Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

Natural Farming, Soil Health, and Microbial Communities: A Comprehensive Perspective

Rohitashv Nagar[1], Shivendra Singh[2], Dr. Gunnjeet Kaur[3]

[1,2] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

[3]Associate Dean, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Abstract

Natural farming has emerged as a promising approach to sustainable agriculture by minimizing reliance on synthetic agrochemicals and enhancing ecosystem functions through biologically driven management practices. This review synthesizes current evidence on the effects of natural farming systems—including crop diversification, cover cropping, organic amendments, composting, reduced tillage, and integrated nutrient management—on soil health and soil microbial communities. Soil health is defined as the capacity of soil to function as a living ecosystem that sustains plants, animals, humans, and the soil microbiome, integrating physical, chemical, and biological attributes. Among these, soil microbial communities play a central role in regulating nutrient cycling, organic matter decomposition, carbon transformation, and soil structural stability. Evidence from long-term field studies indicates that natural farming practices generally improve soil physical properties (e.g., aggregate stability, porosity, and water-holding capacity), enhance chemical fertility (e.g., soil organic carbon and nutrient availability), and stimulate biological activity, including microbial biomass, diversity, and enzyme activities. Practices such as crop rotation, cover cropping, compost application, and reduced tillage consistently promote more diverse and functionally active microbial communities compared with conventional systems dominated by synthetic inputs. Although responses vary with soil type, climate, and management intensity, the overall trend supports the role of natural farming in restoring degraded soils and strengthening soil ecological functions. The review also highlights key challenges in adoption and emphasizes future research needs, particularly the integration of soil physical, chemical, and biological indicators with advanced molecular tools to better quantify the long-term sustainability and productivity of natural farming systems.

Keywords: Natural Farming, Soil Health, Microbial Communities, Soil Microbiome, Sustainable Agriculture, Organic Nutrient Cycling, Agroecology

Introduction

Natural farming practices aim to promote sustainable agriculture by minimizing or completely avoiding the use of synthetic agrochemicals while enhancing biodiversity conservation and soil health through the stimulation of beneficial microbial communities. These approaches typically integrate crop diversification, cover cropping, organic amendments, reduced tillage, and integrated livestock management, among other ecologically based techniques. Collectively, such practices play a pivotal role in improving soil quality, as reflected in the restoration and maintenance of soil physical, chemical, and biological properties. Consequently, natural farming has gained increasing attention as a viable strategy for restoring degraded soils and enhancing long-term agricultural sustainability. This review synthesizes contemporary evidence on the effects of natural farming practices on soil health and soil microbial communities. Soil health is broadly defined as the capacity of soil to function as a vital living system that sustains plants, animals, humans, and the soil microbiome. This concept encompasses a complex interaction of physical properties (such as structure, texture, porosity, and water-holding capacity), chemical characteristics (including nutrient availability, pH, and cation exchange capacity), and biological attributes (notably microbial biomass, diversity, and activity). Among these components, soil microbial communities are central to soil health because they drive key ecosystem processes such as nutrient cycling, organic matter decomposition, carbon transformation, and pollutant remediation. Chen *et al*. (2018) reported that natural farming practices enhance soil health primarily by minimizing soil disturbance and incorporating diverse crop species through crop rotations or multi-cropping systems, often coupled with livestock integration.

Role of Organic Amendments and Compost in Soil Health

Among the various methods that foster soil quality under natural farming, compost application is particularly effective in promoting soil microbial communities. The incorporation of compost supplies essential nutrients while simultaneously increasing carbon inputs, thereby supporting the establishment and functioning of diverse microbial populations. Increased microbial diversity and activity, in turn, promote vegetation growth

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

and nutrient availability, highlighting the critical role of microorganisms in soil health restoration and maintenance.

Overview of Natural Farming Practices

Natural farming systems rely primarily on foliar delivery of plant nutrients and the application of biologically derived nutrient amendments. These practices influence plant nutrition, increase carbon inputs into specific soil compartments, stimulate microbially mediated mineralization processes, enhance populations of plant-growth-promoting bacteria, and redirect microbial nitrogen use towards assimilation. As a result, improved nutrient availability, modified nutrient cycling dynamics, and enhanced microbial activity collectively contribute to sustained crop productivity (Singh *et al*., 2023).

