"Advancing Sustainable Agriculture: A Comprehensive Review of Organic Farming Practices and Environmental Impact"

Abstract

Organic farming, characterized by the exclusion of synthetic fertilizers and chemical pesticides, represents a sustainable approach to agriculture. This study investigates the impact of organic farming practices on soil health, focusing on the proliferation and activity of soil microorganisms. Natural fertilizers such as farmyard manure, poultry litter, composts, green manures, and oil-free cakes were utilized to enhance soil fertility. The research reveals that these practices significantly improve soil health by fostering a robust microbial community, which plays a crucial role in nutrient cycling and overall soil vitality.The safety and nutritional benefits of organic food products were also evaluated. Comparative analysis with conventionally grown foods indicates that organic produce contains lower levels of harmful residues such as pesticides, nitrates, metals, and antibiotics. This reduction in contaminants mitigates potential risks to human health associated with conventional farming practices. Furthermore, organic foods are found to be richer in essential nutrients, vitamins, and antioxidants, thereby offering superior nutritional value.The economic implications of organic farming were explored, highlighting its potential to enhance the economic viability of small-scale farmers. With increasing consumer awareness and demand for organic products, farmers practicing organic methods can command higher prices for their produce, thereby improving their economic sustainability and resilience. In conclusion, organic farming emerges as an environmentally friendly and economically viable alternative to conventional agriculture. By promoting soil health, reducing chemical residues in food, and meeting consumer demand for nutritious products, organic farming offers a pathway towards sustainable agricultural practices.

Keywords: organic farming, soil health, food safety, economic sustainability

Introduction

Over recent decades, conventional agriculture has predominantly focused on maximizing food production using extensive chemical inputs such as fertilizers, insecticides, pesticides, fungicides, and weedicides, often overlooking their detrimental effects on environmental and public health. Despite ongoing efforts by researchers, organizations, and policymakers to increase per capita food grain production through chemical means, organic farming has garnered significant attention over the last decade from researchers, farmers, and government bodies. This shift is reflected in the rapid growth of organic farming, which has expanded by approximately 20 percent annually [1]. Presently, Asia leads with 36 percent of its agricultural land under organic cultivation, followed by Africa and Europe at 29% and 17%, respectively. [2]. The surge in organic farming is driven by a rising consumer preference for organic products, which are perceived as safer and beneficial for environmental sustainability and personal health [3]. In affluent nations, organic foods are valued for their lower pesticide residues, contributing to their reputation as health enhancers [4, 5]. Organic farming enhances soil nutrient content through the decomposition of plant debris and naturally controls pest infestations without chemical agents. Techniques such as green manuring, crop rotation, and cover cropping are pivotal in producing quality food grains, improving soil microorganism populations, and enhancing soil health. Organic cultivation primarily utilizes legume green manures, including farmyard manure, compost from crop residues, vermicompost, and organic waste from animals. [6]. These practices not only increase soil organic matter, enhancing water retention, porosity, and reducing soil compaction but also lessen erosion risks [7, 8]. Furthermore, organic farming promotes biodiversity, strengthens ecosystems, and optimally uses natural resources, thereby boosting crop yields. The market for organic grains, vegetables, fibers, and their by-products commands higher prices, significantly bolstering the economic viability of farmers compared to conventional farming practices.

Sources of Organic Manures:

Organic fertilizers are generally classified into two types: bulky organic fertilizers and concentrated organic fertilizers. Bulky organic manures primarily originate from plant material, animal waste, and other organic refuse, including green plant tissues. These encompass well-rotted animal and plant byproducts such as farmyard manure (FYM), vermicompost, and composts derived from agricultural and urban waste, alongside poultry litter, human excreta, and sewage sludge. Conversely, green manure refers to unrotted matter from fresh green plant material. Frequently used leguminous plants for green manuring include sunhemp, dhaincha, mung, cowpea, guar, senji, khesari, and berseem. Non-leguminous crops like bhang, sorghum, maize, and sunflower are also grown for the purpose of being incorporated back into the soil. This technique greatly enhances the soil's nutrient content and organic matter. [9].

