VIDYA - A JOURNAL OF GUJARAT UNIVERSITY

Peer-Reviewed, Multidisciplinary & Multilingual Journal

ISSN: 2321-1520 **E-ISSN:** 2583-3537

COMPRESSION OF SOIL FERTILITY BETWEEN ORGANIC AND CHEMICAL FARMING

Sunita Chauhan[1], Merodi Charles Sanga[1], Dr. Hitesh Solanki[1], Dr. Linz-Buoy George[2]

1- Department of Environmental Science, School of Sciences, Gujarat University, Ahmedabad, Gujarat 380009, India

2-Department of Zoology, School of Sciences, Gujarat University, Ahmedabad, Gujarat 380009, India

Abstract

Context This comparative study investigates soil nutrient retention in organic versus chemical farming systems. As agricultural practices evolve to meet growing food demands, understanding impacts on soil health becomes increasingly crucial. Aims This study aims to elucidate how different farming practices influence soil nutrient dynamics which are essential for sustainable crop production and environmental conservation. Methods The study investigates the impact of organic and chemical farming practices on soil parameters including pH, electrical conductivity (EC), moisture content, the availability of macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (Su) and micronutrients such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and chlorine (Cl). Key results Data from experimental fields subjected to organic and chemical treatments were analyzed to determine differences in nutrient retention and overall soil health. Findings indicate that organic farming significantly enhances soil organic matter and microbial activity, improving nutrient retention and cycling. The organic plots exhibited higher levels for many soil parameters and nutrients, which is attributed to the slow-release nature of organic inputs. Chemical soils often exhibit lower levels of essential nutrients and micronutrients, and their reliance on synthetic inputs may result in adverse environmental impacts such as nutrient runoff and soil pollution. Conclusion These findings underscore the importance of organic farming practices in improving soil nutrient retention and fostering sustainable agriculture.

Keywords*: Soil Parameter, Agriculture, chemical soil, organic soil*

INTRODUCTION

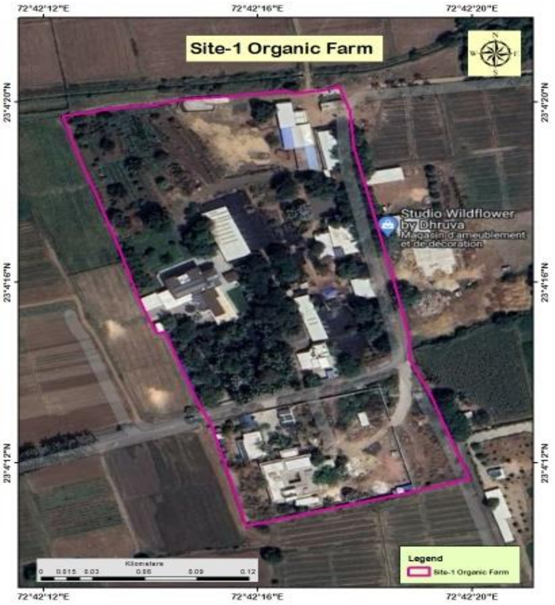
Agriculture plays a pivotal role in global food security and maintaining soil health is essential for productive and sustainable farming (Kassam et al., 2013). One of the critical factors influencing soil health is its capacity to retain vital nutrients such as nitrogen (N), phosphorus (P), and potassium (K) (Costantini et al., 2022). Effective nutrient retention ensures that plants receive a consistent supply of necessary elements for growth while minimizing environmental impacts, such as water pollution from nutrient runoff (Mueller et al., 2012). Soil health and fertility are fundamental to sustainable agriculture, directly impacting crop yield, quality, and the long-term viability of farming systems (Pingali et al., 2005). In this context, nutrient availability in the soil is a critical factor. Contemporary agriculture is dominated by two primary farming systems: organic and chemical (or conventional) farming (Acs et al., 2007). Each system employs distinct practices influencing soil nutrient availability, plant health, and productivity. This research aims to provide a comprehensive overview of soil nutrient dynamics in organic versus chemical farming systems, emphasizing a comparative analysis of their effects on soil parameters and nutrient availability.

