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Relevance of Soil Management in Sustainable Agriculture

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Abstract

Soil management plays a pivotal role in sustainable agriculture by ensuring the long-term health and productivity of agricultural systems. By adopting practices such as crop rotation, cover cropping, and reduced tillage, farmers can maintain soil fertility, prevent erosion, and enhance water retention. Healthy soils support diverse microbial communities that contribute to nutrient cycling and pest control, reducing the need for synthetic fertilizers and pesticides. Moreover, sustainable soil management practices promote carbon sequestration, mitigating climate change impacts by storing atmospheric carbon in the soil. By improving soil structure and biodiversity, farmers can increase the resilience of their crops to climate variability and extreme weather events. Overall, effective soil management not only sustains agricultural productivity but also protects the environment conserves natural resources, and fosters resilient farming systems for future generations.
Keyword: Soil health, climate change and carbon sequestration

Introduction

Agriculture is the backbone of the livelihood, civilization, culture and heritage of India. India is now the world's second most populous nation, with a population of 1.39 billion people; but, according to projections, it will overtake China as the most populated country between the years 2027 and 2030. With an area of 328.73 Mha, it is the seventh biggest nation in terms of geographical size in the globe. In 2022-23, India's total food grain output is 330 mt, oilseed production is 40.01 m ha, cotton production is 33.72 m ha, sugarcane production is 468.78 m ha, and jute and mesta production is 10.04 m ha from 155 m ha arable land (Pathak *et al*., 2022). The great challenge in agriculture is to meet the food requirement need of the growing population by controlling biotic and abiotic factors. The biotic process of agriculture is majorly controlled by abiotic factors of climate, water and soil. Most often, agricultural productivity is seriously limited by various abiotic stresses such as salinity, drought, flooding, heat, cold and freezing. The high agricultural productivity will have a negative effect on soil health. The green revolution was run by the farmer without caring about soil health. Now, the effect of the green revolution was high food grain production and degraded soil. The increase of food grain production without degrading the soil quality and to still get high food grain production in the future, farmer has to follow

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sustainable soil management practices. In this context, the author has described the soil function and different soil management practices for sustainable agriculture.

Soil function:

Soil function is mainly categories into three classes: socioeconomic function, technical-industrial function, and ecological function. The ecological function is subcategories into production biomass, filtration, buffering, biotransformation and preservation of genetic diversity.

"Socioeconomic" function: involves the supply, by soils, of water and of different kinds of raw materials such as clay, sand, gravel, or coal, that are used in a wide range of building, industrial, and manufacturing operations.

"Technical - industrial" functions: relate to the fact that soils, generally after being sealed in some way, serve as structural supports for many different types of buildings, roads, sports facilities, as well as landfills.

Ecological function

production of biomass: e.g., crops on agricultural fields, or trees in forests. Soils serve as physical support for roots and as a nutritive substrate, supplying air, water, and nutrients required for plant growth.

Filtration: soils are important filters of chemical or biological contaminants

Biotransformation: as a medium that fosters biological/biochemical transformations of toxic organic compounds

preservation of genetic diversity: preservation of a myriad of genes that could be of potential use to humans, for example for the production of new types of antibiotics. In addition, the preservation of paleontological and archeological treasures of high value for the understanding of the history of human populations and of the earth.

"Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern".

Different soil management options for sustainable agriculture (Indoria *et al.*, 2016)

Soil Constraints for Sustainable Agriculture	Soil Management
Water erosion	If slope <2% – Contour cropping, strip cropping, crop rotation, cover crop, intercropping, mulching, conservation tillage, ridge and furrow system and broad bed and furrow system

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	If slope > 2 – 6% Contour bunding slope >6 – 10% Graded bunding slope < 30% Contour terracing slope up to 30% Bench Terracing slope > 66% Contour wattling slope >40% Crib structure
Wind erosion	Vegetation residues, mulch tillage, crop residue incorporation, vegetative cover, surface roughness and maintaining clods, crosswind strip cropping, windbreak and shelter break, reshaping land, maintaining soil moisture, manure application, and application of soil stabilizers etc
Soil salinity	Good quality of irrigation water for leaching, FYM application, deep tillage, soil subsurface rotation, green manuring, water stagnation, stripping of surface soil layer
Soil Sodicity	Gypsum application, Sulphur containing material for reclamation, acidic fertilizer
Soil acidity	Lime material, basic fertilizer,
Heavy metal contamination	Capping, subsurface barriers, Solidification/stabilization, vitrification, chemical treatment, phytoremediation, bioleaching, biochemical processes, Soil washing
Soil compaction	Deep tillage, conservation agriculture, tillage in dry soil condition, control tractor wheel etc
Crusting and hardening	Tank silt application, organic manure application, soil conditioner, ca- containing material, cover cropping, intercropping,
Slow permeability	Deep tillage, subsurface drainage, application of organic manure, application of sand, following broad bed and furrow method
High permeability	Application of tank silk, application of organic manure and crop residues
Subsurface hard pan	Chisel ploughing, crop residues retention, control traffic wheel, cultivation of deep-rooted crop
Shallow depth	Shallow root cropping system, intercropping, contour bunding, graded bunding, cover cropping,
Low fertility status	Balanced Nutrient Management, Integrated Nutrient Management
Low organic carbon	Green manuring, application of manures, crop residue incorporation, conservation agriculture

Conclusion

Effective soil management practices, such as crop rotation, cover cropping, reduced tillage, and erosion control measures, are essential for maintaining soil health, fertility, and structure. These practices support diverse microbial communities, enhance nutrient cycling, and promote carbon sequestration, thus mitigating the impacts of climate change. Additionally, sustainable soil management strategies address various soil constraints, including erosion, salinity, sodicity, compaction, acidity, and fertility issues, thereby improving overall agricultural productivity and resilience.

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By adopting and implementing sustainable soil management practices, farmers can not only ensure the long-term viability of agricultural systems but also contribute to environmental conservation, resource preservation, and the creation of resilient farming systems for future generations.

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