INDUS JOURNAL OF SCIENCE
https://induspublishers.com/IJS
Volume 1, Issue 2 (2023)

Original Article

INVESTIGATING THE POTENTIAL OF ORGANIC FARMING PRACTICES FOR SUSTAINABLE AGRICULTURE AND SOIL HEALTH IMPROVEMENT

Muhammad Arshad Khan [a], Muhammad Waheed [b], Huma Aziz[c]

[a]PARC Arid Zone Research Centre, Dera Ismail Khan, KP, Pakistan
[b]Directorate of Soil Survey, Khyber Pakhtunkhwa, Pakistan
[c]Pakistan Agricultural Research Council, Adaptive Research cum Demonstration Institute, Matora Lakkimarwat, KP, Pakistan

ARTICLE INFO

Key Words:
* Composting
* Crop cultivation
* Nutrient conservation
* Organic farming
* Soil nutrition
* Weeds growth

***Corresponding Author:**

Muhammad Arshad Khan
muhammadarshad@aup.edu.pk

ABSTRACT

Objectives: This study aimed to evaluate the potential of organic farming practices for sustainable agriculture and soil health improvement.

Methods: Representative organic farming sites in the region of Dera Ismail Khan were selected, considering factors such as soil type, climate, crop rotation practices, and farm management techniques. Interviews and surveys were conducted with organic farmers to gather information on farm management practices, soil amendments used, and pest control strategies. Soil samples were collected from each selected farm site, and various soil parameters, including pH, organic matter content, nutrient levels, and soil microbial activity, were recorded. Experimental plots were set up within each farm, and different organic farming practices, such as compost application, cover cropping, and crop rotation, were evaluated. Control plots with conventional farming practices were included for comparison.

Results: Statistical analysis was performed to compare soil parameters and crop yield between different treatments and control groups. The results indicated that organic farming practices had significant effects on soil parameters, with improvements observed in pH, organic matter content, and nitrogen levels. Crop yield was significantly higher in the treatment groups compared to the control group for wheat, corn, and soybean. Additionally, the implementation of organic practices resulted in reduced weed density for foxtail, chickweed, and lambsquarters.

Conclusion: These findings highlighted the potential of compost application, cover cropping, and crop rotation for enhancing soil health and agricultural productivity in organic farming systems. The study contributed to the scientific understanding of organic farming practices and provides practical recommendations for promoting sustainable agriculture.

INTRODUCTION

Organic farming practices have gained significant attention in recent years as a potential solution for sustainable agriculture and soil health improvement [1]. With increasing concerns over the environmental impacts of conventional agriculture, such as soil degradation, water pollution, and loss of biodiversity, there is a growing need to explore alternative farming methods that promote ecological balance and long-term agricultural sustainability [2-3]. Organic farming, characterized by the use of natural fertilizers, biological pest control, and the exclusion of synthetic chemicals, offers a promising approach to address these challenges [4-5].

The potential of organic farming practices lies in their ability to support soil health and fertility. The avoidance of synthetic fertilizers and pesticides encourages the development of diverse soil microorganisms, beneficial insects, and earthworms, which play crucial roles in nutrient cycling and pest control [6]. Organic farming also emphasizes the use of organic matter, such as compost and cover crops, to improve soil structure, water-holding capacity, and nutrient retention. These practices contribute to the enhancement of soil fertility and reduce the risk of nutrient leaching, thereby promoting sustainable agricultural production [7-8].

Moreover, organic farming practices have demonstrated positive effects on the environment. By minimizing the use of synthetic chemicals, organic farmers help reduce water pollution and protect aquatic ecosystems [9-10]. The exclusion of genetically modified organisms (GMOs) in organic production ensures the preservation of biodiversity and promotes the conservation of traditional seed varieties. Additionally, organic farming systems often promote agroecosystem diversification through crop rotations, intercropping, and agroforestry, which enhance ecological resilience and create habitats for beneficial insects and wildlife [11-12].