Organic farming aims to maintain and improve soil fertility using natural inputs and processes (Azarbad et al., 2022). Leading practices include organic amendments like manure, compost, green manures, crop rotation, cover cropping, reduced tillage, and avoiding synthetic fertilizers and pesticides (Behera et al., 2012). On the other hand, chemical farming relies on artificial fertilizers and pesticides for high productivity (Gomiero et al., 2011). This system emphasizes the immediate availability of nutrients by applying specific amounts of N, P, K, and other soluble nutrients for plant uptake (Sumberg et al., 2022). While these inputs lead to rapid crop growth and high yields, concerns exist about their long-term effects on soil health, including potential nutrient imbalances, soil acidification, and the reduction of beneficial soil microorganisms (De Ponti et al., 2012).

VIDYA - A JOURNAL OF GUJARAT UNIVERSITY

Peer-Reviewed, Multidisciplinary & Multilingual Journal

ISSN: 2321-1520 **E-ISSN:** 2583-3537



Soil parameters are essential characteristics used to describe the properties and behavior of soil in various applications, such as agriculture, construction, and environmental studies. These parameters can be classified into physical, chemical, and biological categories (Varella et al., 2012). In the present study, we use organic and chemical farming soil. In this pH, EC, Organic Matter, N, TDS, TS, Ca, Mg, N, P, K, Micronutrient (Zn, Cu, S, Mn, Fe).

MATERIALS AND METHODOLOGY

This study utilizes a comparative analysis approach to examine soil nutrient retention in organic and chemical farming systems.

Study Area:

The research work study areas are Ahmedabad and Gandhinagar. The first set of samples came from Sadar Patel Organic Farm, located on Kathwada Road in Ahmedabad. Here, soil was collected from portions where various crops grow, including rice plants and mango trees. The second set of samples originated from a chemical farm in Shahpur village, situated in Gift City, Gandhinagar. In this farm, soil samples were taken from areas where different crops thrive, including cucumber plants and two samples from okra plants.

Soil sampling:

Soil samples were collected from each site at three different plot parts with a spade about 15 cm (6 inches) depth and 2.5 cm (1 inch) width. Soil samples were collected in different zipper bags with the labeling of date, soil type, and temperature. Soil samples were air-dried, sieved through a 2 mm mesh, and stored at room temperature for subsequent analyses. We performed soil parameters like soil moisture content, soil pH, soil salinity (EC), total solids, Total dissolved Solid (TDS) Calcium and magnesium (Ca & Mg), Nitrogen, Phosphorus, Potassium, and micronutrients (Zn, Cu, Fe, Mn, S).

All the parameters were analyzed by soil and plant analysis (Vadivel & Shivanna, 2020).

All data in this study was the mean value (±SD) of three independent replicates using Microsoft Excel. For Statistical procedures, datasets were prepared with independent variables for the agricultural field based on that, descriptive statistics and t-tests were calculated. Bar graph Charts were drawn using GraphPad Prism (Version 9.4.0) software for statistical analysis.

Chemical:

All the organic and inorganic chemicals purchased by SRL, India.

RESULT AND DISCUSSION

Soil analysis was performed, and data was gathered for the statistical analysis which is shown below **Table-1**, it shows the statistical data of the chemical farm and organic farm in the Ahmedabad district with mean value and standard deviation.

