

Basic Concepts of Soil Fertility



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Basic Concepts of Soil Fertility:

1. 17 essential elements

- function
- form taken up
- mobility in plant

2. Nutrient uptake

- mechanisms
- effect of soil characteristics

3. Cation exchange

- factors affecting
- relative magnitude

Essential nutrients

- Structural

- Carbon

- Hydrogen

- Oxygen

Essential nutrients

- Primary
 - Nitrogen
 - Phosphorus
 - Potassium

Essential nutrients

- Secondary
 - Calcium
 - Magnesium
 - Sulfur

Essential nutrients

- **Micronutrients**
 - Iron
 - Manganese
 - Copper
 - Zinc
 - Boron
 - Molybdenum
 - Chlorine
 - Nickel

Essential nutrients

- Beneficial or Enhancing
 - Sodium
 - Silicon
 - Cobalt
 - Selenium
 - Aluminum

Sources of nutrients to plants

1. Soil solution

- ionic form
- low concentration
- highly buffered

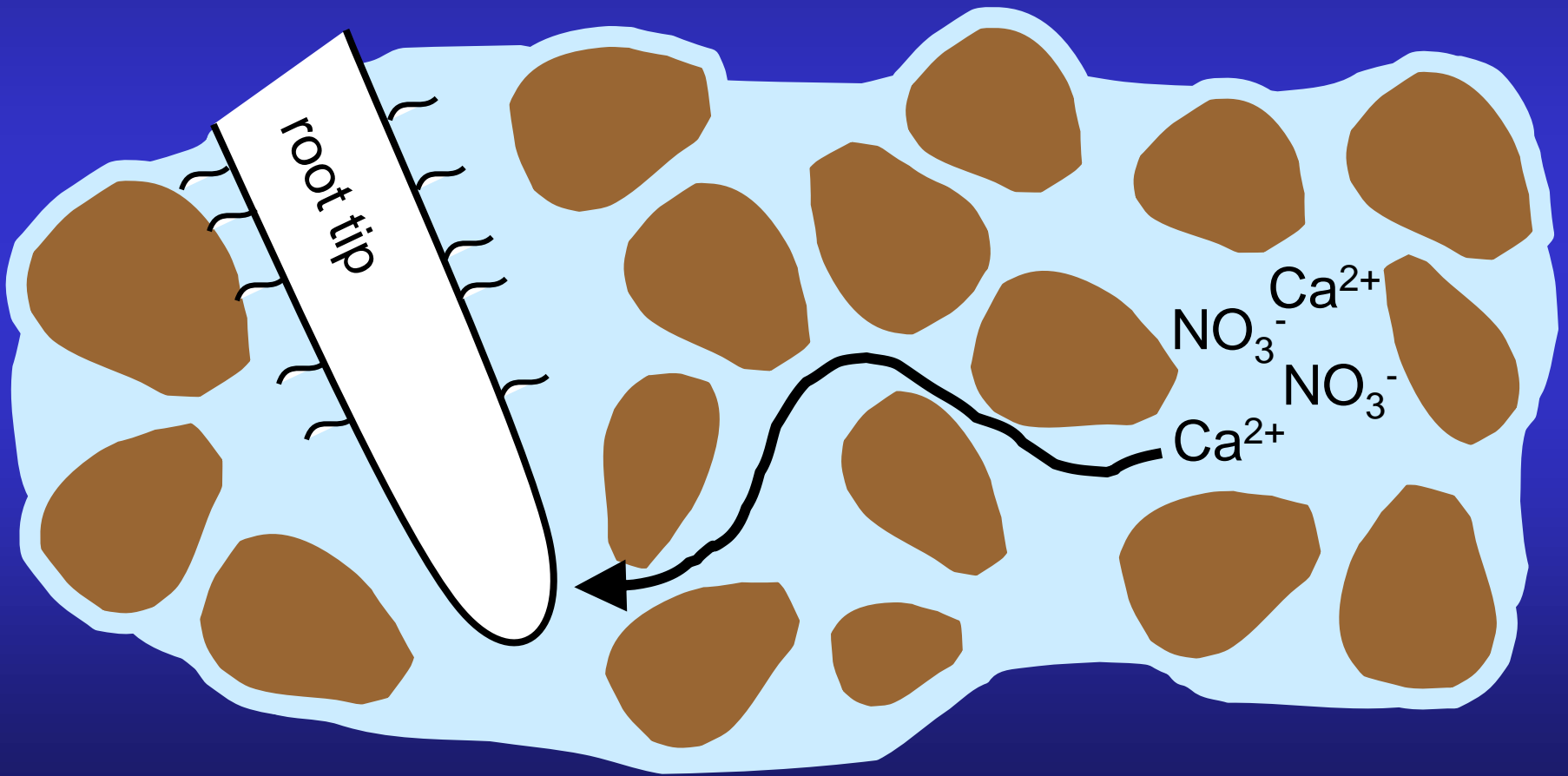
2. Contributors to the soil solution

- exchange sites on clay and organic matter
- organic matter and microorganisms
- soil rocks and minerals
- atmosphere and precipitation
- fertilizer and other additions

Movement of ions from soils to roots

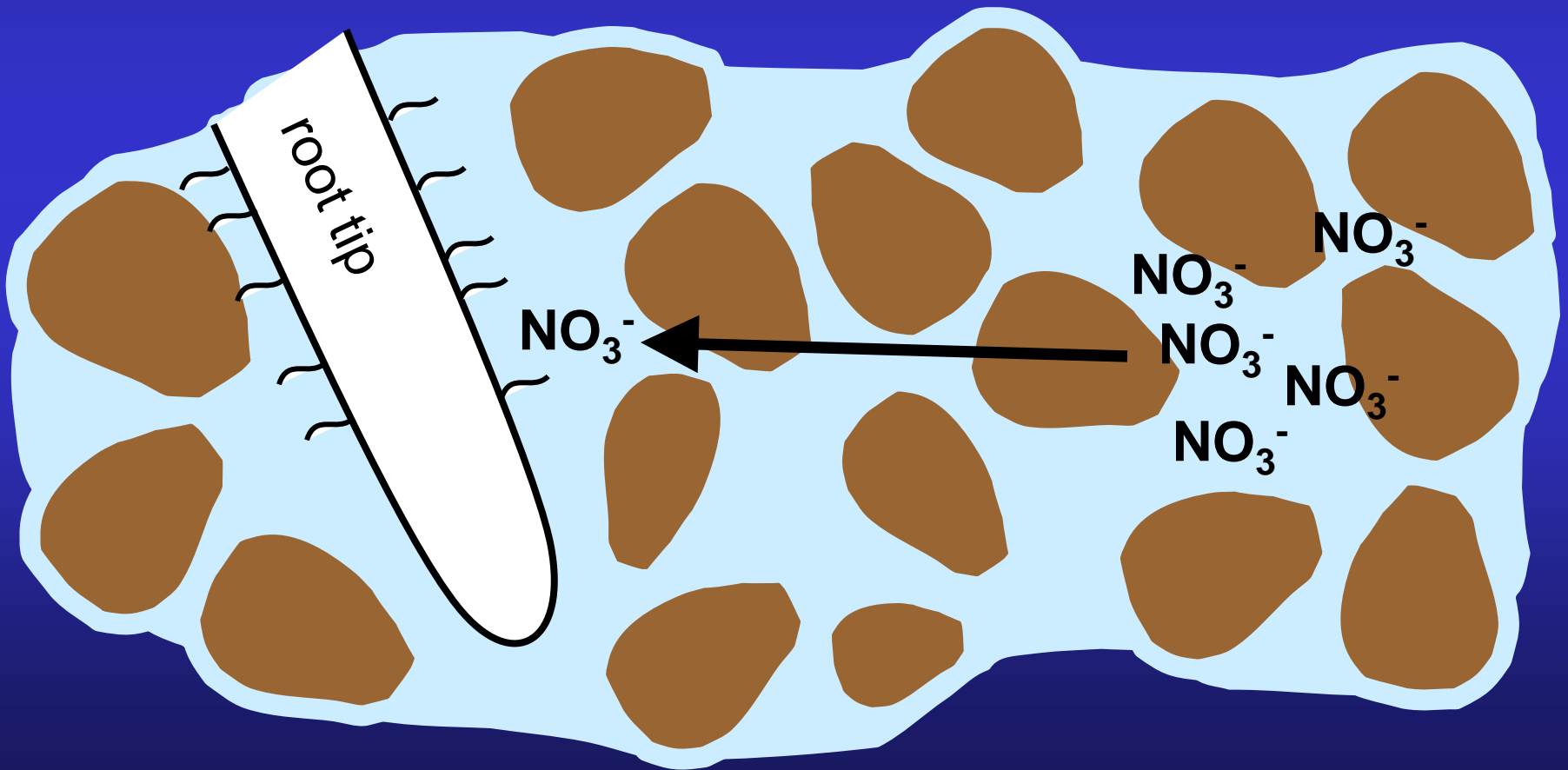
- Root interception
- Mass flow
- Diffusion

