UDC 332; DOI 10.18551/rjoas.2022-10.03

ORGANIC FARMING FOR SUSTAINABLE AGRICULTURE: A REVIEW

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ABSTRACT
Organic Farming is a system designed and maintained to produce agricultural products using methods and substances that preserve the integrity of organic agricultural products. Organic agriculture is a more sustainable alternative to the dominant agricultural model. Organic Farming reduces the risk of adverse environmental effects compared to conventional farming methods; in terms of soil fertility and nutrient management, organic Farming is suited to significantly improve soil fertility and nutrient management on the farm level; and comparative studies on biodiversity demonstrate that organic farming has a greater impact on biodiversity preservation. Furthermore, when comparing organic farming systems to conventional farming systems, the lower crop yields attained by organic systems may outweigh the benefits of using more environmentally friendly practices when calculating the environmental impact per product unit. Modern agriculture, which involves the use of pesticides and fertilizers, harms the environment by affecting soil fertility, water hardness, the development of insect resistance, and an increase in toxic residue through the food chain and animal feed, resulting in increased health problems, and many other serious health concerns and environmental degradation. Organic Farming is one of the most widely used methods, and it is widely regarded as the best alternative to avoiding the negative effects of chemical farming. It also has far more benefits than conventional and other modern agricultural practices. This study demonstrated that organic farming systems could be a viable method of reducing greenhouse gas emissions in the agricultural sector. Also, organic farming is not only the model for sustainable agriculture and food security, but creative hybridizations of organic and conventional farming methods could assist to increase agricultural productivity globally.

KEY WORDS
Biodiversity, conventional farming, greenhouse gas, organic, sustainability.

According to the USDA, organic farming is a system created and maintained to produce agricultural goods using procedures and materials that retain the quality of organic agricultural products up until they are consumed. The critical elements include efficient recycling of organic wastes such as crop residues and livestock wastes, ensuring long-term soil fertility by maintaining organic matter levels, encouraging soil biological activity, careful mechanical intervention, nitrogen self-sufficiency via legumes and biological nitrogen fixation, and weed, disease, and pest control based primarily on crop rotations, natural predators, diversity, and organic manure (Eyhorn et al., 2019). The current agricultural model can be replaced with organic agriculture, which is more environmentally friendly. Society supports its stance on the environment, social inclusion, and economic viability, and recent rises in global consumption, particularly in Europe and the United States, promote the market's growth. Food that is organic is gaining popularity (Froehlich etal., 2018). Farmers' adoption of organic farming and consumer demand for organic food are fueling the rise of the organic sector (Lamine & Bellon, 2009). Consumers buy organic foods as a result because they believe them to be healthier or more fresh than conventional items, as well as because they are better for the environment and the local economy (Annunziata & Vecchio, 2016). The rapid growth of organic farming is being driven by consumer demand for healthier foods and government initiatives supporting the environmental sustainability of agricultural practices (Maggio et al., 2013).

Rozman et al. (2013) stated that subsidies, which serve as the main driving force behind the switch from conventional farming to organic farming, are necessary for conversion to organic farming. Food demand, which is influenced by population size, is another crucial factor. It makes it more difficult to switch to organic farming because larger demand raises food prices. The research by Wheeler (2008) supports the idea that people who are more knowledgeable and experienced about organic farming are more likely to favor it. Bengtsson et al., (2005) claimed that compared to intensive agriculture, which relies on the routine application of inorganic nutrients, pesticides, and herbicides in crop and animal production, organic farming methods are thought to be more environmentally benign. Similarly, Biao et al., (2003) revealed that organic farming generally reduces the risk of negative environmental effects more than conventional farming methods; that organic farming is well suited to improve soil fertility and nutrient management significantly on the farm level; furthermore, biodiversity comparison studies reveal that organic farming has a greater positive impact on biodiversity conservation. Annunziata & Vecchio (2016) demonstrated that organic farming had a positive impact on public health, the environment, and rural communities' economic and social well-being. Both rich and developing countries can benefit from organic agricultural techniques (which protect the environment and improve biodiversity while consuming less energy and emitting fewer greenhouse gases) (sustainable resource use, increased crop yields without relying too heavily on expensive external inputs, environmental and biodiversity protection) (Stockdale et al., 2001). In heterogeneous landscapes, organic farming can increase species richness and abundance of plants and butterflies. It can also increase functional diversity by preventing the homogenization and simplification of biotic communities brought on by earlier agricultural intensification, making communities more resistant to environmental or land-use changes (Halberg, 2012). Around 800 million people, mostly in Asia and Africa, continue to be chronically undernourished. In the future decades, food demand will continue to increase as a result of population and income growth.

