



## FOLIAR NUTRITION, SOILLESS CULTIVATION, AND NUTRIENT DYNAMICS IN PLANTS

M. C. Narendran<sup>1\*</sup>, S. Nadaradjan<sup>1</sup>, K. Manoj kumar<sup>1</sup>, P. Kav<sup>2</sup>,  
O.M. Ramiashree<sup>2</sup>, S. Muthu Mari<sup>2</sup>, B. S. M. Narmada<sup>2</sup>.

*Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal UT of Puducherry.*

*\*Corresponding Author Mail ID: narenmc2k03@gmail.com*

### Abstract:

Foliar nutrition, an effective supplement to soil and soilless fertilization, plays a critical role in plant growth and productivity. This review examines the principles and applications of foliar feeding, with emphasis on droplet size and the use of wetting agents for optimal nutrient absorption. The paper further explores soilless cultivation techniques such as hydroponics and aeroponics, providing insights into their advantages and limitations.

Essential nutrient interactions such as ion competition, antagonism, and synergism are discussed in the context of nutrient availability. Finally, the mechanisms of mineral uptake and transport in plants are reviewed, including major theories of ion uptake such as passive and active transport, carrier-mediated mechanisms, and electrochemical gradients.

**Keywords:** Nutrition, growth, development, soilless culture, plant uptake, Hydroponics, Aeroponics

### 1. Introduction

The increasing demand for sustainable agricultural practices has highlighted the significance of efficient nutrient delivery systems. Foliar feeding, a method of supplying nutrients directly through leaves, complements root uptake and offers several agronomic advantages. Simultaneously, the

emergence of soilless cultures such as hydroponics and aeroponics has revolutionized controlled environment agriculture. Understanding the physiological and chemical dynamics involved in nutrient absorption and transport is crucial for optimizing plant nutrition.

### 2. Significance of Foliar Nutrition

Foliar nutrition allows for rapid correction of nutrient deficiencies, especially under conditions where root uptake is impaired due to pH imbalances, soil compaction, or drought.

Key advantages include:

- Immediate nutrient availability
- Reduced leaching losses
- Lower application rates compared to soil fertilization

Foliar feeding is particularly effective for micronutrients like iron (Fe), manganese (Mn), zinc (Zn), and boron (B), which often become unavailable in certain soil conditions (Fernandez et al., 2013).

### 3. Foliar Nutrient Droplet Size and Absorption Efficiency:

The size of nutrient droplets significantly influences their adhesion, spreading, and penetration on the leaf surface. Smaller droplets (100–200 microns) provide greater surface coverage and better

penetration through stomata and cuticular pores, but they are more prone to evaporation.

Factors affecting absorption efficiency:

- Droplet size and uniformity
- Surface tension
- Leaf surface morphology
- Environmental conditions (humidity, temperature)

Smaller droplet sizes combined with surfactants enhance nutrient uptake, particularly under low humidity conditions (Schonherr & Bukovac, 1972).

#### 4. Role of Wetting Agents in Nutrient Entry:

Wetting agents or surfactants reduce the surface tension of foliar sprays, allowing droplets to spread uniformly and penetrate more effectively.

Types of surfactants:

- Nonionic (most compatible with nutrients)
- Anionic (can increase phytotoxicity)
- Cationic (rarely used due to potential plant damage)

These agents enhance adhesion to hydrophobic leaf surfaces, increase contact time, and promote the infiltration of nutrients through stomatal openings and the cuticle (Wagner et al., 2000).

#### 5. Soilless Culture: Hydroponics and Aeroponics:

Soilless cultivation systems provide a controlled environment that eliminates soil-related constraints.

##### 5.1 Hydroponics:

Hydroponics involves growing plants in nutrient-rich water solutions. Advantages:

- Precise nutrient management
- Reduced water usage
- Rapid growth and higher yields

Challenges include careful monitoring of pH and electrical conductivity (EC), and a higher initial setup cost (Resh, 2012).

##### 5.2 Aeroponics:

Aeroponics suspends plant roots in air and sprays them with nutrient mist. Benefits:

- Maximum oxygen availability to roots
- Efficient water and nutrient use
- Faster nutrient uptake

It requires high maintenance and is vulnerable to system failures (Stoner & Clawson, 1998).

#### 6. Nutrient Availability: Ion Competition, Antagonism, and Synergism:

Nutrient interactions influence uptake efficiency and plant health.

##### 6.1 Ion Competition:

Occurs when similar ions compete for uptake sites. Example:  $K^+$  and  $NH_4^+$  compete for the same channels.

##### 6.2 Antagonism:

One nutrient interferes with the uptake or utilization of another. Example: Excessive phosphorus can reduce zinc absorption.

##### 6.3 Synergism:

The presence of one nutrient enhances the uptake of another. Example: Adequate nitrogen improves iron uptake.

Understanding these interactions is vital for nutrient formulation (Marschner, 2012).

#### 7. Mechanisms of Mineral Uptake and Translocation:

##### 7.1 Ion Uptake:

- Passive Transport: Driven by diffusion and electrochemical gradients
- Active Transport: Requires ATP for nutrient transport against gradients
- Carrier-Mediated Transport: Specific proteins facilitate ion passage

## 7.2 Translocation:

- Xylem: Transports water and minerals from roots to shoots
- Phloem: Moves organic nutrients and some minerals bidirectionally

Transpiration rate, root pressure, and source-sink dynamics affect translocation (Taiz & Zeiger, 2010).

## 8. Theories Related to Ion Uptake:

Key theories explaining nutrient uptake:

- Ion Exchange Theory: Exchange of ions between soil and root surface
- Mass Flow: Movement of nutrients with water toward root surface
- Diffusion: Movement of nutrients from high to low concentration
- Carrier Concept Theory: Proteins selectively transport ions across membranes

These mechanisms collectively ensure efficient nutrient uptake and transport.

## 9. Conclusion:

Foliar nutrition, when combined with appropriate droplet size and surfactants, can significantly enhance nutrient uptake efficiency. Soilless systems like hydroponics and aeroponics offer solutions for modern, high-efficiency agriculture. A thorough understanding of nutrient interactions and transport mechanisms is essential for formulating effective fertilization strategies and achieving sustainable crop productivity.

## References:

- Fernandez, V., Eichert, T., Del Rio, V., Lopez-Casado, G., Heredia-Guerrero, J.A., Abadia, A., & Heredia, A. (2013). Leaf surface characteristics affect foliar nutrient uptake: a review. *Frontiers in Plant Science*, 4, 289.
- Marschner, P. (2012). *Marschner's Mineral Nutrition of Higher Plants* (3rd ed.). Academic Press.
- Resh, H. M. (2012). *Hydroponic Food Production*. CRC Press.
- Schönherr, J., & Bukovac, M. J. (1972). Penetration of stomata by liquids. *Plant Physiology*, 49(5), 813–819.
- Stoner, R. J., & Clawson, J. E. (1998). Aeroponics: Innovative technology for high quality crop production. *Acta Horticulturae*, 468, 219–225.
- Taiz, L., & Zeiger, E. (2010). *Plant Physiology* (5th ed.). Sinauer Associates.
- Wagner, G. J., Mulready, P., & Hoffmann-Benning, S. (2000). Surfactant and foliar nutrient interactions in agriculture. *Journal of Plant Nutrition*, 23(3), 283–297.