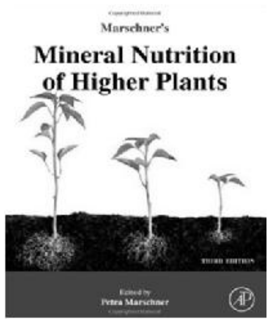
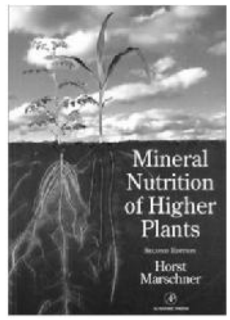
http://smtom.lecture.ub.ac.id/
Password:sm-plantnut

PLANT NUTRITION LECTURE 1: INTRODUCTION





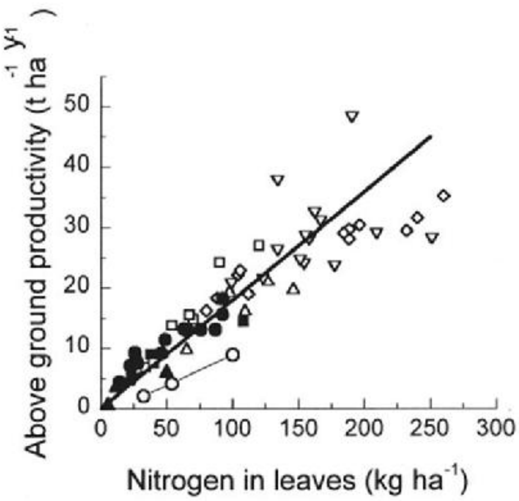
"We are made for loving. If we don't love, we will be like plants without water."
— Desmond Tutu

http://www.ebook3000.com/Marschner-s-Mineral-Nutrition-of-Higher-Plants--Second-Edition_57063.html

LECTURE FLOW

- Plant Growth
- Nutrient Characteristics
  - Ion diameter, Valency ,Coefficient Diffusion, Concentration (concentrations of individual ions & relative proportions of individual ion concentrations) & total concentration of salts (EC or osmotic potential)
- Environmental Factors
  - Light, Temperature, Water, O_2, pH, CO_2 concentration & rooting medium volume
- Plant Species

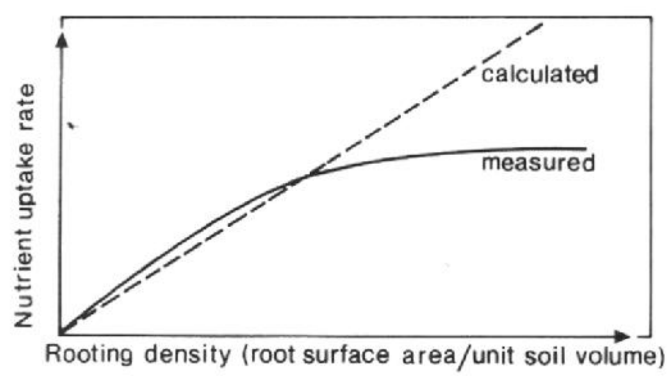
I. Plant Growth
1. Aboveground biomass



Pinus Radiate(△▽◇), *Eucalyptus grandis* & *Eucalyptus globules* (□), *Danthonia richardsonii* (▲), *Triticum aestivum* (■) (Austin *et al.*, 1980); *Lolium perenne* (●) & pasture (▼)

In Evans, J.R. and Edwards, E., 2001

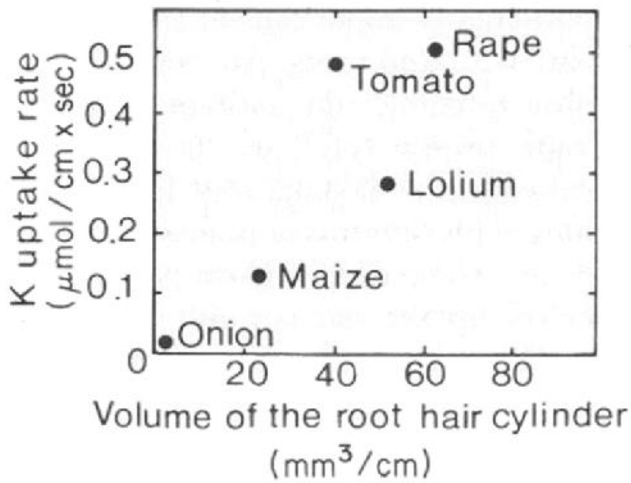
2. Root Growth



Relationship between rooting density and uptake rate of nutrients delivered by diffusion