Despite the potential benefits, organic farming also presents challenges and knowledge gaps that require further investigation. One key aspect is understanding the economic viability and scalability of organic farming practices [13]. Research is needed to assess the economic performance of organic farms, identify potential barriers to adoption, and develop strategies to overcome these challenges. Additionally, further studies are necessary to explore the effectiveness of organic farming in different agroecological regions, as well as its impact on crop productivity and nutritional quality [14-15].

In this study, we aim to investigate the potential of organic farming practices for sustainable agriculture and soil health improvement. By examining the scientific literature, conducting field experiments, and analyzing data from organic farms, we will contribute to the understanding of the benefits and limitations of organic farming, provide evidence-based recommendations, and support the transition towards more sustainable agricultural systems.

MATERIAL AND METHODS

Study Site Selection

Representative organic farming sites in the target region of Dera Ismail Khan was identified and selected. Factors such as soil type, climate, crop rotation practices, and farm management techniques were considered. The selected sites had a history of organic farming for at least five years to establish the effectiveness of organic practices.

Data Collection

Interviews and surveys were conducted with organic farmers to gather information on farm management practices, crop rotations, soil amendments used, and pest control strategies. Soil samples were collected from each selected farm site at multiple depths (e.g., 0-15 cm, 15-30 cm) using a soil auger. Soil parameters such as pH, organic matter content, nutrient levels, and soil microbial activity were recorded. Soil physical properties, including bulk density, water holding capacity, and infiltration rate, were measured. The presence and abundance of earthworms, beneficial insects, and other soil macrofauna were assessed.

Experimental Design

Experimental plots were set up within each selected organic farm and PARC Arid zone research Centre, ensuring that the plots were representative of the prevailing farm practices. A randomized complete block design with multiple replicates was used to account for variability in soil characteristics. Treatment groups were allocated to evaluate the effects of specific organic farming practices, such as compost application, cover cropping, and crop rotation. Control plots with conventional farming practices were included for comparison.

Data Analysis

Statistical analysis was performed using appropriate software to compare the measured soil parameters and crop performance between different treatments and control groups. Analysis of variance (ANOVA) was utilized to determine significant differences in soil health indicators and crop yield. Descriptive statistics, such as means and standard deviations, were calculated to summarize the data. Post-hoc tests, such as Tukey's Honestly Significant Difference (HSD) test, were conducted to identify specific treatment differences.

Interpretation of Results

The data obtained from soil and crop measurements were analyzed and interpreted to evaluate the effects of organic farming practices on soil health and agricultural productivity. The findings were discussed in relation to the existing scientific literature and theories on organic farming. The implications of the results for sustainable agriculture and potential strategies for further improvement were considered.

Limitations

By following this methodology, the study aimed to provide empirical evidence on the potential of organic farming practices for sustainable agriculture and soil health improvement. The data collected and analyzed contributed to the scientific understanding of organic farming systems and informed recommendations for farmers, and stakeholders interested in promoting sustainable agricultural practices.

RESULTS

The results of the experiment examining the effects of different agricultural practices on various soil parameters revealed the specific soil parameter in different treatment groups: control group, compost application, cover cropping, and crop rotation. The pH levels in the control group, compost application, cover cropping, and crop rotation were 6.9, 7.2, 7.2, and 7.3 respectively. The control group had an organic matter content of 2.5%, while the compost application, cover cropping, and crop rotation resulted in organic matter contents of 3.3%, 3.7%, and 3.2% respectively ($p<0.05$). The control group had a nitrogen content of 22.1 mg/Kg, while the compost application, cover cropping, and crop rotation resulted in nitrogen contents of 24.8 mg/Kg, 26.2 mg/Kg, and 25.3 mg/Kg respectively ($p<0.05$). The control group had a phosphorus content of 13.4 mg/Kg, while the compost application, cover cropping, and crop rotation resulted in phosphorus contents of 15.2 mg/Kg, 15.6 mg/Kg, and 14.7 mg/Kg respectively. The control group had a potassium content of 120 mg/Kg, while the compost application, cover cropping, and crop rotation resulted in potassium contents of 143 mg/Kg, 142 mg/Kg, and 145 mg/Kg respectively (Table 1).

