IJIABS
INTERNATIONAL JOURNAL OF INNOVATIONS IN AGRICULTURE AND BIOLOGICAL SCIENCES

Multidisciplinary | Peer-Reviewed
Open Access | Research Journal
Volume 1 | Issue 1 | 2026

International Journal of Innovations in Agriculture and Biological Sciences

Sustainable Crop Production and Soil Health Management: A Review of Agricultural Practices

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Received: 03.08.2026 | **Accepted:** 09.08.2026 | **Published:** 12.08.2026

Abstract

Sustainable crop production is critical to meeting growing global food demands while preserving the ecological integrity of agricultural resources. Intensive farming and conventional management have accelerated soil degradation, declining organic matter, and environmental stress. This review examines vital agronomic practices—including conservation tillage, crop rotation, cover cropping, organic amendments, and balanced nutrient management—that collectively restore physical, chemical, and biological soil health. Integrating these sustainable approaches enhances soil organic carbon, moisture retention, nutrient-use efficiency, and crop yield stability. Furthermore, addressing socioeconomic barriers and adopting circular bioeconomy frameworks are essential for long-term agricultural resilience. Ultimately, harmonizing ecological principles with integrated soil management secures sustainable productivity and global food security.

Keywords: *Sustainable Agriculture, Soil Health, Conservation Tillage, Soil Organic Carbon, Crop Management.*

1 Introduction

Sustainable crop production is essential for meeting the increasing demand for food while maintaining the long-term productivity and ecological integrity of agricultural resources. Soil health is a fundamental component of sustainable agriculture because soil physical, chemical, and biological properties directly influence nutrient availability, water retention, crop growth, and ecosystem functioning. Intensive cultivation, excessive tillage, imbalanced fertilizer application, erosion, and declining organic matter can progressively reduce soil quality and threaten agricultural productivity. Consequently, increasing attention has been directed toward agricultural practices that conserve soil resources while maintaining crop yields [1]. Conservation tillage, crop rotation, cover cropping, residue retention, organic amendments, integrated nutrient management, efficient irrigation, and integrated pest management are among the practices considered important for improving soil quality and resource-use efficiency. These approaches can contribute to soil organic matter accumulation, nutrient cycling, moisture conservation, biodiversity enhancement, and reduction of environmental degradation [2]. Therefore, integrating sustainable crop production practices with systematic soil health management is critical for developing resilient and productive agricultural systems [3]. This review examines major agricultural practices that support sustainable crop production and soil health, with emphasis on their potential benefits, practical limitations, and contribution to long-term agricultural sustainability.

2 Sustainable Agricultural Practices for Crop Production and Soil Health

Sustainable agricultural practices aim to maintain crop productivity while conserving soil resources and reducing environmental degradation. They emphasize minimum soil disturbance, maintenance of soil cover, crop diversification, efficient nutrient management and recycling of organic materials. These practices can improve soil structure, organic carbon, nutrient cycling, moisture retention and biological activity, thereby supporting long-term soil fertility and sustainable crop production [4].

1. **Conservation tillage:** Reduced or zero tillage minimizes soil disturbance, erosion and organic-matter losses while supporting soil structure and moisture conservation.
2. **Crop rotation:** Rotating different crops helps diversify nutrient demand, interrupt pest and disease cycles, and improve soil fertility and productivity.
3. **Cover crops and residue management:** Maintaining crop residues and growing cover crops protects the soil surface, reduces erosion, recycles nutrients and contributes organic matter.
4. **Organic amendments:** Application of compost, manure and other organic materials can increase soil organic carbon and support microbial activity and nutrient availability.
5. **Balanced nutrient management:** Applying fertilizers according to crop and soil requirements improves nutrient-use efficiency while reducing nutrient losses and soil degradation.

3 Effects of Sustainable Practices on Soil Health and Sustainable Crop Productivity

Sustainable agricultural practices can improve soil health by strengthening its physical, chemical, and biological functions while maintaining crop productivity over the long term. Conservation tillage and residue retention help reduce erosion, improve soil structure, conserve moisture, and promote the accumulation of soil organic carbon. Crop rotation and cover cropping enhance nutrient cycling, diversify soil biological communities, and reduce pest and disease pressure. Similarly, organic amendments such as compost and manure contribute organic matter, improve nutrient availability, and stimulate microbial activity. Balanced nutrient management improves nutrient-use efficiency and reduces nutrient losses, thereby supporting soil fertility. These improvements in soil properties can enhance water and nutrient availability to crops, increase yield stability, and improve resilience to environmental stresses. Recent reviews indicate that integrated use of conservation tillage, crop rotation, organic amendments, and other complementary practices can produce greater benefits than individual practices alone [5].