Concentrated organic manures, noted for their high organic matter content, contain substantially more essential plant nutrients such as nitrogen (N), phosphorus (P_2O5), and potassium (K_2O) than bulky manures. These include oil-free cakes such as mustard cake, soybean cake, as well as nutrient-rich products like blood meal, bone meal, meat meal, fish manure, and other derivatives such as horn and hoof meal, and wool waste. Additionally, non-edible oil cakes from plants like mahua, neem, castor, cotton, karanj, safflower, and jatropha are grouped with edible varieties such as coconut, decorticated cotton, safflower seed cakes, mustard, groundnut, linseed, sesame, and soybean oil-free cakes.These materials are particularly valuable in organic farming for their nutrient-rich content and soil enhancement properties. Average nutrient composition of organic manures as detailed in Table 1.

Table 1: Average nutrient content of organic manures(11,12,54,55)

	Content (%)		
Manure	**N**	**P_2O_5**	**K_2O**
Animal waste	0.3-0.4	0.1-0.2	0.1-0.3
Fresh cattle manure	0.4-0.5	0.3-0.4	0.3-0.4
Fresh horse manure	0.5-0.5	0.4-0.6	0.3-1.0
Fresh poultry litter	1.0-1.8	1.4-1.8	0.8-0.9
Cattle urine	0.9-1.2	trace	0.5-1.0
Dry rural compost	0.5-1.0	0.4-0.8	0.8-1.2

Dry urban compost	0.7-2.0	0.9-3.0	1.0-2.0
Farmyard manure	0.4-1.5	0.3-0.9	0.3-1.9
Raw bone meal	3.0-4.0	20.0-25.0	trace
Steamed bone meal	1.0-2.0	25.0-30.0	trace
Fish meal	4.0-10.0	3.9	0.3-1.5
Castor cake	4.3	1.8	1.3
Neem cake	5.2	1.0	1.4
Safflower cake	4.9	1.4	1.2
Coconut cake	3.0	1.9	1.8
Groundnut cake	3.0	1.9	1.8

Nutrient composition of key green manure crops

Crop	**Nutrient content % (on dry weight basis)**		
	N	**P**	**K**

Sesbania aculeate	3.3	0.7	1.3
Crotalaria juncea	2.6	0.6	2.0
Sesbania speciosa	2.7	0.5	2.2
Phaseolus trilobus	2.1	0.5	-

Current Insights into Organic Agriculture and Crop Yields

The debate whether organic agriculture can sustain global food demands is ongoing. Meta-analyses analyzed 1071 yield comparisons across 115 studies, finding a 19.2% lower yield in organically managed fields compared to conventional ones [13, 14, 15]. The USDA (2018) noted a disparity in yields, with organic farms achieving 84% of conventional yields across 292 comparisons [16]. Notably, 55 of these comparisons showed higher yields for organic farms, predominantly in hay and silage rather than food crops. Yield variations in organically grown fruits and vegetables are recognized, influenced by crop type and geographical factors.

Organic soil amendments are known to enhance crop yields. Various studies have shown improvements in both yield and crop quality following the application of organic manures. For instance, farmyard manure (FYM) has notably improved wheat yields and quality [17, 18], while significant enhancements in radish root and shoot weights were observed with the use of poultry litter, bone meal, and PSB (phosphate solubilizing bacteria) culture [19]. The highest radish weights were recorded with poultry manure and vermicompost applications [20, 21]. Despite organic vegetables constituting only 1.1% of total vegetable production in 2017, their growth, yield, and quality have been positively impacted by organic manures [22, 23].