The results of the experiment indicate that the agricultural practices being evaluated had a significant impact on crop yield for all three crops: wheat, corn, and soybean. In each case, the treatment groups, which included compost application, cover cropping, and crop rotation, consistently outperformed the control group in terms of crop yield. For wheat, the control group had a yield of 2300 Kg/ha, while the compost application, cover cropping, and crop rotation treatments resulted in yields of 2550 Kg/ha, 2400 Kg/ha, and 2600 Kg/ha, respectively ($p<0.05$). Similarly, for corn, the control group had a yield of 8800 Kg/ha, while the compost application, cover cropping, and crop rotation treatments resulted in yields of 10500 Kg/ha, 10000 Kg/ha, and 9900 Kg/ha, respectively ($p<0.05$). For soybean, the control group had a yield of 1100 Kg/ha, while the compost application, cover cropping, and crop rotation treatments resulted in yields of 1300 Kg/ha, 1250 Kg/ha, and 1250 Kg/ha, respectively ($p<0.05$). These findings highlight the effectiveness of these agricultural practices in enhancing productivity and emphasizing their potential value for farmers and agricultural systems (Table 2).

In the case of foxtail, the control group had a weed density of 21 plants/m2, whereas the treatment groups that received compost application, cover cropping, and crop rotation showed reduced densities of 14 plants/m2, 16 plants/m2, and 15 plants/m2 respectively ($p<0.05$). For chickweed, the control group had a density of 14 plants/m2, while the treatment groups that received compost application, cover cropping, and crop rotation exhibited reduced densities of 11 plants/m2, 10 plants/m2, and 9 plants/m2 respectively. Regarding lambsquarters, the control group had a density of 10 plants/m2, whereas the treatment groups that received compost application, cover cropping, and crop rotation showed decreased densities of 6 plants/m2, 8 plants/m2, and 5 plants/m2 respectively ($p<0.05$). In summary, the results highlight that the implementation of compost application, cover cropping, and crop rotation can significantly reduce the density of foxtail, chickweed, and lambsquarters (Table 3).

Table 1: Comparison of soil parameters for organic and conventional farming

Soil parameter	Control group	Compost application	Cover cropping	Crop rotation	p-value
pH	6.9	7.2	7.2	7.3	0.1299
Organic matter	2.5%	3.3%	3.7%	3.2%	**0.00001***
Nitrogen content	22.1 mg/Kg	24.8 mg/Kg	26.2 mg/Kg	25.3 mg/Kg	**0.04611***
Phosphorus content	13.4 mg/Kg	15.2 mg/Kg	15.6 mg/Kg	14.7 mg/Kg	**0.05617***
Potassium content	120 mg/Kg	143 mg/Kg	142 mg/Kg	145 mg/Kg	0.6677

***indicated the significant value at p<0.05**

Table 2: Comparison of organic farming practices and crop yield

Crop	Control group (Kg/ha)	Compost application (Kg/ha)	Cover cropping (Kg/ha)	Crop rotation (Kg/ha)	p-value
Wheat	2300	2550	2400	2600	**0.0001***
Corn	8800	10500	10000	9900	**0.0001***
Soyabean	1100	1300	1250	1250	**0.0001***

***indicated the significant value at p<0.05**

Table 3: Comparison of weed species growth rate in the crops

Weed species	Control group (Plants/m^2)	Compost application (Plants/m^2)	Cover cropping (Plants/m^2)	Crop rotation (Plants/m^2)	p-value
Foxtail	21	14	16	15	**0.00015***
Chickweed	14	11	10	09	**0.00527***
Lambsquarters	10	06	08	05	**0.00001***

***indicated the significant value at p<0.05**

DISCUSSION

The results of the study investigating the potential of organic farming practices for sustainable agriculture and soil health improvement provide valuable insights into the effects of different agricultural practices on soil parameters, crop yield, and weed density.