Soil Health and Its Importance in Natural Farming Systems

Soil health refers to the continued capacity of soil to function as a living ecosystem that sustains plants, animals, humans, and the soil microbiome. A wide range of physical, chemical, and biological properties contribute to soil health, including nutrient availability, pH, texture, structure, infiltration rate, and organic matter content (Singh *et al*., 2023). Enhanced soil health is critical for sustainable agriculture, as soil provides physical support, nutrients, and water for crop growth and plays a major role in the global carbon cycle. Therefore, changes in soil properties and microbial communities under natural farming systems have a direct and indirect impact on crop growth and productivity.

Organic matter is a cornerstone of soil health because it improves soil physical, chemical, and biological properties (Zarraonaindia *et al*., 2020). It enhances soil structure, stabilizes soil aggregates, and increases water-holding capacity, thereby reducing erosion and runoff. At the same time, it provides a major carbon and energy source for diverse microbial communities that drive nutrient transformations. Natural farming practices strongly emphasize the generation and incorporation of organic matter through residue retention, compost application, and cover cropping, which help maintain or increase soil organic matter levels.

For instance, in aerobic rice systems, continuous organic carbon inputs through the decomposition of rice straw or surface mulching of leguminous residues can achieve near-zero tillage and reduce chemical inputs. Organic matter also improves nutrient availability by

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

increasing cation exchange capacity, buffering soil pH, and enhancing the retention of macro- and micronutrients, thereby reducing nutrient leaching losses. It elevates the availability of key nutrients such as nitrogen, phosphorus, potassium, sulphur, calcium, and magnesium, while simultaneously reducing aluminum toxicity. Compared with conventional systems, organic and natural farming systems generally exhibit greater accumulation of these nutrients.

The presence of organic matter further supports diverse and active microbial populations. Increased substrate availability, reduced disturbance, lower chemical inputs, and greater plant diversity together stimulate microbial growth, enzymatic activity, and a broader range of soil processes. As a result, microbial biomass, respiration rates, and extracellular enzyme activities commonly increase. Microbial communities also shift in response to altered organic inputs, nutrient concentrations, and crop choices, often showing higher diversity and greater abundance of beneficial rhizobacteria such as Pseudomonas spp. and nitrogen-fixing rhizobia. These beneficial rhizobacteria, particularly plant-growth-promoting rhizobacteria (PGPR), can induce systemic resistance (ISR) in plants against pathogen infection.

Soil Microbial Communities and Their Ecological Functions

Soil microbial communities provide critical ecosystem functions and are fundamental to soil health (Chen *et al*., 2018). Their roles include the degradation of organic residues, formation of soil organic matter, mobilization of nutrients, facilitation of nutrient uptake by plants, and the cycling of nitrogen, sulphur, and phosphorus (Lahlali *et al*., 2021). Changes in soil management systems can significantly influence these functions by altering the structure and activity of the soil microbial ecosystem.

Natural Farming and Soil Properties

The adoption of natural farming practices influences a wide range of soil attributes by improving soil physical, chemical, and biological properties. Natural farming is increasingly recognized as a strategy for restoring soil health and mitigating the environmental concerns associated with conventional farming. Evidence suggests that natural farming offers consistent benefits to soil quality, supporting its broader adoption (Zarraonaindia *et al*., 2020).

Physical Properties

Soil physical properties, including texture, structure, and bulk density, respond strongly to natural farming practices. Conventional systems that rely heavily on synthetic fertilizers and pesticides often increase soil bulk density and reduce aggregate stability. In contrast, natural farming practices tend to decrease bulk density and enhance aggregate stability. Aggregate stability, often measured as mean weight diameter, is a key indicator of soil structural quality and is closely linked to organic matter content. Higher aggregate stability improves porosity, promotes water infiltration and root growth, and reduces surface runoff and erosion.