Organic farming techniques can dramatically cut GHG emissions and address several environmental challenges associated with typical agriculture; yet, scaling organic Growing consumer demand for organic food necessitates farming, which will eventually result in better farming techniques and a shift toward greater sustainability (Squalli & Adamkiewicz, 2018). Only if organic agriculture is implemented in a well-designed food system that addresses animal feeding rations, reducing animal numbers and product consumption, as well as food waste, will it be able to feed the world's population in 2050 while also reducing agricultural and environmental consequences. In the future, rather of concentrating just on sustainable production, the development of organic agriculture should address similar issues on the consumption side. So, by evaluating the substantial literature on many elements of certified organic farming, such as its effects on the economy, society, environment, and health, the question of whether organic agriculture is the answer is answered here (Muller et al., 2017).

Productivity. Crop output and quality are both included in production. The yield differences between organic and conventional systems have been studied in numerous research. Boone et al., (2019) the lower crop yields obtained by organic farming systems in contrast to conventional farming systems may, however, offset the advantages of using more environmentally friendly practices when calculating the environmental effect per product unit. Similarly, Ferro et al., (2017) noticed that despite their wide range over the years and dependence on crop variety, organic yields were consistently lower than conventional ones. Reduced availability of nutrients, timing and kind of tillage operations, cropping season, and other management restrictions were the main causes of the lower yields. They claimed that CF produces more on average, particularly more maize (+37.7%) and winter wheat (+37%). Although there were fewer variances and identical output levels in OF and CF in four out of the twelve years, soybean was also more productive in CF (+19%). Results of a similar reduced yield were seen in the article (Krauss et al., 2020). Backer et al.,(2009) indicated that while INF farming was far more productive than inorganic farming, it was statistically similar to organic farming. Reganold & Wachter (2016) stated that due to the better water-holding capacity of organically farmed soil, organically managed farms have regularly been found to produce larger yields than their conventional counterparts under severe drought circumstances, which are projected to become more prevalent with climate change in many locations. Das et al., (2017) reported that the average production of carrot and tomato (Solanum lycopersicum L.) over the past seven years (Daucus carota L.) reported that while rice productivity in sunken beds was identical under organic, inorganic, and INF farming systems, all three had significantly higher yields than control. However, the seven-year average productivity of tomato (Solanum Lycopersicum L.) and carrot (Daucus carota L.) under organic farming systems was significantly higher than both inorganic and control farming systems. Additionally, they observed that the majority of the quality indicators for tomatoes and carrots, such as lycopene content, total sugar, total soluble solids, and beta carotene, were better under organic farming. When all of these long-term findings are considered, organic farming has a variety of benefits for better soil quality and long-term productivity. Hattab et al., (2019) reported a considerable reduction in micronutrients in organically grown vegetables' edible parts. However, the amount of hazardous metals in conventionally farmed crops considerably rose.