In terms of soil parameters, the application of organic farming practices such as compost application, cover cropping, and crop rotation led to significant improvements in key soil characteristics. The pH levels increased slightly in the treatment groups compared to the control group, indicating a more favorable soil pH for crop growth [16]. Additionally, the organic matter content, which is crucial for soil fertility and moisture retention, showed significant increases in the treatment groups. This suggests that organic practices contribute to the accumulation of organic matter in the soil, enhancing its overall health and productivity [17].

The study also revealed positive effects on nutrient levels in the soil. The treatment groups demonstrated higher nitrogen content compared to the control group, indicating improved nutrient availability for plant uptake. Similarly, the phosphorus content showed slight increases in the treatment groups, suggesting enhanced phosphorus availability, which is essential for plant growth and development [18-19]. However, the differences were not statistically significant. The potassium content did not show significant variations among the different treatments, indicating that organic practices may have a limited impact on soil potassium levels [20].

The findings regarding crop yield demonstrated the effectiveness of organic farming practices in enhancing productivity. The treatment groups consistently outperformed the control group in terms of crop yield for all three crops: wheat, corn, and soybean. Compost application, cover cropping, and crop rotation led to statistically significant increases in crop yield, highlighting their potential value in sustainable agriculture. These practices likely improved soil fertility, nutrient availability, and water-holding capacity, leading to better crop growth and higher yields [21].

Furthermore, the study investigated the effects of organic farming practices on weed density. The results indicated that the implementation of compost application, cover cropping, and crop rotation significantly reduced the density of weed species such as foxtail, chickweed, and lambsquarters. This suggests that these organic practices can contribute to effective weed management, potentially reducing the competition between weeds and crops and minimizing the need for synthetic herbicides [22].

The findings of this study align with existing scientific literature on the benefits of organic farming practices for soil health and sustainable agriculture. Organic farming practices, such as compost application, cover cropping, and crop rotation, promote soil fertility, enhance nutrient cycling, improve soil structure, and contribute to the overall sustainability of agricultural systems. The results emphasize the importance of adopting these practices for farmers and stakeholders interested in sustainable agricultural production [1].

However, it is important to acknowledge the limitations of the study. The study focused on a specific region and may not be directly applicable to other geographic areas with different soil types, climates, and farming systems. The duration of the study, although at least five years, may not capture long-term changes in soil health and crop performance. Additionally, the study did not assess the economic aspects of organic farming practices, such as the cost-effectiveness and profitability of implementing these practices on a larger scale [23].

CONCLUSION

This study provided empirical evidence supporting the potential of organic farming practices for sustainable agriculture and soil health improvement. The results highlighted the positive impacts of compost application, cover cropping, and crop rotation on soil parameters, crop yield, and weed density. These findings contributed to the scientific understanding of organic farming systems and offer practical recommendations for farmers and stakeholders interested in promoting sustainable agricultural practices. Further research is warranted to explore the long-term effects and economic viability of implementing organic farming practices on a broader scale.

CONFLICT OF INTEREST

None.

REFERENCES

Tahat MM, Alananbeh KA, Othman YI, Leskovar D. Soil Health and Sustainable Agriculture. Sustainability. 2020;12(12):4859.

Cárceles Rodríguez B, Durán-Zuazo VH, Soriano Rodríguez M, García- Tejero IF, Gálvez Ruiz B, Cuadros Tavira S. Conservation Agriculture as a Sustainable System for Soil Health: A Review. Soil Systems. 2022; 6(4):87.

Tuomisto HL, Scheelbeek PFD, Chalabi Z, Green R, Smith RD, Haines A, Dangour AD. Effects of environmental change on population nutrition and health: A comprehensive framework with a focus on fruits and vegetables. Wellcome Open Res. 2017 Mar 28;2:21.

Benbrook C, Kegley S, Baker B. Organic Farming Lessens Reliance on Pesticides and Promotes Public Health by Lowering Dietary Risks. *Agronomy*. 2021; 11(7):1266.

Durán-Lara EF, Valderrama A, Marican

Natural Organic Compounds for Application in Organic Farming. *Agriculture*. 2020; 10(2):41.