(Marschner, 1986)

3. Root hair volume



Rate of potassium uptake per unit length of root in relation to the volume of the root hair cylinder. The plant species were grown in a silt loam with 21% clay (Modified from Jungk et al., 1982)

II. Nutrient Characteristics

1. Ion diameter

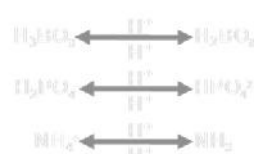
Relationship between ion radius and uptake of alkali cations in barley roots

Ion	diameter (nm)	Uptake rate (µmol g^{-1} fresh wt per 3h)
Cesium	0.31	12
Potassium	0.33	26
Sodium	0.36	15
Lithium	0.38	2

2. Valency

The uptake rate often increases in the following order:

- Uncharged molecules > Cat^{+}
- An^{-} > Cat^{2+}, and An^{2-} > Cat^{3+} & An^{3-}



3. Coefficient Diffusion (D)

$F = -D(¢C/¢x)$

$NH4^+$ Y $NO3^-$ uptake

Ion	Min.	Max.
Cations		
Na^+	1.10^{-7}	1.10^{-5}
K^+	2.10^{-7}	2.10^{-6}
Rb^+	6.10^{-12}	7.10^{-6}
NH_4^+	4.10^{-8}	1.10^{-6}
Ca^{+2}	3.10^{-8}	3.10^{-7}
Zn^{+2}	3.10^{-10}	2.10^{-7}
Mn^{+2}	3.10^{-8}	2.10^{-7}
Anions		
NO_3^-	5.10^{-7}	1.10^{-5}
Cl^-	3.10^{-7}	1.10^{-5}
$H_2PO_4^-$	1.10^{-14}	4.10^{-9}

Table. Range of measured values for the effective diffusion coefficient $Cm^{-2}.s^{-1}$) of various ions in soil (summarized from several authors by Baber, 1974; Fried and Broeshart, 1967)

4. Concentration of Nutrients: NO_3^-

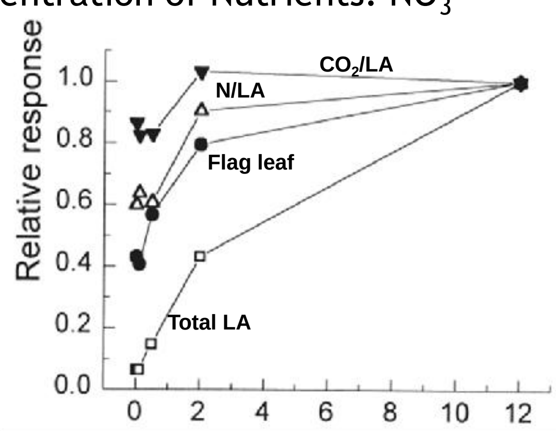
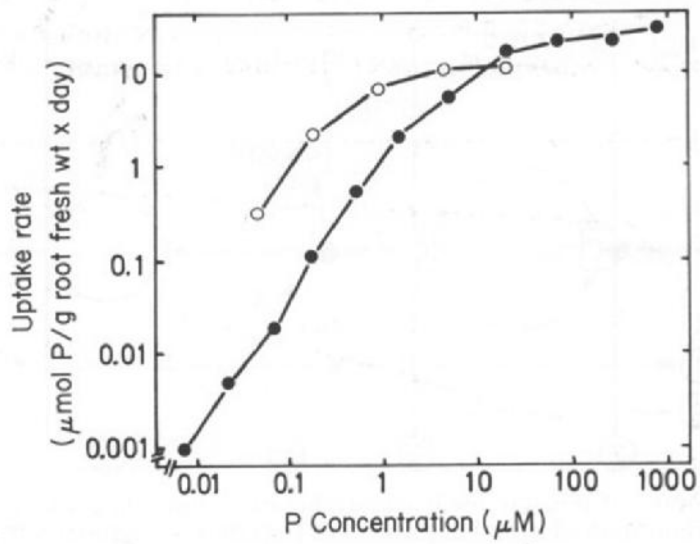
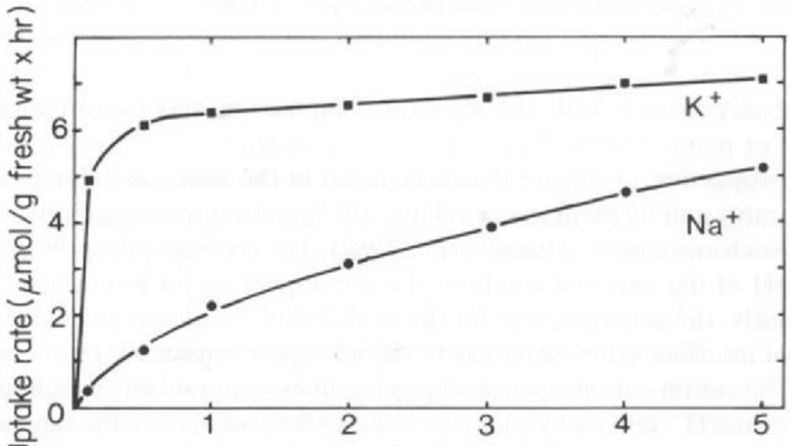


