

Introduction to Plant Nutrition

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Key concepts, essential elements, uptake mechanisms, and practical considerations

1. Why Nutrition Matters for Plants

- **Growth & Development:** Supplies the building blocks for cells, tissues, and organs.
- **Metabolism:** Provides enzymes, co?enzymes, and electron carriers needed for photosynthesis, respiration, and biosynthesis.
- **Stress Resistance:** Adequate nutrition improves tolerance to drought, pests, disease, and temperature extremes.
- **Yield & Quality:** Determines the quantity (biomass, fruit) and quality (nutrient content, flavor) of the harvest.

2. Classification of Plant Nutrients

Category	Elements	Primary Role	Typical Deficiency Symptom
Macronutrients (required in large amounts)	N, P, K, Ca, Mg, S	Structural components, energy transfer, osmotic regulation, enzyme activation	Stunted growth, chlorosis, necrosis, poor root development
Micronutrients (required in trace amounts)	Fe, Mn, Zn, Cu, B, Mo, Cl, Ni	Cofactors for enzymes, hormone synthesis, electron transport	Interveinal chlorosis, leaf tip burn, distorted growth
Beneficial Elements (non ?essential but sometimes helpful)	Si, Na, Co, Al	Strengthen cell walls, improve stress tolerance	Usually no clear visual symptoms

3. The Three Primary Macronutrients

Nutrient	Functions	Common Forms in Soil/Fertilizer	Deficiency Signs
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Nitrogen (N)	Amino acids, proteins, nucleic acids, chlorophyll	Nitrate (NO ₃ ⁻), ammonium (NH ₄ ⁺), urea	Uniform leaf yellowing, reduced leaf size, poor vegetative growth
Phosphorus (P)	ATP, nucleic acids, phospholipids, root development	Orthophosphate (H ₂ PO ₄ ⁻ / HPO ₄ ²⁻)	Dark green or purplish foliage, delayed maturity, weak root system
Potassium (K)	Osmoregulation, enzyme activation, carbohydrate transport	Potassium ion (K ⁺)	Marginal leaf necrosis, weak stems, increased susceptibility to disease

4. Nutrient Uptake Pathways

Pathway	Mechanism	Key Points
Root Absorption	Diffusion, mass flow, active transport through root hairs and epidermal cells	Dependent on root surface area, soil moisture, pH, and mycorrhizal associations
Foliar Uptake	Direct absorption through leaf cuticle and stomata (often via sprays)	Useful for micronutrients and rapid correction of deficiencies
Mycorrhizal Symbiosis	Fungal hyphae extend beyond root zone, increasing surface area for P, Zn, Cu, etc.	Enhances uptake especially in low fertility soils
Rhizosphere Processes	Mineralization, immobilization, chelation, redox reactions	Soil microbes convert organic N to NH ₄ ⁺ /NO ₃ ⁻ , affect availability of Fe, Mn, etc.

5. Factors Influencing Nutrient Availability

1. Soil pH

- Acidic soils (<5.5) limit Ca, Mg, Mo, and increase Al toxicity.
- Alkaline soils (>5.5) limit Fe, Mn, Zn, and Cu availability.