	Organic Soil			Chemical Soil		
Parameter/Sample	S1	S2	S3	C1	C2	C3

Moisture content	15.49±0.09	13±0.06	00.25±0.01	4.83±0.03	11.69±1	9.66±1
Ph	8.4±0.09	7.10±0.18	8.24±0.06	8.39±0.02	8.85±0.01	8.16±0.01
EC (mS/cm)	0.17±0.01	0.24±0.01	0.25±0.01	0.35±0.02	0.36±0.01	0.75±0.01
TS (mg/l)	0.08±0.01	0.024±0.01	0.043±0.01	0.06±0.001	0.47±0.003	0.07±0.003
TDS (mg/l)	0.023±0.005	0.012±0.002	0.011±0.002	0.043±0.003	0.036±0.002	0.055±0.003
Ca (ppm)	0.53±0.06	0.67±0.06	0.6±0.1	0.057±0.58	0.467±0.58	0.7±0.17
Mg (ppm)	0.7±0.08	0.63±0.06	0.5±0.1	1.1±0.1	0.9±0.26	0.73±0.21
Cl (mg/kg)	0.33±0.06	0.23±0.06	0.3±0.1	0.4±0.26	0.23±0.06	0.3±0.1
N (%)	2.18±0.21	1.95±0.2	1.53±0.03	1.483±0.04	0.76±0.265	0.5±0.04
P (mg/kg)	12±0.31	8±1	9±0.3	9±0.17	8.33±0.58	10±0.2
K (mg/kg)	20±0.21	50±0.21	40±0.3	20±1.73	39.97±1.36	35±0.36
Zn (mg/kg)	1.18±0.03	3.08±0.05	0.98±0.02	0.56±0.02	1.28±0.017	1.54±0.03
Fe (mg/kg)	2.28±0.02	26.7±0.1	2.18±0.01	1.82±0.04	1.46±0.03	8.1±0.26
Mn (mg/kg)	7.8±0.1	2.1±0.2	0.58±0.01	0.86±0.03	0.8±0.04	0.92±0.03
Cu (mg/kg)	1±0.17	2±0.04	1.84±0.02	0.66±0.03	0.72±0.02	1.04±0.05
Su (mg/kg)	8.9±0.1	11.6±0.1	7.6±0.1	10.2±0.36	10±0.26	8.8±0.46
OM (%)	3.74±0.08	3.354±0.2	2.6316±0.05	2.5456±0.05	1.3072±0.07	0.86±0.04

Table 1: Table of results for soil parameters analysis showing the mean values and Standard Deviation.