Specifically, FYM applications have increased grain yields in maize [24] and enhanced rice and wheat yields by up to 140% at certain fertilizer rates [25, 26, 27]. Similar positive results were reported for onions, where FYM and inorganic nitrogen applications yielded the highest marketable bulbs [28]. Chilli fruits saw an increase in number and weight, particularly with poultry manure [29]. Garlic showed maximum growth and quality improvements with a 5 ton/ha application of vermicompost [30]. Tomatoes experienced a boost in fruit number, weight, and overall yield with the use of FYM, vermicompost, and waste decomposer [31, 32]. In okra, the application of poultry manure significantly surpassed the yield of other manures, highlighting its effectiveness in organic cultivation [33].

Effects on crop quality metrics

Table 2: Influence of Organic Manures and Fertilizers on Crop Quality Metrics[54]

Wheat	FYM + N_3PK	Elevated crude protein (13.21%) and wet gluten content (30.17%)	Holic *et al*., 2018 [34]
Radish	FYM (Farmyard Manure) + PM (Poultry Manure) + PSB (Phosphate Solubilizing Bacteria) + Bone Meal	Elevated levels of vitamin C (2.87 mg/ml) and total soluble solids (2.20 °Brix)	Gyewali *et al*., 2020 [35]
Chickpea	Vermicompost	Maximum protein content (20.99%)	Kushwaha *et al*., 2021 [36]
Soybean	75% NPK + 25% Vermicompost + Rhizobium + Phosphate Solubilizing Bacteria	Generated oil content (20.1%) and protein content (41.5%)	Verma *et al.*, 2017 [37]
Chilli	Vermicompost + vegetable waste	Protein content increased at 60 days after sowing (DAS) (113 mg/g) and 90 DAS (79 mg/g)	Yadav and Vijayakumari, 2004 [38]

Impact of Organic Farming on Soil Physical, Chemical, and Biological Characteristics

Effective soil fertility management is essential for the sustainability of agriculture and land use. Organic management practices often lead to enhanced biological activity in soils compared to conventional methods. Soils in organic fields typically exhibit increased stability, benefiting from the regular application of organic manures. These organic inputs boost the activity of soil microorganisms and biomass, enhance soil respiration, and increase the activity of soil enzymes, all of which contribute to improved nutrient availability for plants. These integrated effects make organically managed soils more dynamic and fertile.Organic manures on soil properties mentioned in table 3.

Table 3: Impact of Organic Fertilizers on Soil Characteristics[54]

PM + BC	Moisture content, increased porosity, reduced bulk density, and higher levels of calcium and magnesium in the soil.	Adekiya *et al*., 2020; [39)]
BC	Enhances soil moisture content and availability of potassium and phosphorus.	Pandit *et al*., 2018 [40]
BC, PM	Elevated soil pH, organic carbon, nitrogen, potassium, calcium, and magnesium levels. Improvements in physical properties include reduced bulk density, enhanced soil porosity, increased water content, better aggregate stability, decreased penetration resistance, and improved dispersion ratio.	Agbede, 2021 [41]
Rice husk BC + organic	In clay soil, there was a	Widowati *et al.*, 2020 [42]

manure	reduction in bulk density by 23.1%, an increase in soil organic matter by 135.3%, enhanced porosity by 45.6%, higher sand fraction by 81.5%, increased macropore volume by 40.1%, greater micropore volume by 60.9%, and elevated moisture content at field capacity by 30%.	

PM stands for poultry manure, BC for biochar, MC for moisture content, OC for organic carbon, FYM for farmyard manure, CM for chicken manure, LM for livestock manure, VC for vermicompost, BF for biofertilizer, OF for organic fertilizer, CD for cow dung, and EC for electrical conductivity.

