

Soil Fertility Management

Soil fertility is the ability of soil to supply essential nutrients to plants in the right amount, right proportion and right time for optimum growth.

Soil fertility refers to the inherent ability of soil to support plant growth by supplying essential nutrients.

Types of Soil fertility

↓
Natural or
Inherent Fertility

↓
Acquired
fertility

Natural Fertility

Fertility present in
soil by nature.
(Parent material, soil formation).

By birth nutrient status

Acquired fertility

Developed through human
activities like manuring,
irrigation, fertilization.

Not by birth.

Factors Affecting Soil Fertility.

- Soil Texture
- Soil Structure
- Biological activity
- Soil Reaction
- Climate
- Soil Organic matter
- Cation Exchange Capacity

Soil productivity

Soil productivity is the capacity of soil to produce crops under a defined management system.

Soil productivity is the capacity of soil to produce crops or yield under a defined set of management practices.

Soil fertility
ability of soil to provide supply of Essential Plant nutrient.

Soil productivity

Related to Nutrient availability

Soil Fertility

- Ability of the soil to supply essential plant nutrient.

- Related to nutrient availability.

- All fertile soil may not be productive.

- Soil fertility can be measured by soil testing.

Soil Productivity

Capacity of the soil to produce crop yield.

Fertility + Management + Climate

All productive soil are always fertile.

Measured by Crop yield
(Kg/hect) (q/hect).

Nutrients

Nutrients are the chemical compounds required by an organism.

They are converted to cellular material or used for energy through metabolic processes.

Plant Nutrition

Plant Nutrition is defined as the supply and absorption of chemical compounds required for plant growth and metabolism.

Criteria of Nutrient Essentiality

According to Arnon & Stout (1939)

1. Without the element, plant cannot complete its life cycle.

The element is directly involved in metabolism or structure.

Deficiency can only be corrected by supplying that specific element.

Total essential Plant Nutrients

- According to Arnon & Stout (1939) : 16.

In 1987 (Brown et al.):

Nickel

[17]

Based on Quantity of Nutrients Required

a) Macromineral

→ Required more than > 100 ppm.

→ 9 Nutrients.

→ Uptake → Soil.

- Primary - N, P, K, Secondary - Ca, Mg, S

Micro Nutrients

- Less than < 100 ppm.
Also called obligo Nutrients or Trace Nutrients.
→ 8 Nutrients.
→ Uptake → soil.

Beneficial Plant Nutrients

- Not essential, but enhance growth at very low concentrations.

Ex- Silicon (Si), Sodium (Na), Aluminium (Al), Cobalt (Co),
Selenium (Se), Gallium (Ga), Vanadium (V).

According to ICAR - [4]
Paddy, Silicon (Si), Sodium (Na), Cobalt (Co),
Iodine (I).

Functional Nutrients

Concepts - Nicholes (1963)

- Essential Nutrients (17) [17 + 4 = 21]
- Beneficial Plant Nutrients (4)

Essential Plant Nutrient : Role, Deficiency, and Toxicity Symptoms.

Plant uptake, $\text{N as } \text{NO}_3^-$, NH_4^+

(1) Nitrogen (N)
 Role $\rightarrow$ Promote vegetative growth $\rightarrow \text{C}_5\text{H}_{12}\text{O}_5\text{N}_4\text{Mg}$
 Essential for chlorophyll and protein formation.
 Deficiency $\rightarrow$ Yellowing of older leaves, $\vee$ shaped chlorosis.
 Stunted growth.
 Toxicity $\rightarrow$ Delayed flowering and weak stems. $\rightarrow$ Buttoning of Cauliflower.
 N present in Amino acids, nucleic acid, protoplasm, enzyme.

(2) Phosphorus (P) $\rightarrow$ Key of life.
 H_2PO_4^- , HPO_4^{2-} , PO_4^{3-}
 (R) Root development, Nitrogen fixation, Energy conversion.
 Energy transfer and seed formation.
 (D) Poor root growth. Kicker of leaf.
 Dark green or purplish leaves.

(3) Potassium (K) K^+
 (R) Water regulation.
 Disease resistance.
 (D) Yellowing and scorching of leaf margins.
 Weak stems.
 (T) May cause magnesium or calcium deficiency.

(4) Calcium (Ca)
 (R) Cell wall formation.
 Growth of root & shoot tips.
 (D) Death of growing points.
 Blossom end rot in fruits.
 (T) Role; may reduce magnesium uptake.

5. Magnesium (Mg)

- (R) Central component of chlorophyll
Activates enzymes.
- (D) Intervenal chlorosis in older leaves
- (T) may interfere with calcium uptake.

6. Sulphur (S)

- (R) Protein synthesis
Formation of certain vitamins.
- (D) Yellowing of younger leaves.
- (T) Leaf burn and reduced growth (crasses).