Mass flow – dissolved nutrients move to the root in soil water that is flowing towards the roots

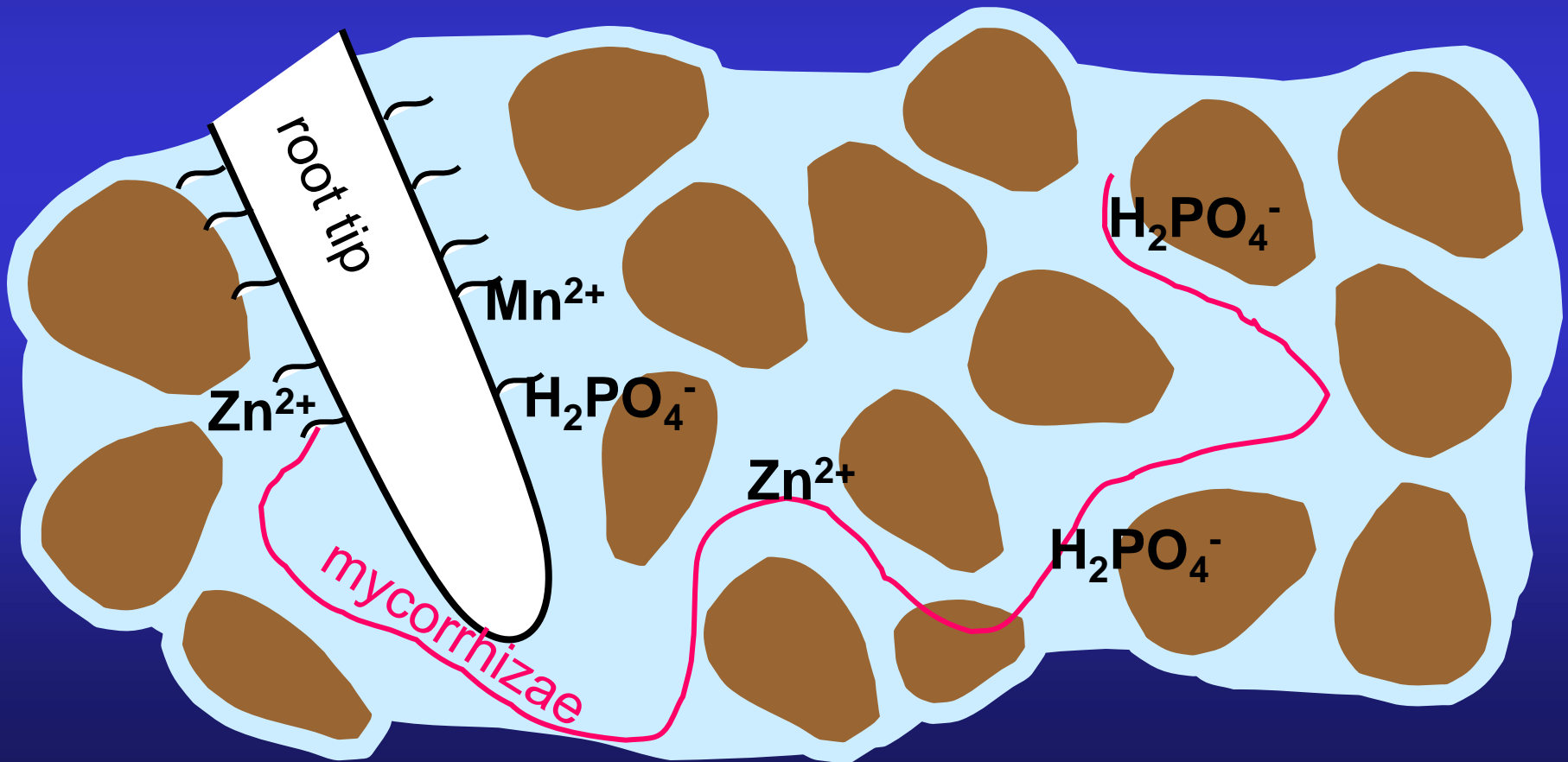


Diffusion – nutrients move from higher concentration in the bulk soil solution to lower concentration at the root;

- In the time it takes NO_3^- to diffuse 1 cm, K^+ diffuses 0.2 cm, and H_2PO_4^- diffuses 0.02 cm



- Root interception** – roots obtain nutrients by physically contacting nutrients in soil solution or on soil surfaces;
- roots contact ~1% of soil volume;
 - mycorrhizal infection of root increase root-soil contact



Principal ways in which ions move from soil to the roots of corn

Nutrient	Amount of Nutrient Required for 150 bu/a of Corn (lb/a)	Percentage Supplied by		
		Root Interception	Mass Flow	Diffusion
N	170	1	99	0
P	35	3	6	94
K	175	2	20	78
Ca	35	171	429	0
Mg	40	38	250	0
S	20	5	95	0
Cu	0.1	10	400	0
Zn	0.3	33	33	33
B	0.2	10	350	0
Fe	1.9	11	53	37
Mn	0.3	33	133	0
Mo	0.01	10	200	0

Barber, *Soil Bionutrient Availability*, (1984). Diffusion estimated be difference between total nutrient need and nutrient supply by root interception & mass flow

Ion absorption by plants:

1. Passive uptake

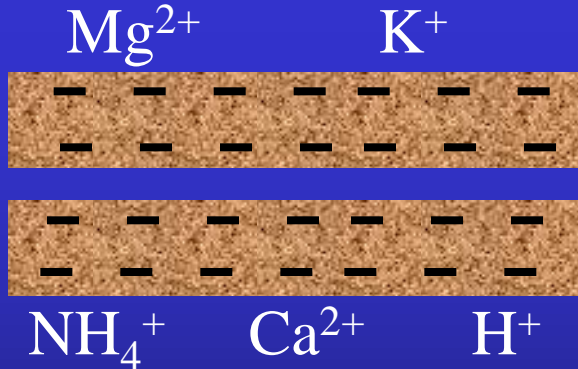
- diffusion
- ion exchange

2. Active ion uptake

