



Source: <https://cropaido.com>

Components of Soil Health and Fertility

1. Physical Properties

Soil physical properties play a crucial role in determining root growth, water movement, and soil aeration. Key indicators include soil texture, which affects water retention and nutrient availability; soil structure, influencing aggregation and porosity; bulk density, which impacts root penetration; porosity, determining air and water movement and water-holding capacity, essential for crop hydration. Soils with well-developed structure and good aggregation facilitate better root development, efficient water infiltration, and retention, while poorly structured or compacted soils restrict root growth, reduce aeration, and limit nutrient and water availability, ultimately affecting crop productivity and soil health.

2. Chemical Properties

Soil chemical properties are key determinants of nutrient availability, soil fertility, and plant growth. Important parameters include soil pH, which affects nutrient solubility; electrical conductivity (EC), indicating salinity levels; organic carbon, essential for nutrient retention and microbial activity; cation exchange capacity (CEC), reflecting the soil's ability to hold and supply nutrients; and the availability of macro- and micronutrients necessary for healthy plant development. Maintaining balanced soil chemistry ensures efficient nutrient uptake by crops, prevents nutrient deficiencies or toxicities, and supports overall soil fertility and productivity, contributing to sustainable and resilient agricultural systems.

3. Biological Properties

Biological properties are vital indicators of soil health and fertility, reflecting the activity and diversity of soil organisms. Microorganisms such as bacteria, fungi, actinomycetes, along with soil fauna like earthworms, play essential roles in decomposing organic matter, fixing atmospheric nitrogen, solubilizing nutrients, and improving soil structure. High biological diversity enhances nutrient cycling, soil aggregation, and disease suppression, increasing the resilience of soils to environmental stresses. Active and diverse soil biota contribute to sustained crop productivity, better soil fertility, and the long-term sustainability of agricultural ecosystems.

Importance of Soil Health and Fertility

- Enhances crop growth, yield, and quality
- Improves nutrient use efficiency and reduces input costs
- Increases water infiltration, retention, and drought tolerance
- Reduces soil erosion and land degradation
- Supports beneficial soil organisms and biodiversity
- Contributes to climate change mitigation through carbon sequestration
- Ensures long-term sustainability of agricultural systems

INTRODUCTION

Soil is a vital natural resource that forms the foundation of agricultural productivity and ecosystem sustainability. Healthy and fertile soil supports plant growth by providing essential nutrients, regulating water availability, and creating a favorable environment for root development and beneficial microorganisms. It also plays a key role in nutrient cycling, carbon sequestration, and maintenance of biological diversity. In modern agriculture, soil health and fertility are under serious threat due to intensive cultivation, excessive use of chemical fertilizers and pesticides, soil erosion, and the adverse impacts of climate change. Declining soil quality directly affects crop yields, input use efficiency, and environmental stability. Therefore, understanding the principles of soil health and fertility and adopting appropriate, sustainable management practices are essential for ensuring long-term agricultural productivity, food security, and environmental protection.



Source: <https://koshishindia.in>

Concept and Definition of Soil Health

Soil health refers to the continued capacity of soil to function as a living system that sustains plants, animals, and humans. A healthy soil maintains its physical structure, chemical balance, and biological activity over time.

Definition: Soil health is the ability of soil to function as a vital living ecosystem that sustains plant productivity, maintains environmental quality, and promotes plant and animal health. Healthy soils are resilient to stresses such as drought, floods, and pest pressure. They support efficient nutrient cycling, root growth, and microbial activity while minimizing degradation and pollution.

Concept and Definition of Soil Fertility

Soil fertility is a narrower concept compared to soil health and mainly focuses on the soil's ability to supply essential nutrients to plants in adequate amounts and proper balance.

Definition: Soil fertility is the capacity of soil to provide essential plant nutrients in available forms, in sufficient quantity and proportion, for optimum plant growth and yield. While soil fertility emphasizes nutrient availability, soil health includes physical, chemical, and biological properties, making fertility an important component of overall soil health.