Figure 1 Nitrate concentration applied (mM)

Responsiveness of total area (□), flag leaf area (●), nitrogen content per unit leaf area (∆) and photosynthetic rate per unit leaf area (▼) of wheat plants grown with varying concentrations of nitrate (Evans, 1983).

Phosphorus


Uptake rate
(μmol P/g root fresh wt x day)
10
1
0.1
0.01
0.001
0.01
0.1
1
10
100
1000
P Concentration (μM)


Uptake rate (μmol/g fresh wt x hr)
6
4
2
0
1
2
3
4
5
Concentration (mM)
K+
Na+

5. Interaction between ions

- Competition (Antagonism): one ion inhibits the absorption of another ion
  - Ion hydration radius K^+=5.32, Rb^+=5.90, Cs^+=5.05.
- Synergism: one ion enhances the absorption of another ion.

Interaction between uptake of NH_4^+ and K^+ in Maize roots				
$(NH4)_2SO_4$ (mM)	Content in roots (µmol.g^{-1} fresh wt)			
	$NH4^+$		K^+	
	$-K^+$	$+K^+$	$-K^+$	$+K^+$
0	6.9	6.7	8.2	53.7
0.15	7.3	7.1	6.7	48.4
0.5	17.1	13.5	8.9	41.1
5	29.4	31.5	9.3	27.1

Effect of K^+ and Ca^{2+} on the Uptake of Labeled Mg^{2+} (^{28}Mg) by Barley Seedlings[a]

	Mg^{2+} Uptake (µeq Mg^{2+} $(10\ g)^{-1}$ fresh wt $(8\ h)^{-1}$)		
	$MgCl_2$	$MgCl_2 + CaSO_4$	$MgCl_2 + CaSO_4 + KCl$
Roots	165	115	15
Shoots	88	25	6.5

Competition between:
- Cation versus Cation
- Anion versus Anion
- Same valence
- Different valence

Effects of Nitrate Concentrations in the Nutrient Solution on Chloride Contents in Roots and Shoots of Barley Plants[a]

Concentration in nutrient solution (mM)		Chloride content (μmol g^{-1} fresh wt)	
Cl^-	NO_3^-	Roots	Shoot
1	0	52	93
1	0.2	26	73
1	1.0	13	54
1	5.0	9	46