Environmental Impact of Organic Farming Practices

Organic agriculture benefits the environment and enhances biodiversity through direct and indirect means. Directly, it restricts the use of synthetic agrochemicals and inorganic fertilizers. Indirectly, it alters agricultural practices through changes in cropping systems, crop rotations, and the use of organic manures. Biodiversity in organic farms is reported to be up to 30% greater than in conventional farms, with studies indicating significant increases in species diversity (30-34%), abundance of organisms (up to 50%), and even distribution of species. [45, 46]. Organic farms also demonstrate lower energy usage, ranging from 10-70%, and reduced greenhouse gas emissions by up to 39%, with notably lower emissions of nitrous oxide (14-31%) per unit of land compared to conventional farms [47, 48, 49]. Additionally, nutrient leaching is less prevalent in organic systems, with reductions in nitrate (30-31%), ammonia (18%), and phosphorous [48, 49]. Organic farms also show higher soil organic matter levels (6-7%), alongside greater soil microorganism presence and activity [49, 50].

Impact of Organic Agriculture on Community Health

The market for organic food products is experiencing consistent growth as consumers increasingly recognize the potential health dangers and environmental impacts associated with conventionally produced foods that rely on synthetic agrochemicals and fertilizers. Organic foods are favored by consumers for their minimal chemical input, enhancing their appeal as safer and healthier choices [51]. Research indicates that foods grown organically contain higher levels of antioxidants and substantially fewer pesticide residues and cadmium (Cd) [52]. Additionally, the rigorous exclusion of synthetic insecticides, pesticides, herbicides, and chemical fertilizers in organic agriculture helps minimize health risks related to environmental contamination. This leads to lesser water, soil, and air pollution, as well as reduced soil degradation and lower emissions of particulate matter and various oxides (N, C, and S) [53].

Future Prospects of Organic Farming

1. **Economic Empowerment for Small Farmers:** Organic farming can enhance the economic stability of small-scale and marginal farmers by opening up new market opportunities.
2. **Cost-Effective Agriculture:** By reducing dependency on expensive synthetic inputs, organic farming can lower overall production costs.
3. **Sustainability in Agriculture:** Organic practices promote long-term sustainability, preserving essential ecological balances and enhancing soil fertility.
4. **Reduced Chemical Dependence:** Organic agriculture minimizes reliance on harmful agrochemicals and synthetic fertilizers, decreasing environmental and health risks.
5. **Enhanced Soil Health:** The application of organic nutrients improves soil structure and fertility, supporting robust plant growth.
6. **Biodiversity Preservation:** Organic farming supports biodiversity by providing habitats for various plant and animal species and maintaining genetic diversity in crops.
7. **Environmental Protection:** Organic methods help minimize pollution of soil, water, and air, contributing to cleaner and healthier ecosystems.
8. **Water Conservation:** Efficient water use in organic farming can be particularly beneficial in areas prone to drought, helping preserve precious water resources.
9. **Renewable Energy Utilization:** Organic farms often incorporate renewable energy sources, reducing carbon footprints and conserving non-renewable resources.
10. **Meeting Market Demand:** As consumer demand for organic products grows, organic agriculture can meet this need, ensuring a steady supply of healthy food options.

11. **Ecological Balance:** By maintaining natural cycles and minimizing human impact, organic farming helps sustain ecological balance.
12. **Job Creation:** Organic agriculture creates employment opportunities in farming, as well as in related sectors like food processing and marketing.

Conclusion

Our findings suggest that organic farming is an effective approach for maintaining environmental balance and conserving natural resources without causing damage. By recycling agricultural and animal by-products and managing nutrients effectively, this method promotes ecological stability and supports biodiversity. The use of organic manures enhances soil water retention, prevents soil erosion, and avoids the pollution associated with synthetic fertilizers and agrochemicals, leading to cleaner soil, water, and air. Moreover, the application of organic manures not only boosts crop quality and yield but also preserves soil fertility and productivity over time. Organically produced foods are safer and healthier, largely free from agrochemical residues. Additionally, the increasing consumer demand and higher market prices for organic produce contribute to the financial prosperity of farmers.

References

1. Acharya S, Belbase P, Kaphle S, Bista A, Bhandari S. The Effect of different fertilizers on vitamin C content of cauliflower. Agri-connection. 2020;5(1):16-17.