- ion carriers
- selective / competitive

Cation Exchange Capacity (CEC)

- Cations – positively charged ions eg. K^+
- CEC – soil property
 - Ability of soil to hold cations
 - Nutrients or other chemicals (herbicides)



- Units are meq/100 g or $cmol_c/kg$
 - Number is the same regardless of units

Importance of CEC

- Nutrient retention
- Nutrient availability
- Act as buffer
- Control levels of waste disposal
- Control levels of herbicide

Soil properties that affect CEC

- Amount of clay
- Amount of organic matter
- pH
- Type of clay
- Estimated by summing exch. Ca + Mg + K

$$\text{Est. CEC} = \frac{\text{ppm Ca}}{200} \times \frac{\text{ppm Mg}}{122} \times \frac{\text{ppm K}}{391} \times \frac{5 \text{ g}}{\text{wt. of soil in 5 g scoop}}$$

CEC range for various soil textures

Texture	CEC (meq/100g)
Sands (light colored)	3 – 5
Sands (dark colored)	10 – 20
Loams	10 – 15
Silt loams	15 – 25
Clays and clay loams	20 – 50
Organic soils	50 – 100

Determining nutrient need:

- Visual symptoms
- Plant analysis
- In-field plant tests
- In-field soil “quickkit” tests
- Soil tests

Describe how the following soil characteristics affect nutrient availability:

- Texture
- Structure
- Drainage/aeration
- Soil moisture
- Organic matter
- CEC



Questions?