Organic matter plays a central role in improving structural stability, and the incorporation of large quantities through compost and crop residues significantly enhances aggregate formation. Crop rotations that produce extensive root systems and large biomass inputs also contribute to structural improvement. Improved soil structure facilitates root penetration, seedling emergence, efficient aeration, and balanced water movement, whereas poor structure can lead to water logging or poor aeration, thereby restricting plant growth (Singh *et al*., 2023).

Chemical Properties

The chemical properties of soils under natural farming are generally characterized by increases in soil organic carbon, total nitrogen, available phosphorus, and exchangeable potassium and calcium. Long-term studies have demonstrated that continuous chemical fertilization and pesticide use can negatively affect soil physico-chemical properties. In contrast, systems based on organic amendments and the absence of chemical fertilizers often maintain soil fertility at levels comparable to or even higher than conventional systems.

Chemical fertilizers also influence soil microbial communities, often reducing microbial diversity, richness, and evenness compared with manure-based or organic systems (Zarraonaindia *et al*., 2020). Luan *et al*. (2020) reported dramatic changes in soil microbial community structure in response to long-term chemical fertilization in greenhouse soils, highlighting the negative impacts of such inputs on microbial diversity and ecosystem stability.

Biological Properties

The biological properties of soils under natural farming are closely linked to indigenous microbes and soil fauna. These biological components interact with mineral nutrition and nutrient cycling processes, forming the foundation of soil ecosystem functioning. Maintaining indigenous microbial communities supports ecosystem stability, enhances nutrient transformations, and improves soil structure through processes such as the production of exopolysaccharides (EPS), which contribute to aggregate formation and soil physical stability.

Impact of Natural Farming on Soil Microbial Diversity

Agricultural practices exert a profound influence on soil microbial communities, which are central to ecosystem functioning and crop health (Chen *et al.*, 2018). Natural farming, characterized by low external inputs and soil-conserving practices, affects microbial communities differently from conventional systems. Common techniques include crop rotations with legumes, reduced or no tillage, organic mulching, application of indigenous microorganisms, and the use of fermented plant and animal extracts.

Long-term natural farming practices can alter bacterial and fungal community composition without necessarily causing uniform changes in overall diversity. Organic systems often enrich bacterial groups such as Acidobacteria, Actinobacteria, Bacteroidetes, Chloroflexi, and Gemmatimonadetes, while certain fungal groups become more prominent under organic management (Zarraonaindia *et al*., 2020). However, variability among studies remains high due to differences in climate, soil type, and management practices.

Crop Rotation

Crop rotation is a cornerstone of sustainable farming systems and involves growing different crops in a planned sequence over time. It helps prevent nutrient depletion, enhance yields, and reduce soil-borne pathogens (Kracmarova *et al*., 2022). Long-term studies have shown that crop rotation significantly influences soil microbial diversity and community structure, often increasing diversity compared with monocropping systems. These changes highlight that microbial community composition and temporal dynamics may be more informative indicators of soil health than total microbial biomass alone.

Cover Cropping

Career Point International Journal of Research (CPIJR)
©2022 CPIJR ǀ Volume 4 ǀ Issue 4 ǀ ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

Cover cropping is an effective natural farming strategy for reducing soil degradation and improving soil health. By maintaining continuous soil cover, cover crops reduce erosion, conserve organic carbon, and improve soil physical properties. Soil microbial communities, which are essential for organic matter decomposition, soil aggregation, and ecosystem service provision, are highly responsive to cover cropping (Kim *et al.*, 2020). The use of cover crops promotes diverse and stable microbial communities that support long-term soil fertility and agricultural productivity (Seitz *et al*., 2024).

Composting

Composting is a central component of natural farming systems and plays a major role in shaping the soil microbiome by building and maintaining soil organic matter (Kraut-Cohen et al., 2023). Continuous compost application alters soil microbial community structure, diversity, and function, with the magnitude of change depending on both the application rate and the microbial composition of the compost (Zhen *et al*., 2014).