Synergism

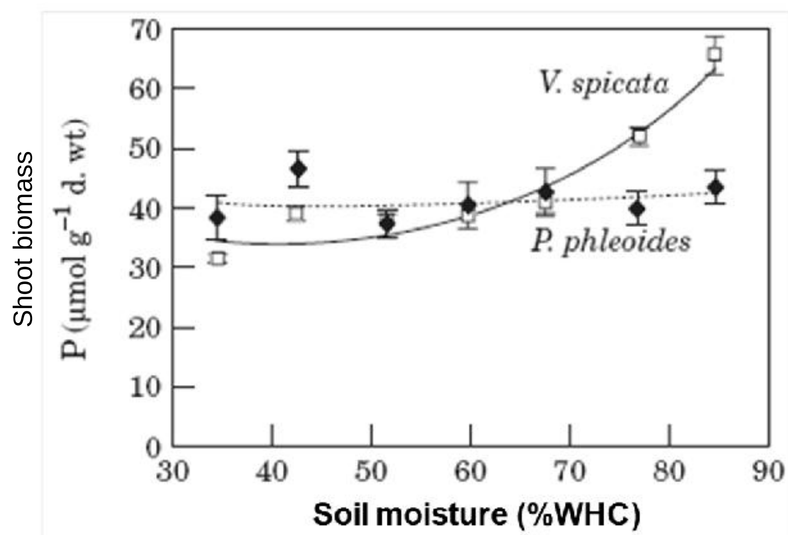
- Anions promote cations uptake
- Divalent cations promote monovalent cations

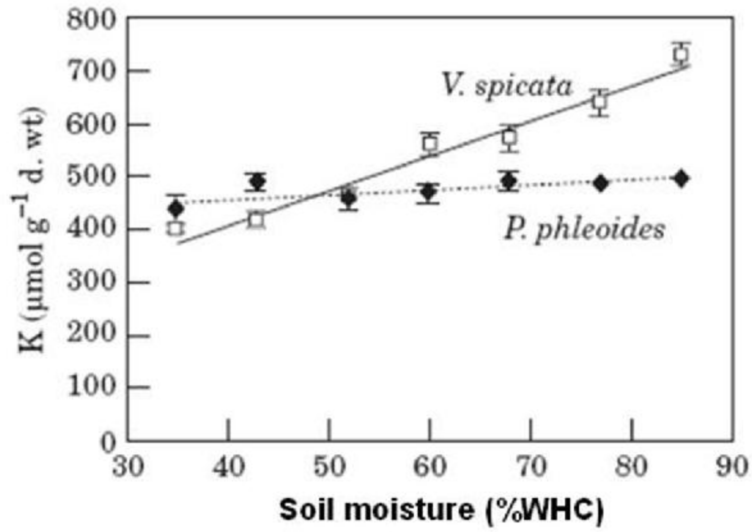
Effect of Ca^{2+} on the Rates of K^+ and Cl^- Uptake in Barley Roots. External pH 5.0

External solution (mM)	Uptake rate (μeq g^{-1} dry wt $(2\ h)^{-1}$)			
	K^+ Influx	K^+ Net uptake	Cl^- Influx	Cl^- Net uptake
0.1 KCl	116 ± 3	117 ± 6	35 ± 1	34 ± 4
0.1 KCl + 1.0 $CaSO_4$	137 ± 2	140 ± 7	53 ± 3	52 ± 4