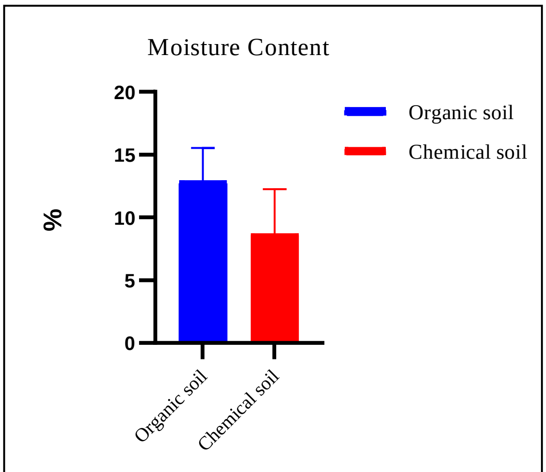


Fig.1 comparission of Moisture content between organic and chemical soil

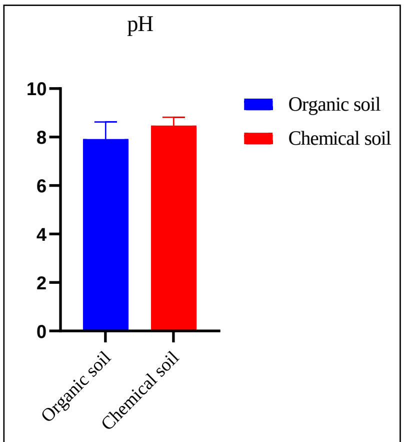


Fig. 2 comparrison of pH between organic and chemical soil

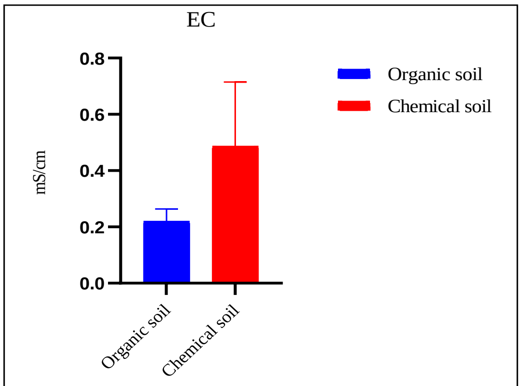


Fig.3 comparission of EC between organic and chemical soil

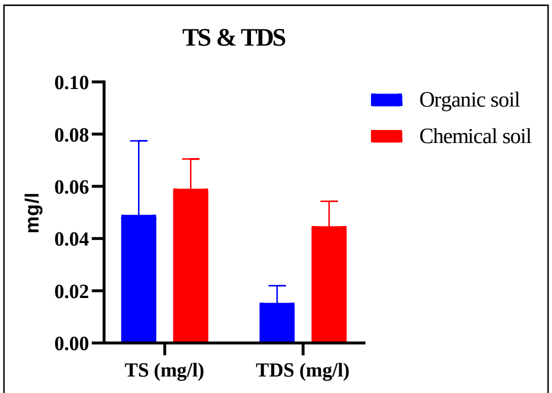


Fig.4 comparission of TS & TDS between organic and chemical soil

Moisture content:
In this study, organic farming plots maintained a higher moisture content compared to chemical farming plots. Specifically, the moisture content is 12% in organic soil samples and 8.7% is observed in chemical soil samples. Additionally, the soil texture in organic plots often silty clay loam or clayish—facilitates water retention, allowing fine soil particles to bind water for longer periods. In contrast, chemical farming practices occur in soil plots with different characteristics.

VIDYA - A JOURNAL OF GUJARAT UNIVERSITY
Peer-Reviewed, Multidisciplinary & Multilingual Journal
ISSN: 2321-1520 E-ISSN: 2583-3537

Soil pH

In the study, organic farming plots exhibited a higher average pH (7.9) equated to chemical farming plots (8.5). This difference suggests a neutralizing effect of organic amendments. Notably, the pH of organic farming soil was slightly more acidic than that of chemical farming soil. Over time, the application of organic amendments—such as compost and manure—can lead to soil acidification, while chemical fertilizers (particularly those containing lime) tend to neutralize soil pH.

Electrical conductivity (EC)

The EC of organic soil is approximately 0.2 mS/cm. This lower EC value indicates a moderate level of soluble salts in the soil, suggesting that organic farming practices result in less accumulation of soluble salts. The EC of chemical soil is significantly higher, reaching nearly 0.6 mS/cm. This elevated EC value suggests a higher concentration of soluble salts, typical for soils subjected to synthetic fertilizers and amendments. The higher EC in chemical soil indicates a greater accumulation of soluble salts. This can be attributed to the frequent use of synthetic fertilizers, which provide nutrients in readily soluble forms. This can enhance root growth and overall plant health.

Total solids

In this study, organic soil samples consistently displayed lower total solids (TS) than chemical soil samples. These lower TS and TDS concentrations in organic soil indicate a reduced risk of soil salinity. Conversely, the higher TS and TDS values in chemical soil samples suggest a greater concentration of both total and dissolved solids, including excess nutrients and salts from synthetic fertilizers and chemical inputs.

Hardness (Ca & Mg)

In this study, organic soil samples displayed higher calcium concentrations, averaging around 0.6 mg/kg, compared to chemical soil samples with an average of 0.41 mg/kg. These elevated calcium levels in organic soils suggest improved soil fertility, enhanced soil structure, and greater nutrient availability for plant growth. Notably, the mean available magnesium content was higher in chemical farming soil (0.91 ppm) than in organic farming soil (0.61 ppm), highlighting the impact of distinct farming practices.

Macronutrients (N, P, K)

Organic farming showed a significantly higher total nitrogen content (1.8%) than chemical farming (0.9%). This increase in nitrogen levels in organic soil is attributed to the regular addition of compost and manure, which decompose slowly, gradually releasing nitrogen. The higher nitrogen content in organic soils is particularly beneficial for long-term soil fertility, as organic nitrogen sources provide a sustained nitrogen supply.