Reduced Tillage

Tillage practices strongly influence soil degradation, carbon sequestration, and microbial biomass. Microorganisms produce extracellular enzymes that decompose complex organic polymers, thereby regulating soil organic matter dynamics. Zuber (2017) demonstrated that no-tillage and cover crop systems increase microbial biomass and enzyme activities, contributing to long-term improvements in carbon and nitrogen cycling and overall soil health.

Case Studies and Comparative Perspectives

Case studies across different regions consistently show that natural farming systems support robust populations of nitrogen-fixing and phosphorus-solubilizing microorganisms, along with microbial groups involved in sulphur cycling. Long-term adoption of natural farming often results in higher microbial abundance and shifts in dominant taxa, reflecting improved soil biological functioning (Chen *et al*., 2018; Singh *et al*., 2023).

Compared with conventional farming, natural farming practices generally enhance soil quality and beneficial microbial populations (Zarraonaindia *et al*., 2020). While chemical

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

fertilizers mainly alter soil chemical properties, organic amendments exert a stronger influence on microbial communities and soil ecological functions (Chen *et al*., 2018). High-throughput sequencing studies have revealed that many bacterial and fungal taxa respond sensitively to management practices, underlining the importance of understanding soil microbial ecology for designing sustainable farming systems.

Soil Health Metrics and Microbial Indicators

Soil health assessment integrates physical parameters (such as bulk density, porosity, penetration resistance, and water retention), chemical indicators (nutrient availability and pH), and biological indicators (microbial biomass, diversity, and activity) (Singh *et al*., 2023). Organic and natural farming systems generally exhibit higher microbial diversity and abundance than conventional systems, particularly under stable environmental conditions (Zarraonaindia *et al*., 2020).

Challenges in Implementing Natural Farming

Despite its benefits, the adoption of natural farming faces several practical, economic, and ecological challenges. Transitioning from conventional systems requires new knowledge and skills related to organic inputs, crop diversification, and soil biological management. Initial yield reductions, limited availability of organic materials, and the need for alternative pest and disease management strategies can constrain adoption. Addressing these challenges is essential for the wider implementation of natural farming and for fully realizing its potential benefits for soil health and microbial communities (Chen *et al*., 2018; Gupta *et al*., 2022).

Future Thrust

Natural farming has gained substantial momentum across different regions of the world over the past few decades. Although its philosophical roots can be traced to traditional and indigenous farming systems, it entered the global discourse more prominently through the work of Masanobu Fukuoka, who, in the post–Second World War period, advocated a return to ecologically harmonious agriculture in Japan as a response to the rapid intensification of farming through chemical fertilizers and pesticides. Natural farming emphasizes minimal external intervention and seeks to harness naturally available resources such as rainfall, sunlight, on-farm biomass, and biological nutrient recycling to maintain soil fertility and crop productivity. By reducing dependence on synthetic inputs, this approach aims to achieve sustainable and environmentally benign agricultural production while minimizing risks to ecosystem and human health.

Soil represents a highly complex living system composed of mineral particles, organic matter, water, air, and an immense diversity of microorganisms. Together, these components create a dynamic matrix that supports seed germination, root development, and plant growth. However, maintaining soil health is challenging, particularly across diverse cropping systems and farm scales. An imbalance between water retention and drainage can result in either water logging or excessive drying and cracking, both of which severely constrain crop growth. Consequently, soil fertility—defined as the soil's capacity to supply nutrients and provide a favorable physical environment for plant growth is often used as a practical indicator of soil health.

Soil is commonly described as consisting of four major components: solids (mineral particles and organic matter), liquids (soil water), and gases (soil air). The combined volume of soil water and air forms the pore space, which is critical for root respiration and microbial activity through the exchange of oxygen and carbon dioxide. In the absence of adequate pore space, soils become poorly aerated and water stagnation occurs, leading to adverse conditions for both plants and microorganisms. Mineral particles derived from the long-term weathering of rocks largely determine soil texture, which is defined by the relative proportions of sand, silt, and clay. Soil texture, in turn, strongly influences water retention, nutrient-holding capacity, and overall soil physical behavior.