III. Environmental Factors

1. Soil water content

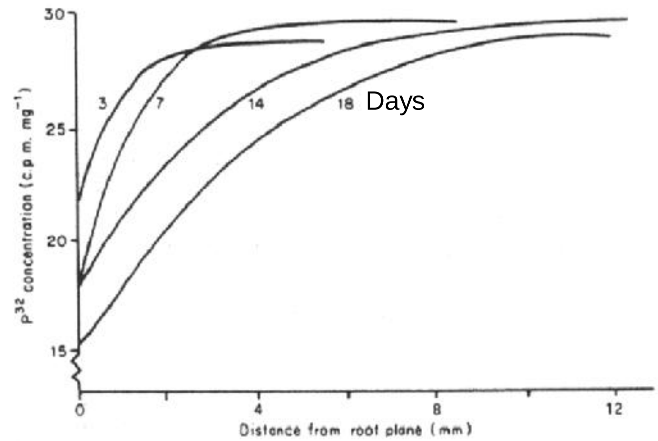




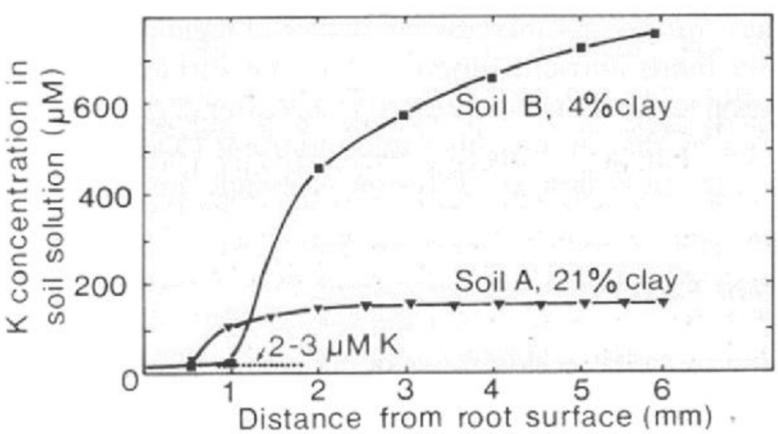
Water

Nutrients	Treatment (% Field Capacity)		
	100	70	40
% N	1.47a	1.38ab	1.10b
% K	0.64a	0.59ab	0.51b
% N	0.41a	0.35ab	0.28b
% P	0.25a	0.23a	0.22a
% S	0.91a	0.81a	0.80a
% Ca	0.70a	0.64a	0.48a
% Mg	0.70a	0.64a	0.59a

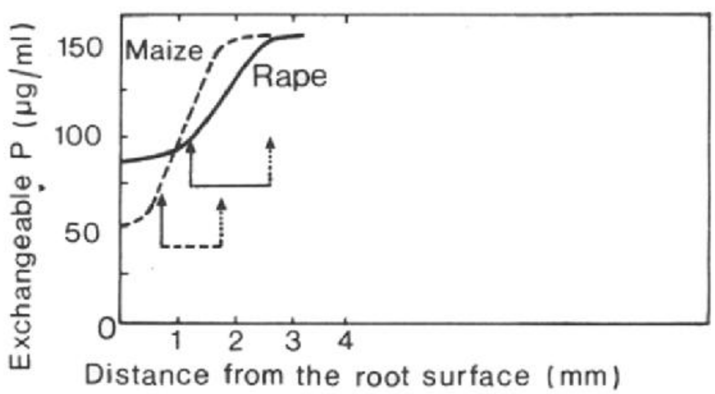
2. The distance of Nutrients from roots



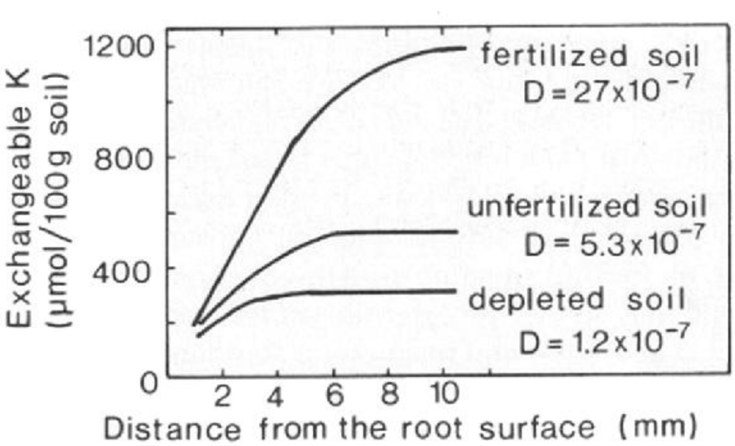
Development of depletion zones for phosphate around an actively absorbing root (figures on curves represent days from start of experiment) (From Bagshaw et al., 1972)



The distance of Nutrients from roots

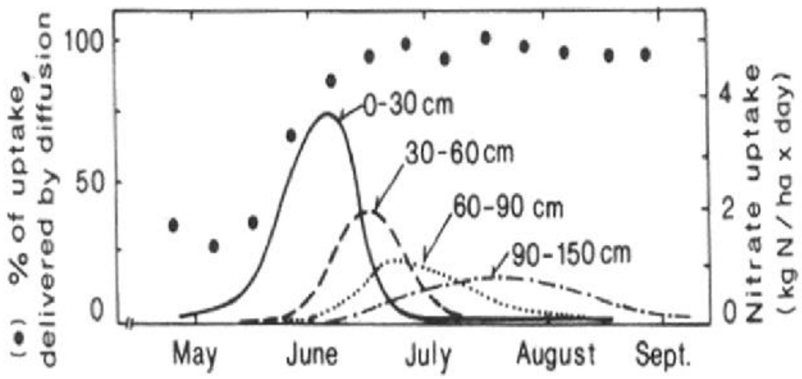


Concentration profile of phosphate around individual roots of maize and rape growing in a sandy soil. Solid arrows denote average and dotted arrows maximal root hair length (Modified from Hendriks et al., 1981)