However, phosphorus availability was significantly greater in chemical plots (9.67 mg/kg) than in organic plots (9.11 mg/kg). Chemical fertilizers provide readily available phosphorus, whereas organic amendments release phosphorus more slowly. Similar trends were observed for potassium, with chemical farming soil having higher available potassium (36.67 mg/kg) compared to organic soil (31.66 mg/kg). The quick-release nature of chemical potassium fertilizers contrasts with the gradual release from organic sources. The lower availability of phosphorus and potassium in organic farming is attributed to the slow-release nature of organic amendments. While this can limit immediate nutrient availability, it can also prevent nutrient leaching and ensure a steady nutrient supply over time.

Organic Matter

The bar graph illustrates the comparison of organic matter content between organic and chemical soils. The blue bars represent organic soil, while the red bars represent chemical soil. The organic matter content is measured as a percentage. The organic matter content in organic soil is approximately 4%, indicating a high level of organic material present. This is a significant indicator of soil health and fertility. The organic matter content in chemical soil is around 2%, which is considerably lower than in organic soil. This suggests a reduced presence of organic material in chemically managed soils.

VIDYA - A JOURNAL OF GUJARAT UNIVERSITY
Peer-Reviewed, Multidisciplinary & Multilingual Journal
ISSN: 2321-1520 **E-ISSN:** 2583-3537

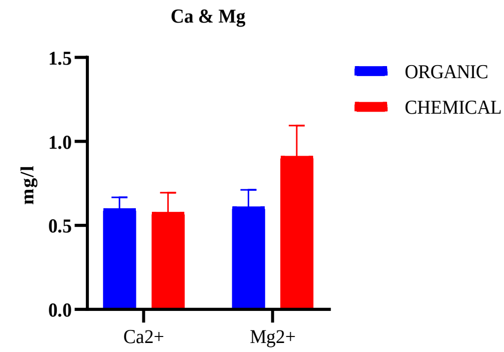


Fig.5 comparission of Hardness between organic and chemical soil

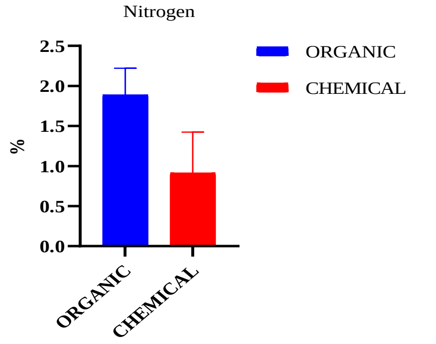


Fig.6 comparission of Hardness between organic and chemical soil

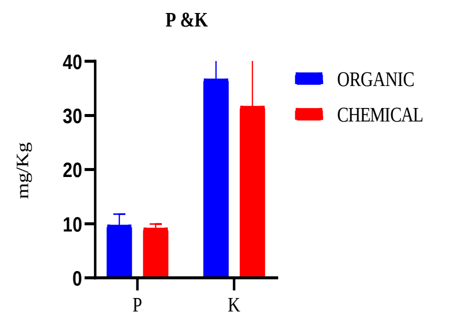


Fig.7 comparission of Phosphorus and potassium between organic and chemical soil

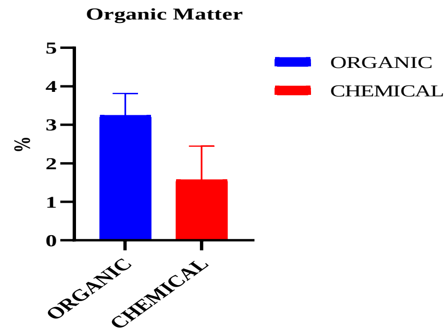


Fig.8 comparission of Organic matter between organic and chemical soil

Micronutrients (Zn, Cu, Fe, Mn)

