mineral-Ecological Cropping System (MECS), which allows for the continued use of mineral fertilizers with the aim of ensuring high yields. The system can be considered a compromise between current conventional and ecological cropping systems. The research provides a comprehensive analysis of specialized literature regarding the economic, social, and environmental effects of pesticides and the reasons why farmers should or shouldn't use them. The strengths of using this system are as follows: productivity and stability of yields are higher compared to ecological farming, but lower than conventional farming; profitability decreases due to the high costs of inputs and energy consumption; increase in soil fertility and biodiversity protection as a result of applying alternative pest and disease control measures; crop rotations will be broader and more diverse than in conventional farming; mineral fertilizers cannot be used optimally by crops unless there is a balanced nitrogen input. The research presents an innovative and sustainable cropping system and proposes measures to compensate farmers when deciding to abandon pesticides in favor of using mineral fertilizers.	2
Xu, Q., Ling, N., Chen, H., Duan, Y., Wang, S., Shen, Q., Vandenkoornhuyse, P. [35]	2020	mSystems, 5 (4), art. no. e00337-20	Long-term chemical-only fertilization induces a diversity decline and deep selection on the soil bacteria	The study analyzes the widespread use of fertilizers, establishing new perspectives on conservation, restoration, and management efforts for cultivated and microbiologically degraded lands.	38
Daelemans, R., Hulsmans, E., Honnay, O. [6]	2022	Journal of Environmental Management, 303, art. no. 114191	Both ecological and integrated pest management of apple orchards maintain soil health as compared to a semi-natural reference system	Starting from the negative impact that agriculture has on the environment, the research identifies those agricultural systems that try to reconcile production with environmental sustainability. Considering that the functioning of ecological management is still little understood in terms of maintaining soil health in real and heterogeneous commercial agricultural environments, compared to conventional management, and especially compared to a natural reference system, the research conducts an analysis based on a set of soil health indicators. The study establishes that perennial cropping systems can be managed sustainably without jeopardizing soil health, because of measuring certain soil variables.	4

Singh, U., Choudhary, A.K., Sharma, S. [25]	2022	European Journal of Soil Biology, 99, art. no. 103197	Comparative performance of conservation agriculture vis-a-vis ecological and conventional farming, in enhancing plant attributes and rhizospheric bacterial diversity in Cajanus cajan: A field study	The study evaluates the performance of conservation agriculture and makes a comparison between conventional and ecological agriculture. The research compares the three agricultural practices, establishing the relationship between agricultural management practices and the cropping system.	34
Spiegelaar, N.F., Tsuji, L.J.S. [28]	2013	Rural and Remote Health, 13(1), 2211	Impact of euro-canadian agrarian practices: In search of sustainable import-substitution strategies to enhance food security in subarctic Ontario, Canada	The paper analyzes food insecurity among the aboriginals living in the northern communities of Canada, which is due to their dependence on the industrialized food system based on imports. The study evaluated the soil properties in this area associated with the use of agricultural lands and productivity. The conclusions indicate that agro-ecosystem management practices and autonomous food security programs have the potential to increase the availability of locally grown food in a sustainable manner.	18

Source: Own processing, based on Scopus and WOS [3, 6, 8, 9, 11, 15, 20, 21, 22, 25, 27, 28, 35].

The analysis of specialist articles highlighted the researchers' concerns regarding conventional and ecological farming systems, but also in identifying other alternative, regenerative systems that contribute to both achieving the profitability of agricultural enterprises and respecting sustainability and food security. However, the information provided by international databases shows that multidisciplinary studies are insufficient. Although they are based on case studies carried out in different agricultural areas of the world, on different crops, resulting in technological aspects or agricultural practices, they are not correlated with economic aspects. Some reasons include the lack of sufficient indicators to measure the economic sustainability of ecological farming enterprises, the ongoing conflicts between areas related to environmental performance, or the absence of policies supporting alternative cultivation systems.

CONCLUSIONS

In the world of agriculture, striking the right balance between profitability and sustainability is pivotal for a resilient future. This investigation delves into the pronounced contrasts between conventional and ecological farming methodologies, elucidating their unique merits and challenges. Conventional farming, often marked by enhanced yields thanks to its dependence on state-of-the-art technology and chemical fertilizers, faces scrutiny over its environmental and health repercussions.

On the other side, ecological farming, with its environmentally conscious stance, occasionally faces doubts over its economic feasibility. Notably, this exploration unveils gaps in current knowledge, especially in harmonizing economic and technological aspects within ecological practices.

For a deeper and more nuanced understanding of the multifaceted agricultural systems and their interrelations, it's imperative for the research community to adopt an interdisciplinary approach, integrating insights from agricultural sciences, economics, sociology, and ecology. With this comprehensive perspective, we can navigate towards an agricultural model that seamlessly blends profitability with sustainability.

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