Natural farming practices induce several beneficial changes in soil properties that collectively contribute to the restoration and maintenance of soil health. These systems generally promote higher soil moisture retention, primarily through improved soil cover and organic matter inputs that reduce evaporation losses. Although full surface coverage is not always achieved, studies indicate that approximately 20–30% more moisture can be retained compared with bare mineral soils, which is particularly important for enhancing drought resilience. The surface microenvironment created by mulching and residue retention acts as an effective buffer against temperature extremes and moisture loss.

With respect to soil fertility, while the macronutrients nitrogen, phosphorus, and potassium may not always exhibit dramatic short-term changes, several secondary and micronutrients such as silicon, sulphur, iron, manganese, calcium, and magnesium often show moderate increases under natural farming systems. Over longer time scales, the gradual accumulation of organic matter and associated nutrients is expected to sustain plant growth and improve soil buffering capacity and nutrient cycling efficiency (Chen *et al*., 2018). These long-term improvements underscore the need for extended field experiments and landscape-scale studies to better quantify the cumulative benefits of natural farming under diverse agroecological conditions.

Future research should therefore focus on integrating soil physical, chemical, and biological indicators to develop robust, region-specific soil health assessment frameworks for natural farming systems. In addition, advances in molecular and ecological tools offer new opportunities to elucidate the functional roles of soil microbial communities and their interactions with plants under low-input, biologically driven management systems.

Policy Implications

Agricultural policy should actively encourage the adoption of natural farming practices to curb the ongoing degradation of ecosystems and socio-ecological systems (Gupta *et al*., 2022). Evidence increasingly indicates that soil microbial community composition, diversity, and richness exert a strong influence on crop yield and food nutritional quality (Chen *et al*., 2018). Natural farming systems promote diverse groups of microorganisms, including bacteria, fungi, protozoa, and algae, which collectively enhance soil biological functioning and resilience. Policy support in the form of training, financial incentives, and extension services is therefore essential to facilitate farmer transitions from input-intensive systems to biologically based, sustainable farming practices.

Conclusion

Soil health represents the capacity of soil to function as a living ecosystem that supports plant and animal productivity, regulates water flow, filters and buffers potential pollutants, sustains biological activity, maintains environmental resilience, and promotes overall ecosystem health. Microbial communities underpin many of these functions by driving nutrient cycling, organic matter decomposition, and biomass production. In agroecosystems, soil

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

microorganisms influence nutrient availability, support plant health, and regulate the fate of pesticides and other pollutants. Although microbes do not govern every aspect of soil health, they are fundamental to nutrient transformations and plant–soil feedback mechanisms. The incorporation of natural farming practices into arable systems has been shown to enhance bacterial and fungal biomass, maintain or increase microbial diversity, stimulate species richness, and support key microbial groups involved in below-ground ecosystem processes essential for soil functioning (Zarraonaindia *et al*., 2020). Recent evidence further highlights the dynamic interactions between plants and soil microbiomes; for instance, a study published in Science (August 14, 2025) reported that maize plants grown under high-density conditions can communicate with neighboring plants, triggering rapid immune responses associated with jasmonic acid signaling and concurrent shifts in the soil and rhizosphere microbiome. Such findings emphasize that plant–microbe interactions are not static but responsive to both biotic and management-driven cues. Overall, natural farming emerges as a promising pathway for restoring soil health, strengthening soil biological functions, and promoting resilient and sustainable agricultural systems. Continued interdisciplinary research, coupled with supportive policies and farmer-centered extension efforts, will be critical to fully realize the potential of natural farming for long-term food security and environmental sustainability.

