

Soil Testing and Soil Health Management

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INTRODUCTION

Soil is one of the most valuable natural resources and forms the foundation of agricultural production. It provides essential nutrients, water, air, and physical support required for healthy plant growth and high crop yields. However, intensive cultivation, excessive use of chemical fertilizers, soil erosion, nutrient depletion, salinity, and poor land management practices have significantly degraded soil quality in many regions. This degradation reduces soil fertility, lowers crop productivity, and threatens long-term agricultural sustainability. Therefore, maintaining and improving soil health has become a major priority in modern agriculture. Soil testing is a scientific method used to assess the physical, chemical, and biological properties of soil, enabling precise nutrient management and balanced fertilizer application. Combined with effective soil health management practices, it enhances soil fertility, increases productivity, reduces production costs, conserves natural resources, and promotes environmentally sustainable and climate-resilient farming systems.

2. Soil Testing

Definition

Soil testing is the scientific process of collecting and analyzing soil samples to evaluate their physical, chemical, and biological properties. It provides valuable information about soil fertility, nutrient availability, pH, electrical conductivity (EC), organic carbon content, salinity, and the presence of essential macro- and micronutrients required for plant growth. Soil testing helps determine the nutrient status of the soil and identifies deficiencies, excesses, or imbalances that may affect crop performance. Based on the test results, appropriate fertilizer and soil amendment recommendations can be made to optimize crop production.

It is an essential tool for precision agriculture, balanced nutrient management, and sustainable farming, ensuring efficient use of resources while minimizing environmental pollution and maintaining long-term soil health.

Objectives of Soil Testing

The major objectives of soil testing are:

- To determine the nutrient status of the soil by measuring the availability of essential macro- and micronutrients.
- To identify nutrient deficiencies, toxicities, and imbalances that may limit crop growth and yield.
- To assess important soil properties such as pH, electrical conductivity (EC), organic carbon, salinity, and sodicity.
- To recommend suitable fertilizer doses based on crop requirements and soil nutrient status.
- To improve crop productivity and quality through balanced and efficient nutrient management.
- To reduce unnecessary fertilizer application, thereby lowering production costs and preventing nutrient losses.
- To enhance nutrient use efficiency and maximize the return on fertilizer investment.
- To maintain and improve soil fertility and overall soil health for long-term agricultural sustainability.
- To minimize environmental pollution caused by excessive fertilizer use, nutrient leaching, and greenhouse gas emissions.
- To support sustainable and climate-resilient agriculture by promoting

responsible soil and nutrient management practices.

- To assist farmers in making informed decisions regarding crop selection, fertilizer scheduling, and soil management strategies.
- To monitor changes in soil fertility over time, enabling effective long-term soil health management.

3. Importance of Soil Testing

Soil testing is a fundamental component of modern and sustainable agriculture. It provides accurate and scientific information about the physical, chemical, and biological properties of soil, enabling farmers to make informed decisions regarding nutrient management, fertilizer application, and crop production. By identifying the nutrient status and fertility level of the soil, soil testing helps optimize input use, improve crop performance, and maintain long-term soil health. It also supports precision agriculture by ensuring that nutrients are applied according to crop requirements, thereby increasing productivity while minimizing environmental impacts.

Importance

- Helps in balanced fertilizer application.
- Improves nutrient use efficiency.
- Reduces production costs.
- Increases crop yield and quality.
- Prevents environmental pollution.
- Identifies soil-related problems.
- Supports site-specific nutrient management.
- Promotes sustainable agricultural practices



4. Soil Sampling Procedure

Accurate soil testing begins with proper soil sampling. The reliability of laboratory results depends largely on the quality and representativeness of the collected soil sample. A poorly collected sample may lead to incorrect fertilizer recommendations and improper soil management practices. Therefore, soil samples should be collected carefully using standardized procedures to ensure that they accurately represent the fertility status of the entire field. Proper soil sampling helps farmers obtain reliable information for balanced nutrient management, improved crop productivity, and sustainable soil health.

Steps in Soil Sampling

1. Selection of Sampling Area

The first step in soil sampling is selecting a representative sampling area. The field should be divided into uniform units based on soil type, cropping history, slope, and management practices. Each unit should be sampled separately to obtain accurate results. Avoid collecting samples from unusual areas such as compost pits, manure heaps, bunds, irrigation channels, waterlogged spots, and recently fertilized locations, as they may not represent the true fertility status of the field.