Similarly, compared to conventionally produced crops, organic systems generate less food and organic foods have little to no synthetic pesticide residues (Reganold & Wachter, 2016). Responses to conventional versus organic farming in cauliflower, endive, and zucchini showed that a variety of interconnected factors influence the general quality of organic products. Without mulching, organic farming boosted the activity of liposoluble antioxidants; organic farming encourages the buildup of K in zucchini cultivated in clay soil but not in sandy soil (Maggio et al., 2013). Musyoka et al., (2017) revealed that under conventional farming systems, potatoes had higher N uptake, N uptake efficiency (NUpE), N utilization efficiency (NUtE), and agronomic N-use efficiency (AEN), whereas maize and vegetables, conventional farming systems, and organic farming systems had similar effects on NUpE, AEN, NUtE, and NHI, it was observed. The seminal root length and weight of organic composite cross populations (CCPs) increased in comparison to conventional CCPs, whereas total- and specific root lengths dramatically decreased. Under organic conditions, rooting patterns have a superior capacity to access deeper soil resources (Vijaya et al., 2019). Schrama et al., (2018) reported that while requiring less nitrogen inputs, yields in the organic farming method were initially lower but eventually approached those of both conventional systems after 10–13 years. Suja et al., (2017)**'s** study has shown that higher yields can be obtained even for a nutrient-depleting tuber crop like taro by using less expensive and locally produced organic manures, including green manure cowpea. Plant growth and organic matter decomposition were greater in organic than in conventional soils under plastic tunnels and soil microbial communities (Bonanomi et al., 2016). When compared to conventional fields, organic fields had higher flower densities, relative growth rates, and bee colony fecundities; nevertheless, there were no variations in the number of reproductive (queens, workers, and males) between the two systems (Adhikari et al., 2019).

Biodiversity. Blundell et al. (2020) reported that the increased biodiversity and abundance of beneficial predators, as well as changes in plant nutrient content, have been primarily attributed to the decreased insect pest populations observed on long-term organic farms. They also suggested that healthy soils cultivated using organic methods can promote sustainable and resilient yields in the face of hemipteran pest pressure. Therefore, organic farming has a big potential to significantly enhance the provision of important ecosystem services necessary for the resilience of the food supply and the sustainability of farming systems. According to certain studies, organically maintained soils and microbial communities may unwittingly contribute to a reduction in plant pest attraction by boosting plant resistance. According to Bengtsson et al. (2005), organic farming has a more varied crop rotation and doesn't use pesticides, herbicides, or inorganic fertilizers. They came to the conclusion that this strategy increases biodiversity in agricultural landscapes because organic farming typically has good effects on species richness and abundance when compared to conventional farming systems. However, its effects will certainly differ depending on the kinds of species and environments. While non-predatory insects and pests did not respond well to organic farming, birds, predatory insects, soil organisms, and plants did. In organic farming systems, organisms were 50% more abundant on average. According to the main findings of Goded et al., (2019), organic vineyards had greater arachnid densities and a stronger correlation between their species richness and the amount of ground cover. No of the location, farming was unable to boost bat activity or species diversity. The research instead showed that vineyard management was less important for bats than landscape factors, with substantially higher bat activity being seen on grape plots near rivers and hedgerows. Therefore, they suggested that maintaining a high level of ground plant cover and managing vineyard plots under organic farming practices are the two main recommendations to support arachnid biodiversity.

Halberg (2012) reported that organic farms have better functional richness than conventional farms in terms of both butterfly species and diversity. Additionally, when less agriculture was present around organic farms, the functional evenness of butterflies was higher. Contrarily, it was also found that plant species richness or functional diversity were unaffected by organic farming. The prevalence, diversity, succession, and relationship of denitrifying bacteria with agricultural systems are mainly unknown. Han et al. (2020) found that the ORG had much larger levels of the nosZ gene than the CON, where N2O emission was 35% lower. While having no impact on bacterial populations that largely thrived seasonally, nitrite-reducing populations were enhanced by long-term organic farming as compared to CON. Industrial processes used in conventional agriculture significantly alter soil quality, which can occasionally have a negative impact on soil life. Henneron et al. (2014) observed that all major soil species, including microorganisms, nematofauna, and macrofauna, saw long-term increases in number and biomass under both organic and conservation farming methods, with the exception of predaceous nematodes. Organic farming primarily enhanced endogeic and anecic earthworms as well as the bacterial food chain in the soil. For organic agriculture, preserving biodiversity in agricultural systems is a top goal (Biao et al., 2003). Although the reason(s) for this are unknown, natural enemy evenness is typically higher on organic farms than conventional farms. Aldebron et al., (2020), Carabid activity density, species richness, and species evenness were found to be higher on organic farms than on conventional farms in 65 fields of broccoli (B. oleracea). This may be because composted manure applications on organic farms provide habitat for predators as well as food for detritus-feeding arthropods that are important supplemental prey. It's probable that growing organic matter enhanced the soil's microclimate to ground beetles' advantage. The likelihood that carabids on organic farms responded to additional ecological or management strategies that weren't available on conventional farms cannot, however, be fully ruled out. The research by Atandi et al. (2017) showed that organic farming has the ability to reduce PPN at the farmer level because it was successful in doing so for a longer length of time (4 months) than conventional farming and farmer practices (2 months).