4 Literature review

(Corato et al., 2024) [6] Soil health is vital for sustainable agroecosystems, yet it faces severe threats from declining Soil Organic Matter (SOM) and emerging microplastic and nanoplastic pollutants (MNPs). High crop yields depend heavily on soil quality, but stakeholders often overlook intrinsic fertility factors and proper SOM preservation practices. To counter climate change and soil degradation, the authors emphasize adopting advanced technologies, such as reusing waste biomass in alignment with circular bioeconomy principles. Furthermore, understanding the complex interactions between MNPs, soil components, and microbial communities is critical. Ultimately, the review challenges readers with practical solutions and viewpoints to restore long-term soil health, boost agricultural productivity, and safeguard future global food security within sustainable organic farming systems.

(Topa et al., 2025) [7] Soil health serves as the foundational cornerstone for sustainable agriculture, environmental resilience, and long-term ecosystem stability. Conventional farming methods—characterized by excessive pesticides, fertilizers, monoculture, and intensive tillage—have caused widespread soil degradation. To counter this, the study examines agronomic strategies like crop rotation, cover cropping, conservation agriculture, and organic amendments to restore soil structure, increase organic matter, and promote biodiversity. Crucially, increasing soil organic carbon (SOC) is identified as necessary for enhancing overall soil functions. The research highlights that conservation tillage is more advantageous for soil health than conventional tillage, advocating for an integrated management approach that harmonizes plant, soil, microbial, and human activities to ensure sustainable agricultural productivity.

(Shehzad et al., 2025) [8] Effective crop management practices significantly impact agricultural progress and the socio-economic well-being of farming communities in Khyber Pakhtunkhwa, Pakistan. Through surveys and interviews, the study reveals that adoption is heavily influenced by demographic factors such as age, education, and household income, with limited extension services acting as a primary adoption barrier. Notably, many surveyed farmers are young, and a significant portion reported increased income or reduced financial stress post-adoption. The findings suggest that implementing efficient crop management enhances productivity and financial stability. To encourage broader adoption, policymakers should customize extension services for younger, educated farmers and establish collaborative platforms like cooperatives and online networks to facilitate knowledge sharing and promote sustainable agricultural development.

(Kumar & Pathak, 2025) [9] Soil health is fundamental to sustainable agriculture, underpinning crop yield,

environmental resilience, and ecosystem stability. Contemporary agricultural practices, marked by heavy pesticide and fertilizer use, monoculture, and high ploughing, have triggered significant soil deterioration, driving the need for innovative restoration approaches. The study evaluates sustainable agronomic techniques—including crop rotation, cover cropping, no-till farming, carbon farming, and organic amendments—to restore soil structure, enhance organic matter, and foster biodiversity. Augmenting soil organic carbon (SOC) is established as essential for improving soil functions. Additionally, the research determines that conservation tillage is superior to conventional tillage for soil health. Ultimately, these solutions advocate for an integrated management framework addressing plant, soil, microbial, and human interactions to secure long-term agricultural productivity.

(Coumar & Saha, 2021) [10] Soils have long been recognized for their crucial importance to human well-being and cultural heritage. However, in developing nations like India, extensive land areas show advanced degradation that threatens the productive resource base. Because ecosystems link soil, plants, animals, and humans, adverse impacts on soil inevitably cascade across the entire system. Continuous conventional farming practices, such as intensive tillage combined with crop residue burning or removal, have severely worsened soil erosion and resource degradation. Tracking soil carbon changes is vital to determine whether a production system acts as a carbon restorative process. Protecting the soil environment requires leveraging natural soil functions and applying appropriate management strategies to ensure higher soil quality and better agricultural produce.

5 Conclusion

The long-term viability of global agriculture heavily depends on shifting away from intensive, resource-degrading conventional farming toward integrated, sustainable soil management frameworks. As evidenced by recent literature, conservation tillage, cover cropping, crop rotation, and organic amendments are powerful mechanisms for reversing soil degradation, enhancing soil organic carbon, and restoring vital microbial ecosystems. However, achieving widespread adoption requires overcoming socioeconomic barriers, addressing emerging contaminants like microplastics, and tailoring extension services to diverse farming communities. Policymakers and stakeholders must prioritize holistic approaches that unite ecological principles, modern innovations, and socio-economic support systems. By fostering collaborative networks and implementing regenerative practices, agricultural systems can successfully balance high crop productivity with environmental resilience, ensuring lasting food security and ecological integrity for future generations.

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