2. Acharya S, Belbase P, Kafle S, Bista A, Bhandari S. The Effect of different fertilizers on vitamin C content of cauliflower. Agri-connection. 2020;5(1):16-17.

3. Adekiya AO, Agbede TM, Ejue WS, Aboyeji CM, Dunsin O, Aremu CO, *et al*. Biochar, poultry manure and NPK fertilizer: sole and combine application effects on soil properties and ginger (*Zingiber officinale*

4. Agbede TM. Effect of tillage, biochar, poultry manure and NPK 15-15-15 fertilizer, and their mixture on soil properties, growth and carrot (*Daucus carota* L.) yield under tropical conditions. Heliyon. 2021;7:e07391.

5. Alemu-Degwale. Effect of Vermicompost on Growth, Yield and Quality of Garlic (*Allium sativum* L.) in Enebse Sar Midir District, Northwestern Ethiopia. Journal of Natural Sciences Research. 2016;6(3):51-63.

6. Arshpreet Kaur. Impact of Various Organic Manures on Growth, Growth Attributes and Quality of Cabbage (*Brassica oleracea var. capitata* L.). Int. J Curr. Microbiol. App. Sci. 2020;9(4):273-279.

7. Asai H, Rabenarivo M, Andriamananjara A, Tsujimoto Y, Nishigaki T, Takai T *et al*. Farmyard manure application increases spikelet fertility and grain yield of lowland rice on phosphorus-deficient and cool-climate conditions in Madagascar highlands, Plant Production Science. 2021. DOI: 10.1080/1343943X.2021.1908150

8. Ashraf M, Aziz MA, Shahzad SM, Aziz A. Soil and Plant Nutrient Dynamics in Response to Manuring with Different Organic Wastes under Alkaline Conditions. Ann Agric Crop Sci. 2021;6(1):1067.

9. Babu S, Singh R, Avasthe RK *et al.* Impact of land configuration and organic nutrient management on productivity, quality and soil properties under baby corn in Eastern Himalayas. Sci Rep. 2020;10:16129 https://doi.org/10.1038/s41598-020-73072-6.

10. Baranski M, Srednicka-Tober D, Volakakis N, Seal C, Sanderson R, *et al*. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. Br. J Nutr. 2014;112:794-811.

11. BARC. Fertilizer Recommendation Guide-2012. Farmgate, Dhaka-1215; BARC: Dhaka, Bangladesh. 2012.

12. Basnet B, Aryal A, Neupane A, KC B, Rai NH, Adhikari S, *et al*. Effect of integrated nutrient management on growth and yield of radish. Journal of Agriculture and Natural Resources. 2021;4(2):167-174.

13. Basnet M, Shakya S, Baral B. Response of organic manures on post-harvest and soil nutrient restoration on cauliflower production. Journal of Agriculture and Environment. 2017;18:67-72.

14. Bengtsson J, Ahnstrom J, Weibull AC. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. J Appl. Ecol. 2005;42:261-69.

15. Bhandari S, Pandey SR, Giri K, Wagle P, Bhattarai S, Neupane RB. Effects of different fertilizers on the growth and yield of okra (*Abelmoschus esculentus* L.) in summer season in Chitwan, Nepal. Archives of Agriculture and Environmental Science. 2019;4(4):396-403.

16. Bharat Lal Kushwaha, Singh VK, Kaptan Baboo, Satya Dev, Hari Prakash Namdev. Response of Chickpea (*Cicer arietinum* L.) Cultivars to Organic Sources of Plant Nutrients. Int. J Curr. Microbiol. App. Sci. 2021;10(03):1948-1955.

17. Chandra A, Pardha-Saradhi P, Maikhuri RK, Saxena KG, Rao KS. Impact of farm yard manure on cropping cycle in a rainfed agroecosystem of Central Himalaya. Vegetos. 2021;34:249-262.