2. Collection of Soil Samples

After selecting the sampling area, remove surface litter such as leaves, grasses, and crop

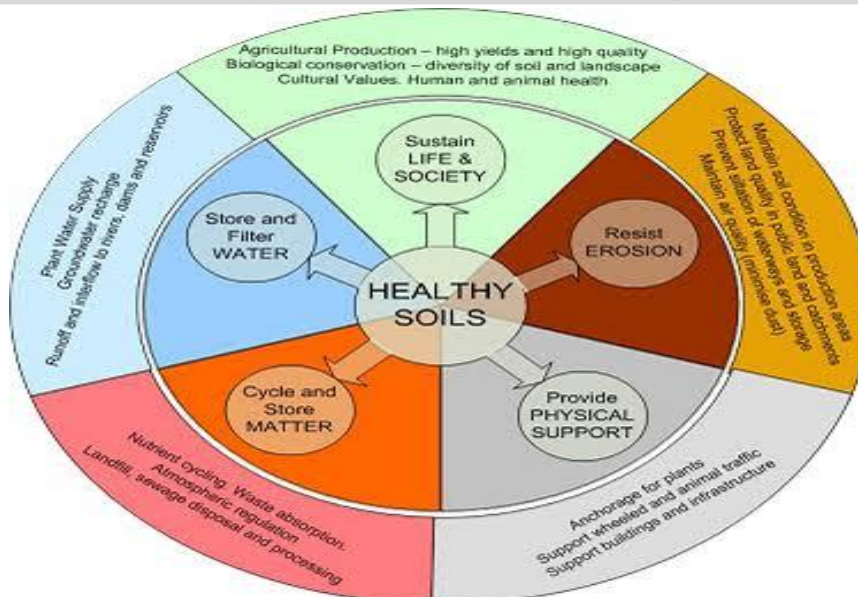
residues before collecting soil. Dig the soil to the recommended depth according to the crop, usually 0–15 cm for field crops. Collect soil samples from 10–15 randomly selected locations in a zigzag pattern using a clean auger or spade. Place all samples in a clean container for preparing a representative composite sample.

3. Preparation of Composite Sample

After collecting soil from different locations, mix all the samples thoroughly in a clean container to obtain a uniform mixture. Remove stones, roots, weeds, and other plant residues that may affect the analysis. Break large soil clods gently and use the quartering method to reduce the sample size. Finally, prepare a representative composite sample of about 500–1000 g for laboratory testing.

4. Packing and Labeling

After preparing the composite sample, dry it in the shade to remove excess moisture while preserving its properties. Pack the dried soil in a clean cloth or polythene bag to prevent contamination. Clearly label each sample with the farmer's name, field location, sampling date, crop details, and sampling depth. Proper packing and labeling ensure accurate laboratory analysis and reliable soil test recommendations.



Source: <https://www.keralasoilfertility.net>

5. Soil Health Management

Soil health management is the practice of maintaining and improving the physical, chemical, and biological properties of soil to support sustainable crop production. Healthy soil provides nutrients, stores water, supports beneficial microorganisms, prevents degradation, and enhances environmental quality. It ensures long-term soil fertility, productivity, and agricultural sustainability.

6. Components of Soil Health

A. Physical Properties

Physical properties determine the soil's ability to support plant growth by regulating root development, water movement, aeration, and nutrient availability. Healthy physical conditions improve crop productivity and overall soil performance.

1. Soil Structure

Soil structure refers to the arrangement of soil particles into aggregates. A well-structured soil provides good aeration, promotes root penetration, improves water infiltration, reduces erosion, and supports healthy plant growth. Stable soil aggregates also enhance microbial activity and nutrient availability.

2. Soil Texture

Soil texture is the proportion of sand, silt, and clay particles in the soil. It influences water-holding capacity, drainage, nutrient retention, aeration, and ease of cultivation. Different soil textures require different management practices for optimum crop production.

3. Bulk Density

Bulk density is the mass of dry soil per unit volume. High bulk density indicates soil compaction, which restricts root growth, water infiltration, and air movement. Maintaining optimum bulk density improves soil health and enhances crop productivity.

4. Water-Holding Capacity

Water-holding capacity is the ability of soil to retain water for plant use after excess water has drained away. Good water-holding capacity ensures adequate moisture availability, reduces drought stress, improves nutrient uptake, and supports healthy crop growth during dry periods.

B. Chemical Properties

Chemical properties determine the fertility status of soil and influence nutrient availability, plant growth, and overall soil productivity.

1. Soil pH

Soil pH measures the acidity or alkalinity of the soil and greatly influences nutrient availability and microbial activity. Most crops grow best in slightly acidic to neutral soils (pH 6.5–7.5), where essential nutrients are readily available for plant uptake.

2. Nutrient Content

Nutrient content refers to the availability of essential macro- and micronutrients such as nitrogen, phosphorus, potassium, zinc, iron, and boron. Adequate nutrient levels ensure healthy plant growth, improve crop yield, and maintain long-term soil fertility.

3. Electrical Conductivity (EC)

Electrical conductivity (EC) measures the concentration of soluble salts in the soil and indicates salinity levels. High EC reduces water uptake, affects nutrient absorption, inhibits plant growth, and decreases crop productivity, especially in salt-sensitive crops.

4. Organic Carbon

Organic carbon is an important indicator of soil fertility and soil health. It improves soil structure, enhances water-holding capacity, supports beneficial microorganisms, increases nutrient availability, and contributes to sustainable crop production by maintaining long-term soil productivity.