Economics. Crop yields, labor and total costs, premiums for organic products, the possibility of reduced income during the organic transition period (typically three years), and potential cost savings from the decreased reliance on non-renewable resources and purchased inputs are the main factors that determine the profitability of organic agriculture (Reganold & Wachter, 2016). Compared to conventional agriculture, 100% conversion to organic agriculture requires more area but uses less pesticides and surplus nitrogen (Rozman et al., 2013). Froidevaux et al., (2017) demonstrated that the profits of organic producers were roughly 10-7% lower than those of conventional producers; the findings supported the working hypothesis that the earnings of organic producers are lower than those of conventional producers. However, in other instances, farmers that obtain certification see higher profits and can therefore access price premiums to make up for the organic output. Blundell et al. (2020) showed that plant resistance may play an underappreciated role in decreasing plant attractiveness to pests through organically maintained soils and microbial ecosystems. Organic farming can help prevent overuse and reliance on toxic chemicals that can damage the environment (Atandi et al., 2017). The benefit-cost ratio for organic shrimp was 1.91 and its production per hectare was 383 pounds, indicating that it was more profitable (Dhar et al., 2020). When compared to imported foods, consumers give locally produced organic foods a higher preference and are prepared to pay more for them (Annunziata & Vecchio, 2016).

Similarly, Halberg (2012) discovered that it has resulted in a growing market for products that are certified organic. The European food system faces several significant systemic vulnerabilities, including the deterioration of the natural resource base for food production, the erosion of its tacit knowledge base, its reliance on outside inputs and government support, the latent instability of the agri-food markets, and the pursuit of efficiency that eliminates diversity in the food system. Organic farming has some potential to strengthen the resilience of the European food system against these systemic vulnerabilities. However, it must be carefully planned and carried out in order to overcome the inconsistencies between the current socio-economic organization of food production and the ability to put all of organic farming's principles—health, ecology, fairness, and care—into practice on a larger scale (Brzezina et al., 2016). Jouzi et al. (2017) showed that even though OF causes small-scale farmers some serious issues, it should still be seen as part of the solution and a strategy to improve their quality of life because it increases farmers' incomes and lowers the price of external inputs. Lee & Choe (2019) indicated that organic Farming is much less energy efficient than conventional Farming (1.923 energy efficiency) (1.046 energy efficiency). The lower output energy productions and higher input energy consumption of organic soybean farms in Korea than those of conventional farms serve as indicators of their poor EEs. Lien et al., (2007) indicated that compared to conventional farming, organic farming is less economically sustainable. Liu et al. (2016), in their comparison of crop yield, soil organic matter, and economic benefits within the practice of Biodiversity Management of Organic Farming (BMOF) at Hongyi Organic Farm (HOF) over eight years, they discovered that CF only found crop yield benefits, while the total economic benefits of BMOF included crop yield benefits, cattle breeding benefits, apple orchard benefits, poultry (chicken and goose) benefits, and cash forest benefits. A sizeable financial gain was also realized by feeding pests non-toxically trapped by solar-powered trapping lights to poultry grown on BMOF property. Muneret et al. (2018) compared to conventional systems, organic systems have substantially higher levels of weed infestation, similar levels of animal pest infestation, and lower levels of disease infestation. In general, organic fields showed greater levels of insect infestation than conventional ones. However, the type of pest had a significant impact on this outcome. The findings showed that while studies examining numerous pest species discovered higher pest infection levels in organic than in conventional fields, just one pest species reported similar pest infestation levels between organic and conventional fields.