18. Chaudhary MV, Thakur Nidhi. Future Prospects of Organic Farming: A Review. Bhartiya Krishi Anusandhan Patrika. 2021;(36):108-111.

19. Crowder DW, Northfield TD, Strand MR, Snyder WE. Organic agriculture promotes evenness and natural pest control. Nature. 2010;466:109-12.

20. De Ponti T, Rijk B, Van Ittersum MK. The crop yield gap between organic and conventional agriculture. Agric. Syst. 2012;108:1-9.

21. Dhama AK. Organic Farming for Sustainable Agriculture. Agro Benificial Publishers (India). 1996.

22. Dixit KG, Gupta BR. Effect of farmyard manure, chemical and bio-fertilizers on yield and quality of rice (*Oryza sativa* L.) and soil properties. Journal of the Indian Society of Soil Science. 2000;48(4):773-780.

23. Enujeke EC. Effects of Poultry Manure on Growth and Yield of Improved Maize in Asaba Area of Delta State, Nigeria. Journal of Agriculture and Veterinary Science. 2013;4(5):24-30.

24. Funk C, Kennedy B. The New Food Fights: US Public Divides over Food Science. Washington, DC: Pew Res. Cent. 2016.

25. Seufert V, Ramankutty N. Many shades of gray—the context-dependent performance of organic agriculture. Sci. Adv. 2017;3:e1602638.

26. Funk C, Kennedy B. The New Food Fights: US Public Divides over Food Science. Washington, DC: Pew Res. Cent. 2016.

27. Gererufae LA, Abraham NT; Reda TB. Growth and yield of onion (*Allium cepa* L.) as affected by farmyard manure and nitrogen fertilizer application in Tahtay Koraro District, Northwestern Zone of Tigray, Ethiopia. Vegetos. 2020;33:617-627.

28. Gomiero T, Paoletti MG, Pimentel D. Energy and environmental issues in organic and conventional agriculture. Crit. Rev. Plant Sci. 2008;27:239-54.

29. Gyewali B, Maharjan B, Rana G, Pandey R, Pathak R, Poudel PR. Effect of different organic manures on Growth, yield, and quality of radish (*Raphanus sativus*). SAARC J Agric. 2020;18(2):101-114.

30. Hand book of Manures and Fertilizers. 1964.

31. Hardman CJ, Harrison DPG, Shaw PJ, *et al.* Supporting local diversity of habitats and species on farmland: a comparison of three wildlife-friendly schemes. Journal of Applied Ecology. 2016;53:171-180.

32. Holík L, Hlisnikovsky L, Kunzova E. The effect of mineral fertilizers and farmyard manure on winter wheat grain yield and grain quality. Plant Soil Environ. 2018;64:491-497.

33. Irfan A, Ishtiaq A, Muhammad N, Malik MY, Bashir A. A review on organic farming for sustainable agricultural production. Pure and Applied Biology. 2016;5(2):277-286.

34**.** Holík L, Hlisnikovsky L, Kunzova E. The effect of mineral fertilizers and farmyard manure on winter wheat grain yield and grain quality. Plant Soil Environ. 2018;64:491-497.

35. Gyewali B, Maharjan B, Rana G, Pandey R, Pathak R, Poudel PR. Effect of different organic manures on Growth, yield, and quality of radish (*Raphanus sativus*). SAARC J Agric. 2020;18(2):101-114.

36. Bharat Lal Kushwaha, Singh VK, Kaptan Baboo, Satya Dev, Hari Prakash Namdev. Response of Chickpea (*Cicer arietinum* L.) Cultivars to Organic Sources of Plant Nutrients. Int. J Curr. Microbiol. App. Sci. 2021;10(03):1948-1955.

37.Verma SN, Sharma M, Verma A. Effect of integrated nutrient management on growth, quality and yield of soybean [*Glycine max*] Annals of Plant and Soil Research. 2017;19(4):372-376.