Gamage A, Gangahagedara R, Gamage J, Jayasinghe N, Kodikara N, Suraweera P, Merah O. Role of organic farming for achieving sustainability in agriculture. Farming System. 2023’1(1):100005.

Urra J, Alkorta I, Garbisu C. Potential Benefits and Risks for Soil Health Derived From the Use of Organic Amendments in Agriculture. Agronomy. 2019; 9(9):542.

Durrer A, Gumiere T, Rumenos Guidetti Zagatto M, Petry Feiler H, Miranda Silva AM, Henriques Longaresi R, Homma SK, Cardoso EJBN. Organic farming practices change the soil bacteria community, improving soil quality and maize crop yields. Peer J. 2021 Sep 23;9:e11985.

Tudi M, Daniel Ruan H, Wang L, Lyu J, Sadler R, Connell D, Chu C, Phung DT. Agriculture Development, Pesticide Application and Its Impact on the Environment. Int J Environ Res Public Health. 2021 Jan 27;18(3):1112.

Aktar MW, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. Interdiscip Toxicol. 2009 Mar;2(1):1-12.

Sánchez MA, Campos H. Coexistence of genetically modified seed production and organic farming in Chile. GM Crops Food. 2021 Jan 2;12(1):509-519.

Wijerathna-Yapa A, Pathirana R. Sustainable Agro-Food Systems for Addressing Climate Change and Food Security. Agriculture. 2022;12(10):1554.

Karipidis P, Karypidou S. Factors that Impact Farmers' Organic Conversion Decisions. Sustainability. 2021;13(9):4715.

Han G, Grudens-Schuck N. Motivations and Challenges for Adoption of Organic Grain Production: A Qualitative Study of Iowa Organic Farmers. Foods. 2022 Nov 4;11(21):3512. Górska-Warsewicz H, Żakowska- Biemans S, Stangierska D, Świątkowska M, Bobola A, Szlachciuk J, Czeczotko M, Krajewski K, Świstak E. Factors Limiting the Development of the Organic Food Sector—Perspective of Processors, Distributors, and Retailers. Agriculture. 2021; 11(9):882.

González-Rosado M, Parras-Alcántara L, Aguilera-Huertas J, Lozano-García B. Crop Diversification Effects on Soil Aggregation and Aggregate-Associated Carbon and Nitrogen in Short-Term Rainfed Olive Groves under Semiarid Mediterranean Conditions. Horticulturae. 2022; 8(7):618.

Gerke J. The Central Role of Soil Organic Matter in Soil Fertility and Carbon Storage. *Soil Systems*. 2022; 6(2):33.

Li C, Zhao C, Zhao X, Wang Y, Lv X, Zhu X, Song X. Beneficial Effects of Biochar Application with Nitrogen Fertilizer on Soil Nitrogen Retention, Absorption and Utilization in Maize Production. Agronomy. 2023; 13(1):113.

Wang T, Cheng K, Huo X, Meng P, Cai Z, Wang Z, Zhou J. Bioorganic fertilizer promotes pakchoi growth and shapes the soil microbial structure. Front Plant Sci. 2022 Nov 8;13:1040437.

Xinxiang X, Xin D, Fen W, Jianchuan S, et al. Effects of Potassium Levels on Plant Growth, Accumulation and Distribution of Carbon, and Nitrate Metabolism in Apple Dwarf Rootstock Seedlings. Frontiers in Plant Science. 2020;11:00904.Khangura R, Ferris D, Wagg C, Bowyer

J. Regenerative Agriculture—A Literature Review on the Practices and Mechanisms Used to Improve Soil Health. Sustainability. 2023; 15(3):2338.

Brozović B, Jug I, Jug D, Stipešević B, Ravlić M, Đurđević B. Biochar and Fertilization Effects on Weed Incidence in Winter Wheat. Agronomy. 2021; 11(10):2028.

Skendžić S, Zovko M, Živković IP, Lešić V, Lemić D. The Impact of Climate Change on Agricultural Insect Pests. Insects. 2021 May 12;12(5):440.