Soil. Comparative studies demonstrate that organic farming is best adapted to increase farm-level soil fertility and nutrient management (Biao et al., 2003). Arb et al., (2020) said that compared to low input systems (organic or conventional), organic farming with high applications of organic inputs, combined with legume intercropping and irrigation improved soil quality, whereas the high input conventional system was intermediate in most assessed parameters. All treatments, meanwhile, resulted in a large buildup of P, indicating unsuitable input levels, particularly for mineral P sources, whereas low amounts of organic input were insufficient to maintain soil organic C and associated soil quality indicators. When compared to conventional tillage in organic farming, conservation tillage improved the organic carbon, total nitrogen, and accessible phosphorus. Contrarily, organic farming using conservation tillage caused more soil compaction than conventional tillage (Peigné et al., 2018). Raised and sunken beds with organic farming had more readily available nitrogen (N) than inorganic and control farming, respectively. Additionally, compared to other farming techniques, organic raised and sunken beds had much greater soil microbial biomass carbon levels (Das et al., 2017). However, Henneron et al., (2014) reported that, with the exception of predaceous nematodes, both organic and conservation methods enhanced the biomass and abundance of all soil species over time. For instance, macrofauna grew by 100 to 2,500 times as much, nematodes by 100 to 700 times as much, and bacteria by 30 to 70%.

Comparatively to conventionally managed soils under mineral fertilization alone, organic farming increased richness, decreased evenness, and dispersion modified the structure of the soil microbiota (Hartmann et al., 2015). Morvan et al., (2018) reported that the aggregate stability was significantly higher in the organic management field (OF) than in the conventional management field (CM), indicating that CM soils are more susceptible to soil crusting than OF soils. Additionally, within the OF field, no runoff was observed when the rainfall intensities were 25 and 40mmh1, respectively, whereas in the CM field, runoff occurred with a runoff coefficient (RC) of 4.8% and 6.9% at these intensities. These findings demonstrate the advantages of recent organic farming conversion in silty soil for aggregate stability and, as a result, for soil crust dynamics, runoff genesis, and soil erosion. Krauss et al., (2020) revealed that the conversion from plowing to reduced tillage and the additional application of composted manure increased SOC by 6% compared to pure slurry application, with little impact on soil microbes, and that these changes caused a shift in microbial communities. The synthesis of 15 years also revealed an increase in topsoil organic carbon (SOC, +25%), microbial biomass (+32%) and activity (+34%) and a shift in microbial communities. Only the compost farms with livestock showed significantly higher grain Cd concentrations in comparison to conventional and organic farms without compost use, while total and available soil Cd concentrations, as well as soil organic carbon concentration (SOC), were significantly higher on the organic farms with compost use than on the conventional farms (Schweizer et al., 2018). Although there was a link between total soil Zn and SOC when all farms were combined, the soil and grain Zn concentrations did not significantly reflect the influence of the agricultural system. Schrama et al., (2018) a lower coefficient of variation, indicating improved spatial stability, pH, nutrient mineralization, nutrient availability, and abundance of soil biota, as well as a significant decrease in groundwater nitrate concentrations and fewer plant-parasitic nematodes. It was also reported that organic farming improved soil structure with higher organic matter concentrations and higher soil aggregation. While temporal stability in the two organic and conventional farming systems was comparable, it was higher in the organic farming system when years with potato Phytophthora outbreaks were excluded. Suja et al., (2017) demonstrated that using organic management in taro is a sustainable choice for producing cormel of high quality and with stable yields while causing less soil degradation. Organic tubers showed increased dry matter, starch, sugar, P, K, Ca, and Mg contents, while there was a little (-5%) yield drop. Under an organic system in taro, the soil's physicochemical characteristics (water-holding capacity, pH, organic C, accessible P, Ca, Mg, Fe, Mn, Zn, and Cu) also improved. They also disclosed that, throughout the trial, total soil profile SOC in the conventional farming system showed substantial negative trends, but not in the organic farming system. However, other research, particularly some from Norway, has found that organic farming results in diminishing soil nutrient concentrations of nitrogen, phosphate, and potassium, raising concerns about the long-term viability of these crop farming techniques (Lien et al., 2007).