7. Iron (Fe)

- (R) Chlorophyll synthesis
Enzyme activation
- (D) Deficiency
Intervenal chlorosis of young leaves
- (T) Bronzing or brown spots on leaves

(8) Zinc (Zn)

- (R) Growth hormone production
Enzyme function
- (D) Small leaves, shortened internodes.
Intervenal chlorosis.
- (T) Chlorosis due to iron deficiency

Non essential Nutrient

(Ni) (Mn) ~~metals~~
 Ba Zn
 Cl Cu
 Mo Fe

9. Boron (B)
- (R) Cell division
Pollen germination
- (A) Death of terminal buds
Brittle tissues.
- (T) Yellowing and scorching of leaf tips. Apical bud
10. Copper (Cu)
- (R) Enzyme activity
Reproductive growth
- (A) Dieback of shoots
Leaf wilting
- (T) Root damage and chlorosis. (deficiency)
- (2)

On the Mobility
 • Immobility → Ca, B
 • Less mobile - S, Ni, Cl, Fe
 Mo, Mn, Zn, Cu, Fe. (New leaf)
 • Moderately mobile → Zn
 Older & new leaves.
 • Highly mobile N, P, K, Mg
 def. in → older leaves.

Mechanism of Nutrient Transport to Plants

Plants absorb nutrients from the soil solution through their roots. It occurs by three main mechanisms.

- (1) Mass flow
- Nutrients move along with water towards the roots.
- This occurs when plants absorb water during transpiration.
- It is the most important mechanism for highly soluble nutrients.

Mainly transported nutrients are Nitrate (NO_3^-), Sulphate (SO_4^{2-}), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Boron (B).

(2) Diffusion

Nutrient move from an area of higher concentration in the soil to an area of lower concentration near the roots.

This happens because roots continuously absorb nutrients, lowering their concentration around the root surface.

Mainly transported nutrients Phosphate, Zinc, Iron, potassium.

(3) Root interception

Occurs when growing roots come into direct contact with soil particles containing nutrients.

Root hairs and mycorrhizal fungi increases the effectiveness of this process.

Nutrient Calcium (Ca^{2+}), Magnesium (Mg^{2+})

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Nutrient Calcium (Ca^{2+}), Magnesium (Mg^{2+})

Factors affecting Nutrient Availability of Plants.

(1) Soil pH:

- Soil pH is one of the most important factors.
- Most nutrients are best available to plants at a pH of 6.0 to 7.5.
- Acidic soils may reduce the availability of phosphorus, calcium and magnesium.
- Alkaline soil may reduce the availability of iron, zinc, manganese and copper.

(2) Soil Moisture

- Water dissolves nutrients and helps their movement to roots.
- Too little moisture reduces nutrient uptake.
- Excess water can cause nutrient leaching and poor aeration.

(3) Soil Temperature

Warm soil promote root growth & microbial activity.
Cold soils slow down nutrient release and absorptions, especially phosphorus.

(4) Soil Aeration

- Adequate oxygen is necessary for root respiration.
- Poorly aerated or waterlogged soils restrict nutrient uptake because of poor condition of oxygen presence.

5. Organic Matter Content

- Organic matter improves soil structure, water-holding capacity, and cation exchange capacity.
- It also supplies nutrients as it decomposes.
- Heavy soil is best.

6. Microbial Activity

Soil microorganisms decompose organic matter and release nutrients.

They also help in nitrogen fixation and phosphorus solubilization.

7. Cation Exchange Capacity (CEC)

- Soils with higher CEC can retain more nutrient cations such as potassium, calcium and magnesium.

8. Nutrients Interactions

Excess of one nutrient can interfere with the uptake of another.

For ex- excess potassium may reduce magnesium uptake.

9. Water Mineralisation (↑ in warm soil)

• 1)

3)

Nutrient deficiency - Zinc.

• Soil Radiation

Soil Fertility Evaluation

It is the process of assessing the nutrients supplying capacity of soil and its ability to support healthy plant growth.

Objectives

- To determine the nutrient status of the soil.
- To identify nutrient deficiencies & toxicities.
- To improve crop yield and maintain soil health.

Methods

(1) Soil testing

- Measures available nutrients, soil pH, organic carbon, electrical conductivity and other properties.

Helps in Fertilizer recommendations.

(2) Plant Analysis

Determine the nutrient content in plant tissues.
Reflect the actual nutrient uptake by plants.
Useful for diagnosing hidden deficiencies.

(3) Visual diagnosis

Based on deficiency or toxicity symptoms shown by plants.

(4) Biological Methods

Include greenhouse or field experiments.
Evaluate crop response to added nutrients.

- Pot culture tests & field trials.

Important Parameters Evaluated

- Soil pH
- Organic matter content
- CEC (Cation Exchange Capacity)
- Salinity & Sodicity

Soil Testing

Soil testing is the process of collecting a soil sample and analyzing it in a laboratory to evaluate its physical, chemical and biological properties.

Objectives

- To determine the available nutrient content of the soil.
- To identify nutrient deficiencies or excesses.
- To measure soil pH, salinity and organic matter.
- To recommend suitable fertilizers.
- To improve crop yield and maintain soil health.
- To ensure balance fertilization for crops.

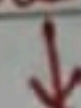
Steps in soil testing

Right Fertilizer Importance

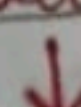
Soil Sampling



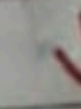
Sample preparation



Laboratory Analysis



Interpretation of Results



Fertilizer Recommendation

- Improves crop productivity
- Saves input cost
- Prevent nutrient deficiencies and toxicities
- Protects the environment
- Maintain long term soil fertility