38. Yadav RH, Vijayakumari B. Impact of vermicompost on biochemical characters of Chilli (*Capsicum annum*). Journal of Ecotoxicology and Environmental Monitoring. 2004;14(1):51-56.

39. Adekiya AO, Agbede TM, Ejue WS, Aboyeji CM, Dunsin O, Aremu CO, *et al*. Biochar, poultry manure and NPK fertilizer: sole and combine application effects on soil properties and ginger (*Zingiber officinale* Roscoe) performance in a tropical Alfisol. De Gruyter. 2020;5:30-39.

40. Pandit NR, Mulder J, Hale SE, *et al*. Biochar improves maize growth by alleviation of nutrient stress in a moderately acidic low-input Nepalese soil. Sci Total Environ. 2018;625:1380-1389.

41. Agbede TM. Effect of tillage, biochar, poultry manure and NPK 15-15-15 fertilizer, and their mixture on soil properties, growth and carrot (*Daucus carota* L.) yield under tropical conditions. Heliyon. 2021;7:e07391.

42. Widowati Sutoyo, Karamina H, Fikrinda W. Soil amendment impact to soil organic matter and physical properties on the three soil types after second corn cultivation. AIMS Agriculture and Food. 2020;5(1):150-168.

43. Mamaril CP, Castillo MB, Sebastian LS. Facts and Myths about Organic Fertilizers; Philippine Rice Research Institute (Phil Rice): Muñoz, Nueva Ecija, Philippines. 2009.

44. Meena AK, Chhipa BG, Ameta KD, Meena SC. Yield and Quality of Tomato (*Solanum lycopersicon* Mill.) as Influenced by Application of Organic Substances under Protected Condition. Int. J Curr. Microbiol. App. Sci. 2021;10(03):577-583.

45. Michael Clark, David Tilman. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. Environ. Res. Lett. 2017;12(6):064016.
https://doi.org/10.1088/1748-9326/aa6cd5

46. Mishra A, Acharya B, Devkota R, Sapkota S, Sedai U. The Effect of different fertilizers. 2018.

47. Mishra B, Sahu GS, Tripathy P, Mohanty S, Pradhan S. Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality of Okra under Integrated Nutrient Management. Int. J Curr. Microbiol. App. Sci. 2019;8(08):66-73.

48. Mondelaers K, Aertsens J, Van Huylenbroeck G. A meta-analysis of the differences in environmental impacts between organic and conventional farming. Br. Food J. 2009;111:1098-119.

49. Mukherjee R. Lal, biochar impacts on soil physical properties and greenhouse gas emissions. Agronomy. 2013;3:313-339.

50. Nasrin A, Khanom S, Hossain SA. Effects of vermicompost and compost on soil properties and growth and yield of Kalmi (*Ipomoea Aquatica* Forsk.) in mixed soil. Dhaka Univ. J Biol. Sci. 2019;28(1):121-129.

51. Nenna MG, Ugwumba COA. Utilization of Organic Farming Technologies among Small-Scale Farmers in Anambra State, Nigeria, International Journal of Agriculture Innovations and Research. 2014, 3(1). ISSN (Online): 2319-1.

52. Pandit NR, Mulder J, Hale SE, *et al*. Biochar improves maize growth by alleviation of nutrient stress in a moderately acidic low-input Nepalese soil. Sci Total Environ. 2018;625:1380-1389.

53. Ponisio LC, *et al*. Diversification practices reduce organic to conventional yield gap. Proc. R. Soc. Lond. B: Biol. Sci. 2015;282:20141396.

54. Kumar A, Kumar A, Kumar Yadav A, Thakur S. Impact of organic farming on eco-friendly sustainable agriculture: A review. The Pharma Innovation Journal. 2022;11(2):709-15.

55. Gelaye Y. Effect of combined application of organic manure and nitrogen fertilizer rates on yield and yield components of potato: A review. Cogent Food & Agriculture. 2023 Dec 31;9(1):2217603.