References

1. Seitz, V., McGivem, B., Borton, M. A., Chaparro, J. M., Schipanski, M. E., Prenni, J. E., & Wrighton, K. C. (2024). Cover crop root exudates impact soil microbiome functional trajectories in agricultural soils. *Microbiome*, *12*, 183.
2. Chen, H., Xia, Q., Yang, T., & Shi, W. (2018). Eighteen-year farming management moderately shapes the soil microbial community structure but promotes habitat-specific taxa. *Frontiers in Microbiology*, *9*, 1776. https://doi.org/10.3389/fmicb.2018.01776
3. Gupta, A., Singh, U. B., Sahu, P. K., Paul, S., Kumar, A., Malviya, D., Singh, S., Kuppusamy, P., Singh, P., Paul, D., Rai, J. P., Singh, H. V., Manna, M. C., Crusberg, T. C., Kumar, A., & Saxena, A. K. (2022). Linking soil microbial diversity to modern agriculture practices: A review. *International Journal of Environmental Research and Public Health*, *19*(5), 3141.

4. Joseph Jr., T. M. (2019). *Long-term land management practices and their effect on soil health and crop productivity* (Doctoral dissertation). Plant and Soil Sciences, University of Kentucky.
5. Kim, N., Zabaloy, M. C., Riggins, C. W., Rodríguez-Zas, S., & Villamil, M. B. (2020). Microbial shifts following five years of cover cropping and tillage practices in fertile agroecosystems. *Microorganisms, 8*(11), 1773.
6. Kráčmarová, M., Uhlík, O., Střeček, M., Száková, J., Černý, J., Balík, J., Tlustos, P., Kohout, P., Demnerová, K., & Stiborová, H. (2022). Soil microbial communities following 20 years of fertilization and crop rotation practices in the Czech Republic. *Environmental Microbiome, 17*, 13.
7. Kraut-Cohen, J., Zolti, A., Rotbart, N., Bar-Tal, A., Laor, Y., Medina, S., Shawahna, R., Saadi, I., Raviv, M., Green, S. J., Yermiyahu, U., & Minz, D. (2023). Short- and long-term effects of continuous compost amendment on soil microbiome community. *Computational and Structural Biotechnology Journal, 21*, 3280–3292.
8. Lahlali, R., Ibrahim, D. S. S., Belabess, Z., Roni, M. Z. K., Radouane, N., Vicente, C. S. L., Menéndez, E., Mokrini, F., Ait Barka, E., Galvão de Melo e Mota, M., & Peng, G. (2021). High-throughput molecular technologies for unraveling the mystery of soil microbial community: Challenges and future prospects. *Heliyon, 7*(10), e08142.
9. Luan, L., Liang, C., Chen, L., Wang, H., Xu, Q., Jiang, Y., & Sun, B. (2020). Coupling bacterial community assembly to microbial metabolism across soil profiles. *mSystems, 5*(3), e00298-20.
10. Zuber, S. M. (2017). *Carbon and nitrogen cycling and soil quality under long-term crop rotation and tillage* (Doctoral dissertation). University of Illinois.
11. Singh, S., Singh, S., Lukas, S. B., Machado, S., Nouri, A., Calderón, F., Rieke, E. R., & Cappellazzi, S. B. (2023). Long-term agromanagement strategies shape soil bacterial community structure in dryland wheat systems. *Scientific Reports, 13*, 13929.
12. Zarraonaindia, I., Martínez-Goñi, X. S., Liñero, O., Muñoz-Colmenero, M., Aguirre, M., Abad, D., Baroja-Careaga, I., de Diego, A., Gilbert, J. A., & Estonba, A. (2020). Response of horticultural soil microbiota to different fertilization practices. *Plants, 9*(11), 1501.

Career Point International Journal of Research (CPIJR)
©2022 CPIJR | Volume 4 | Issue 4 | ISSN : 2583-1895
October-December-2025 | DOI: https://doi.org/10.5281/zenodo.18645499

13. Zhen, Z., Liu, H., Wang, N., Guo, L., Meng, J., Ding, N., Wu, G., & Jiang, G. (2014). Effects of manure compost application on soil microbial community diversity and soil microenvironments in a temperate cropland in China. *PLoS ONE, 9*(10), e108555.
14. Zhu, L., Huang, J., Lu, X., & Zhou, C. (2022). Development of plant systemic resistance by beneficial rhizobacteria: Recognition, initiation, elicitation and regulation. *Frontiers in Plant Science*.