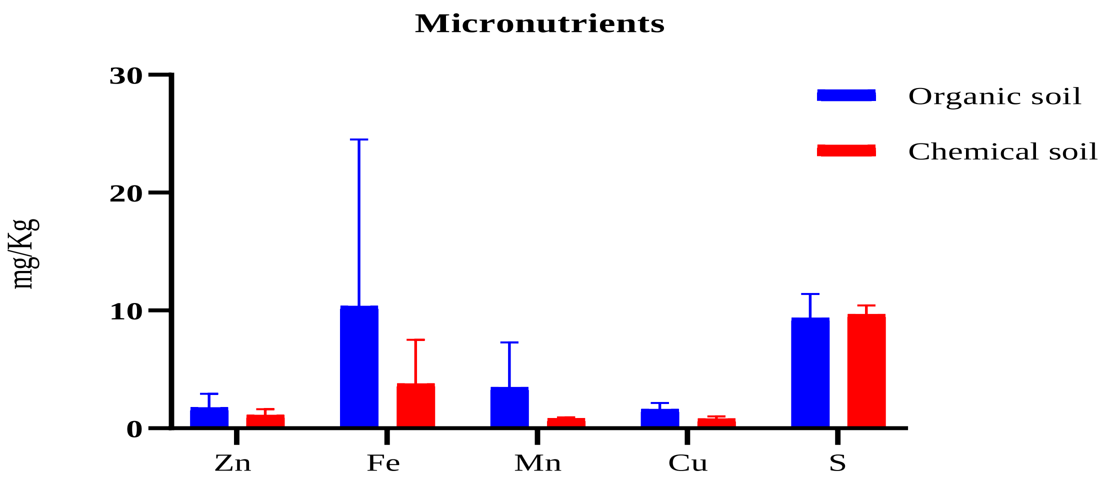


Fig.9 comparission of micronutrients between organic and chemical soil

The comparison of heavy metal concentrations in organic and chemical soils, as illustrated by the bar graph, reveals notable differences influenced by farming practices. Zinc (Zn) levels are slightly higher in chemical soil due to the application of zinc-containing fertilizers, suggesting enhanced immediate availability, whereas organic soil shows marginally lower zinc availability. Iron (Fe) content follows a similar pattern, with higher concentrations in chemical soil, implying that synthetic inputs significantly contribute to iron availability. Conversely, manganese (Mn) levels are elevated in organic soil, likely due to the beneficial effects of organic amendments that enhance manganese availability, whereas chemical soil exhibits lower manganese concentrations, indicating lesser influence from synthetic fertilizers. Copper (Cu) content is slightly higher in organic soil, attributed to the slow nutrient release from organic amendments, contrasting with the lower levels in chemical soil, where synthetic fertilizers have a reduced impact on copper availability. Sulfur (S) concentrations are notably high in both soil types, reflecting the effectiveness of both farming systems in supplying this essential nutrient. The findings indicate that while organic farming promotes a gradual and sustained release of certain heavy metals, enhancing soil health over time, chemical farming ensures the immediate availability of essential nutrients like zinc and iron, facilitating quick nutrient uptake by plants. This duality underscores the potential complementary benefits of both farming practices in maintaining soil health and fertility.

CONCLUSION

This study highlights the contrasting impacts of organic and chemical farming on soil health and sustainability. Organic farming practices, with their focus on increasing organic matter content and crop nutrients, contribute to long-term soil health and ecosystem sustainability. In contrast, chemical farming, while providing immediate nutrient availability, poses risks of soil salinity, degradation, and pollution. The integration of organic principles into conventional farming systems could help mitigate these negative impacts, promoting a more balanced and sustainable agricultural approach. A more comprehensive assessment of the ecological effects of both systems is essential, including considerations of nutrient runoff and habitat impact. Comparing the costs and benefits of organic and chemical farming can guide the adoption of sustainable practices. Additionally, understanding the effects of different farming methods on communities and livelihoods is crucial. Through the exploration of innovative technologies can enhance soil health and nutrient retention, ultimately supporting sustainable agriculture and environmental stewardship.

ACKNOWLEDGEMENT

Sunita Chauhan thanks the Department of Environment Science, Gujarat University, Ahmedabad, India, for the lab facility for research work. The authors also thank to Gujarat State Fertilizer Company (GSFC) Baroda, Gujarat, India for Heavy metal Analysis.

