4. Ion Movement in Soil and Root Absorption

The essential plant mineral nutrient elements that are absorbed by plant roots exist in the soil solution as ions.

The ionic forms for the essential plant mineral nutrient elements are:

Major Element	**Ionic Form(s)**
Nitrogen (N)	NH_4^+ and NO_3^-
Phosphorus (P)	$H_2PO_4^-$, HPO_4^{2-}
Potassium (K)	K^+
Calcium (Ca)	Ca^{2+}
Magnesium (Mg)	Mg^{2+}
Sulfur (S)	SO_4^{2-}
Micronutrient	
Boron (B)	BO_3^{3-}
Chlorine (Cl)	Cl^-
Copper (Cu)	Cu^{2+}
Iron (Fe)	Fe^{2+}, Fe^{3+}
Manganese (Mn)	Mn^{2+}
Molybdenum (Mo)	MoO_4^{2-}
Zinc (Zn)	Zn^{2+}

Ion absorption by plant roots is determined by both root physiology and the mobility of ions in the soil itself and within the soil solution. The nature of the movement of these ions in the soil and soil solution affects plant growth, crop yield, and product quality.

The three processes involved in ion movement in the soil that determine their availability for plant root uptake are:

- mass flow
- diffusion
- root interception

a. Mass flow is the movement of dissolved ions in water within the soil profile, downward movement due to rainfall and applied irrigation water, or upward movement by water evaporation from the soil surface, with this downward/upward movement occurring in the soil mass through its pores. The major ions moved primarily by mass flow are the nitrate (NO_3^-) and chloride (Cl^-) anions, and to a moderate degree the sulfate (SO_4^{2-}) anion, plus the cations, potassium (K^+) and magnesium (Mg^{2+}). Also, other ions may be carried in the moving soil water, depending on the physical and chemical characteristics of the soil and the concentration and characteristic of that element in the soil.

b. Diffusion is the movement of ions within water films that exist around soil particles, the driving force being the ion concentration gradient, always moving from an area of high concentration to an area of lower concentration. Most ions in solution are moved by

diffusion, the movement occurring in very short distances around and between the soil particles.

c. Root interception occurs due to the growth of roots through the soil that increases root surface contact with soil particles, thereby increasing the opportunity for ion absorption.