Environment. Halberg, (2012) reported that organic farming offers alternatives that have been shown to be financially feasible on a large scale and show benefits from various sustainability perspectives, such as in resource use efficiency and Agri-environmental performance, which are significant from a resource sufficiency perspective of sustainability. The same outcomes demonstrated that it is environmentally beneficial (Annunziata & Vecchio, 2016). Organic products frequently have a lesser environmental impact when LCA results are taken into account on a per-area and per-year basis. When assessing the environmental impact per product unit, the lower crop yields achieved by organic systems compared to conventional farming systems exceed the advantages of using more environmentally friendly practices (Boone et al., 2019). According to Dhar et al., (2020), the cause-effect-mitigation analysis revealed that organic shrimp farming could help to lessen the negative environmental effects of traditional shrimp farming. According to their research, organic shrimp farming is not viable from the perspectives of energy consumption, environmental protection, economic viability, and social and political equality. According to Chiriacò et al., (2017), the CF of 1 kilogram of conventional whole grain bread was 24% lower than that of the same amount of organic bread. However, when the CF was measured per cultivated area (hectare), conventional wheat farming produced 60% more GHD emissions than organic farming. The larger usage of raw materials (increased seed density, agrochemicals for fertilization, and plant protection) in relation to the same organic system was the cause of the conventional approaches' higher CF per hectare. Šarauskis et al.,

(2018) reported that farm size effects the total carbon emission inputs of sugar beet production. Accordingly, when farm size grows in the organic farming system, sugar beet production's carbon emissions (kg/ha) decrease by 3.1-4.0% and by 9.9-14.9%, respectively.

According to Han et al., (2020), the nosZ gene is much more abundant in the ORG than the CON, where N2O emission was discovered to be 35% lower. Frimawaty et al., (2013) reported that the CF, WF, and NF were lower in organic farming than those in conventional farming at first when the ecological footprint method was taken as an accounting tool to balance ecological footprint and ecological capacity, but that organic farming practices made greater contributions to regional ecological safety as organic agro-systems had a greater ecological remainder. However, organic farming has the highest energy-related nitrogen impact. Squalli & Adamkiewicz, (2018) estimated that a 1% increase in the area used for organic farming might cut greenhouse gas emissions by 0.049%. Additionally, they discovered that the effect of organic farming on methane and nitrous oxide emissions vary depending on the output share of transportation. Lee & Choe, (2019), however, showed that the greenhouse gas emissions from conventional and organic soybean farming systems (1657.55 kg CO2 eq/ton and 2045.11 kg CO2 eq/ton, respectively) are not significantly different. Additionally, it stated that organic Farming is much less energy efficient than conventional Farming (1.923 energy efficiency) (1.046 energy efficiency). Energy inefficiency in organic farming is caused by high fuel and mulch film usage, as well as by lower agricultural yields. Skinner et al., (2019), In a long-term field area scale study of N2O and CH4 fluxes over a period of 571 days in a grass-clover-silage maize-green manure cropping sequence, it was shown that overall N2O emissions were, on average, 40.2% lower in organic farming systems compared to non-organic farming systems. Atandi et al., (2017) revealed that using hazardous toxic chemicals too frequently can contribute to environmental damage. Organic farming may help to prevent this. Biao et al., (2003) shown that the fundamental principles of organic farming offer suitable methods to reduce environmental contamination and nutrient losses. Organic farming becomes environmentally benign when external inputs like mineral fertilizers and pesticides are eliminated (Leifeld, 2012). Pacini et al., (2003) pointed out that in terms of nitrogen losses, pesticide risk, herbaceous plant biodiversity, and the majority of the other environmental indicators, it has been discovered that OFSs perform better than IFSs and CFSs; nevertheless, on hilly soils, erosion has been found to be higher in OFSs than in CFSs.

CONCLUSION

Organic farming exhibits a more favorable environmental profile when evaluated on an area basis. The overall benefits of organic farming are greatly reduced when yields are taken into account, hence it is essential to find ways to increase yields without significantly increasing the environmental load. However, the problems facing the world's food and agriculture cannot be resolved by simply improving environmental sustainability. To fully profit from the advantages of organic agriculture, it is necessary to take into account the social, economic, and institutional factors. As a result, organic farming is not the best practice for food security and sustainable agriculture, but creative combinations of organic and conventional farming methods may be able to increase agricultural output over the long run.

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