REFERENCES

1. Abdollahi, F., & Ghadiri, H. (2004). Effect of separate and combined applications of herbicides on weed control and yield of sugar beet. *Weed Technology*, *18*(4), 968-976.
2. Acs, S., Berentsen, P. B. M., & Huirne, R. B. M. (2007). Conversion to organic arable farming in The Netherlands: A dynamic linear programming analysis. *Agricultural Systems*, *94*(2), 405-415.
3. Alejandro, Santiago, Stefanie Höller, Bastian Meier, and Edgar Peiter. 2020. "Manganese in Plants: From Acquisition to Subcellular Allocation." *Frontiers in Plant Science* 11:300. doi: 10.3389/fpls.2020.00300.
4. Alloway, B. J. (Ed.). (2012). Heavy metals in soils: trace metals and metalloids in soils and their bioavailability (Vol. 22). Springer Science & Business Media.
5. Aulakh, C. S., and N. Ravisankar. 2017. "Organic Farming in Indian Context: A Perspective." *Agricultural Research Journal* 54(2):149. doi: 10.5958/2395-146X.2017.00031. X.
6. Azarbad, Hamed. 2022. "Conventional vs. Organic Agriculture–Which One Promotes Better Yields and Microbial Resilience in Rapidly Changing Climates?" *Frontiers in Microbiology* 13:903500. doi: 10.3389/fmicb.2022.903500.
7. Bashir, Owais, Shabir Ahmad Bangroo, Nasir Bashir Naikoo, Aamir Hassan Mir, Sandeep Kumar, Rehana Rasool, Hafsa Abdullah, Lareb Mir, and Omer Reshi. 2022. "Determination of Horizon, Its Boundary and Depth in the Soil Profiles of North Western Himalayas." *International Journal of Plant & Soil Science* 1123–34. doi: 10.9734/ijpss/2022/v34i232525.
8. Behera, Kambaska Kumar, Afroz Alam, Sharad Vats, Hunuman Pd. Sharma, and Vinay Sharma. 2012. "Organic Farming History and Techniques." Pp. 287–328 in *Agroecology and Strategies for Climate Change*, edited by E. Lichtfouse. Dordrecht: Springer Netherlands.
9. Bonn, Frick. 2019. *The World of Organic Agriculture: Statistics & Emerging Trends 2019*. edited by Forschungsinstitut für biologischen Landbau. Frick Bonn: FiBL IFOMA-Organics International.
10. Costantini, Edoardo A. C., and Stefano Mocali. 2022. "Soil Health, Soil Genetic Horizons and Biodiversity [#]." *Journal of Plant Nutrition and Soil Science* 185(1):24–34. doi: 10.1002/jpln.202100437.
11. De Ponti, Tomek, Bert Rijk, and Martin K. Van Ittersum. 2012. "The Crop Yield Gap between Organic and Conventional Agriculture." *Agricultural Systems* 108:1–9. doi: 10.1016/j.agsy.2011.12.004.
12. Federal Agricultural Marketing Authority (FAMA), Malaysia, and Abd Razzif Abd Razak. 2023. "A Perspective of Food Security, Marketing and the Role of the Government." *Journal of Agribusiness Marketing* 11(2):60–80. doi: 10.56527/jabm.11.2.5.
13. Gabriel, Doreen, Steven M. Sait, William E. Kunin, and Tim G. Benton. 2013. "Food Production vs. Biodiversity: Comparing Organic and Conventional Agriculture" edited by I. Steffan-Dewenter. *Journal of Applied Ecology* 50(2):355–64. doi: 10.1111/1365-2664.12035.