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कोटा, राजस्थान



Soil Health and Fertility

संकलन

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Factors Affecting Soil Health and Fertility

Several factors influence soil health and fertility:

- Climate: Temperature and rainfall affect organic matter decomposition and nutrient cycling.
- Parent Material: Determines basic soil texture and mineral composition.
- Cropping System: Monocropping reduces diversity, while crop rotation improves soil condition.
- Tillage Practices: Excessive tillage disrupts soil structure and microbial habitats.
- Fertilizer and Manure Use: Balanced and integrated nutrient management maintains fertility.
- Irrigation Practices: Poor water management can lead to salinity and nutrient losses.

Soil Health and Fertility Management Practices

1. Integrated Nutrient Management (INM)

Integrated Nutrient Management (INM) is a holistic approach to soil fertility management that emphasizes the combined and balanced use of chemical fertilizers, organic manures, crop residues, green manures, and biofertilizers. INM ensures the continuous supply of essential nutrients to crops, improves soil physical and biological properties, and enhances nutrient use efficiency. By reducing sole dependence on chemical fertilizers, INM helps maintain long-term soil fertility, sustain crop productivity, and minimize environmental degradation.

2. Organic Matter Management

Organic matter management involves the regular addition of farmyard manure, compost, vermicompost, crop residues, and green manures to the soil. These organic inputs improve soil structure, enhance water-holding capacity, and increase nutrient availability. They also stimulate beneficial microbial activity, support nutrient cycling, and improve soil resilience, thereby playing a crucial role in maintaining soil health, fertility, and sustainable crop production.

3. Balanced Fertilization

Balanced fertilization involves the application of nutrients in appropriate amounts and proportions based on soil test recommendations and crop requirements. This practice prevents nutrient deficiencies and toxicities, ensures efficient nutrient uptake by crops, and improves fertilizer use efficiency. Balanced fertilization also reduces nutrient losses through leaching and runoff, lowers production costs, and supports sustainable soil fertility and crop productivity.

4. Conservation Agriculture

Conservation agriculture focuses on sustainable soil management through practices such as minimum or zero tillage, diversified crop rotation, and retention of crop residues on the soil surface. These practices reduce soil erosion, improve soil structure, and enhance soil organic carbon. Conservation agriculture also promotes better water infiltration, increased microbial activity, and long-term soil fertility, leading to improved crop productivity and resilience to climate variability.

5. Soil and Water Conservation Measures

Soil and water conservation measures play a vital role in maintaining soil health and fertility. Practices such as contour farming reduce runoff and soil erosion on sloping lands, while mulching helps conserve soil moisture and improve organic matter. Bunding prevents nutrient losses, and proper irrigation scheduling ensures efficient water use, reduces leaching, and maintains optimal soil moisture for sustainable crop production.

Soil Testing and Soil Health Assessment

Soil testing is a fundamental tool for evaluating soil fertility status and guiding efficient nutrient management practices. It provides critical information on soil pH, organic carbon content, and the availability of essential macro- and micronutrients. Soil Health Cards help farmers understand soil constraints and apply fertilizers in balanced and recommended doses, reducing unnecessary input costs. In recent years, advanced technologies such as soil sensors, remote sensing, and digital soil mapping have enhanced soil health assessment by enabling real-time and site-specific monitoring. These modern approaches support precision agriculture, improve nutrient use efficiency, and contribute to sustainable soil and crop management.

Role of Soil Health in Sustainable and Climate-Smart Agriculture

Healthy soils play a critical role in climate-smart agriculture by enhancing carbon sequestration, improving water use efficiency, and increasing resilience to climate extremes. Maintaining soil health helps reduce greenhouse gas emissions and supports sustainable intensification of agriculture.

CONCLUSION

Soil health and fertility are fundamental to sustainable agricultural production and environmental sustainability. While soil fertility focuses on nutrient supply, soil health encompasses the overall physical, chemical, and biological functioning of soil. Adoption of integrated and conservation-based soil management practices is essential to restore degraded soils, enhance productivity, and ensure food security for future generations. Protecting and improving soil health is not only a responsibility of farmers but a collective effort involving researchers, policymakers, and extension agencies.