C. Biological Properties

Biological properties reflect the living organisms present in the soil that contribute to nutrient cycling, organic matter decomposition, and maintenance of soil fertility.

1. Soil Microorganisms

Beneficial soil microorganisms such as bacteria, fungi, actinomycetes, algae, and protozoa decompose organic matter, fix atmospheric nitrogen, recycle nutrients, suppress soil-borne pathogens, and improve overall soil fertility, supporting healthy plant growth and sustainable agriculture.

2. Earthworms

Earthworms are natural soil engineers that improve soil aeration, drainage, and aggregation through their burrowing activities. They decompose organic matter, enhance nutrient availability, stimulate microbial activity, and produce nutrient-rich castings that improve soil fertility and crop productivity.

3. Soil Biodiversity

Soil biodiversity includes the wide variety of microorganisms, insects, earthworms, nematodes, and other soil organisms. A diverse soil ecosystem maintains ecological balance, enhances nutrient cycling, improves soil resilience, suppresses pests and diseases, and supports sustainable agricultural productivity.

7. Practices for Soil Health Management

Maintaining soil health requires the adoption of scientific and sustainable management practices that improve soil fertility, conserve natural resources, and ensure long-term agricultural productivity. The major practices for soil health management are described below.

1. Balanced Fertilization

Balanced fertilization involves applying fertilizers according to soil test recommendations and crop nutrient requirements. Both macro- and micronutrients should be supplied in appropriate amounts to maintain soil fertility and maximize crop yield. Avoiding excessive fertilizer application improves nutrient use efficiency, reduces production costs, and minimizes environmental pollution.

2. Organic Matter Addition

The addition of organic materials such as farmyard manure (FYM), compost, vermicompost, green manure, and crop residues improves soil structure, increases organic carbon, enhances microbial activity, and boosts water-holding capacity. Organic matter also improves nutrient availability, reduces soil erosion, and promotes long-term soil fertility and sustainability.

3. Crop Rotation

Crop rotation is the practice of growing different crops in a planned sequence on the same field. It improves soil fertility, balances nutrient use, reduces pest and disease incidence, suppresses weeds, and enhances soil biological activity. Legume-based rotations also enrich soil nitrogen through biological nitrogen fixation.

4. Integrated Nutrient Management (INM)

Integrated Nutrient Management (INM) combines chemical fertilizers, organic manures, and biofertilizers to provide balanced nutrition for crops. This approach improves nutrient use efficiency, maintains soil fertility, enhances soil microbial activity, reduces dependence on chemical fertilizers, and supports sustainable agricultural production.

5. Conservation Agriculture

Conservation agriculture includes minimum tillage, crop residue retention, and crop diversification to protect soil resources. These practices reduce soil erosion, improve soil structure, conserve moisture, increase organic matter, and promote beneficial soil organisms, resulting in healthier soils and sustainable crop production.

6. Biofertilizer Use

Biofertilizers such as *Rhizobium*, *Azotobacter*, *Azospirillum*, and Phosphate Solubilizing Bacteria (PSB) naturally enhance nutrient availability by fixing atmospheric nitrogen and solubilizing phosphorus. Their use improves soil fertility, increases microbial activity, reduces chemical fertilizer requirements, and supports environmentally friendly and sustainable agriculture.

7. Soil and Water Conservation

Soil and water conservation practices, including contour farming, terracing, mulching, check dams, and rainwater harvesting, reduce soil erosion, improve water infiltration, conserve soil moisture, and prevent nutrient losses. These measures protect soil resources, improve

productivity, and strengthen climate-resilient and sustainable farming systems.

8. Soil Health Card Scheme

The Soil Health Card Scheme was launched by the Government of India in 2015 to promote balanced nutrient management and sustainable agriculture. Under this scheme, farmers receive a Soil Health Card containing information on soil pH, organic carbon, macro- and micronutrient status, along with crop-specific fertilizer recommendations. The main objectives are to provide accurate soil nutrient information, encourage balanced fertilizer use, improve soil fertility, enhance crop productivity, and reduce unnecessary fertilizer application. The scheme helps lower cultivation costs, increases nutrient use efficiency, protects the environment, and supports sustainable farming. It has benefited millions of farmers by enabling informed soil and nutrient management decisions.

CONCLUSION

Soil testing and soil health management are essential components of sustainable agriculture. Soil testing provides valuable information about nutrient status and soil fertility, enabling farmers to apply fertilizers efficiently and economically. Soil health management focuses on maintaining and improving soil physical, chemical, and biological properties through balanced fertilization, organic matter addition, crop rotation, conservation practices, and integrated nutrient management. Together, these approaches enhance soil productivity, improve crop yields, conserve natural resources, and protect the environment. Maintaining healthy soil is crucial for ensuring long-term agricultural sustainability, food security, and the well-being of future generations.

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