14. Gomiero, Tiziano, David Pimentel, and Maurizio G. Paoletti. 2011. "Environmental Impact of Different Agricultural Management Practices: Conventional vs. Organic Agriculture." *Critical Reviews in Plant Sciences* 30(1–2):95–124. doi: 10.1080/07352689.2011.554355.
15. Graham, Robert C. 2006. "Factors of Soil Formation: Topography." Pp. 151–64 in *Soils: Basic Concepts and Future Challenges*, edited by G. Certini. Cambridge University Press.
16. Karipidis, Philippos, and Sotiria Karypidou. 2021. "Factors That Impact Farmers' Organic Conversion Decisions." *Sustainability* 13(9):4715. doi: 10.3390/su13094715.
17. Kassam, Amir, and Hugh Brammer. 2013. "Combining Sustainable Agricultural Production with Economic and Environmental Benefits." *The Geographical Journal* 179(1):11–18. doi: 10.1111/j.1475-4959.2012.00465.x.
18. Kumar, Suresh, Santosh Kumar, and Trilochan Mohapatra. 2021. "Interaction Between Macro- and Micro-Nutrients in Plants." *Frontiers in Plant Science* 12:665583. doi: 10.3389/fpls.2021.665583.
19. Leiva Soto, Andrea, Steve W. Culman, Catherine Herms, Christine Sprunger, and Douglas Doohan. 2023. "Managing Soil Acidity vs. Soil Ca: Mg Ratio: What Is More Important for Crop Productivity?" *Crop, Forage & Turfgrass Management* 9(1):e20210. doi: 10.1002/cft2.20210.
20. Łuczka, Władysława, and Sławomir Kalinowski. 2020. "Barriers to the Development of Organic Farming: A Polish Case Study." *Agriculture* 10(11):536. doi: 10.3390/agriculture10110536.
21. Mátyás, Bence, Maritza Elizabeth Chiluisa Andrade, Nora Carmen Yandun Chida, Carina Maribel Taipe Velasco, Denisse Estefania Gavilanes Morales, Gisella Nicole Miño Montero, Lenin Javier Ramirez Cando, and Ronnie Xavier Lizano Acevedo. 2018. "Comparing Organic versus Conventional Soil Management on Soil Respiration." *F1000Research* 7:258. doi: 10.12688/f1000research.13852.1.
22. Mueller, Nathaniel D., James S. Gerber, Matt Johnston, Deepak K. Ray, Navin Ramankutty, and Jonathan A. Foley. 2012. "Closing Yield Gaps through Nutrient and Water Management." *Nature* 490(7419):254–57. doi 10.1038/nature11420.
23. Pandalai, S. G. 2007. *Recent Research Developments in Soil Science: Vol. 2*. Trivandrum: Research Signpost.
24. Panneerselvam, P., John Erik Hermansen, and Niels Halberg. 2010. "Food Security of Small Holding Farmers: Comparing Organic and Conventional Systems in India." *Journal of Sustainable Agriculture* 35(1):48–68. doi: 10.1080/10440046.2011.530506.
25. Patel, Prakash L., Nirmal P. Patel, Prakash H. Patel, and Anita Gharekhan. 2014. "Correlation Study of Soil Parameters of Kutch District Agriculture Land." 4(5).
26. Pingali, Prabhu, Luca Alinovi, and Jacky Sutton. 2005. "Food Security in Complex Emergencies: Enhancing Food System Resilience." *Disasters* 29(s1). doi: 10.1111/j.0361-3666.2005.00282.x.
27. Sucheta, Karande, Gamit Sheela, and Prajapati Dhaval. 2020. "Analysis of Soil Samples for Its Physical and Chemical Parameters from Mehsana and Patan District."
28. Sumberg, James, and Ken E. Giller. 2022. "What Is 'Conventional' Agriculture?" *Global Food Security* 32:100617. doi: 10.1016/j.gfs.2022.100617.Vaghela, I. D., J. K. Patel, J. K. Malav, J. P. Chaudhary, and R. P. Pavaya. 2018. "Status of Available Sulphur and Micronutrients in Soils of Patan District of Gujarat." *Journal of Pharmacognosy and Phytochemistry* 7(5):2256–61.
29. Varella, Hubert, Samuel Buis, Marie Launay, and Martine Guérif. 2012. "Global Sensitivity Analysis for Choosing the Main Soil Parameters of a Crop Model to Be Determined." *Agricultural Sciences* 03(07):949–61. doi: 10.4236/as.2012.37116.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Declaration of funding

This research did not receive any specific funding