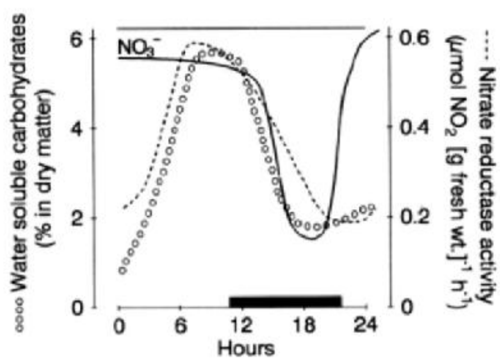
Concentration profile of potassium around a maize root grown in a silt loam soil with various levels of exchangeable potassium (D = diffusion coefficient expressed as square cm per second) (Modified from Jungk et al., 1982)

3. Soil depth



Delivery of nitrate nitrogen to sugar beet plants as a function of soil depth (cm) and time. Soil: luvisol derived from loess (Bassed on Strebel et al., 1983)

4. Diurnal fluctuations in nitrate uptake

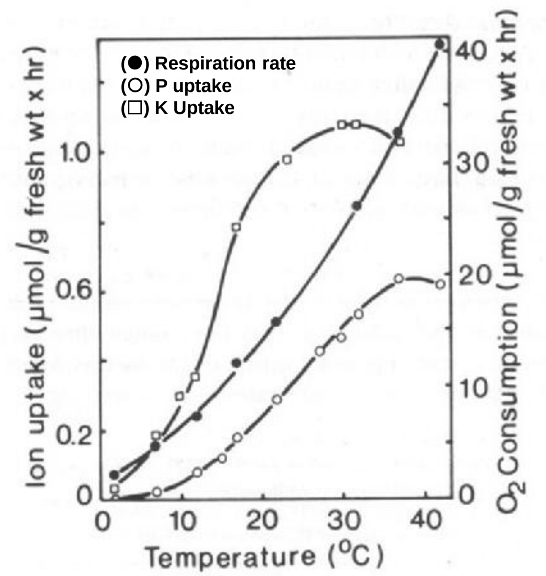


Effect of light on nutrient uptake in rice (Relative nutrient uptake)

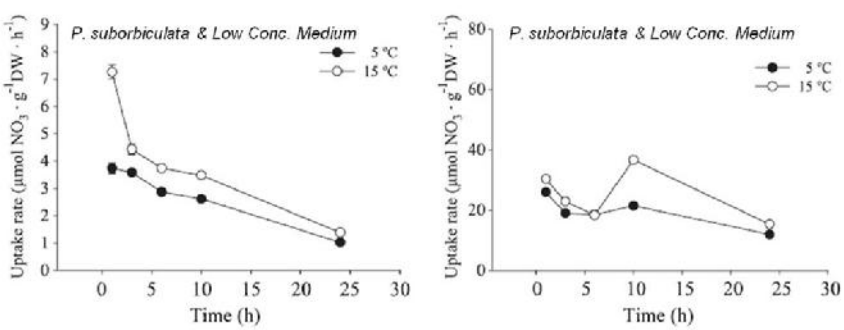
LI	NH4+	$H_2PO_4^-$	K^+	Ca_2^+	Mg_2^+	Mn_2^+	SiO_2
100	100	100	100	100	100	100	100
58	58	76	78	107	103	85	85
56	40	33	41	64	68	46	65
5	17	15	13	49	40	22	35

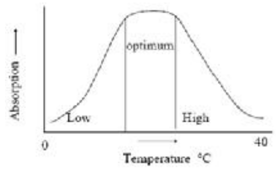
LI = Light Intensity

5. Temperature

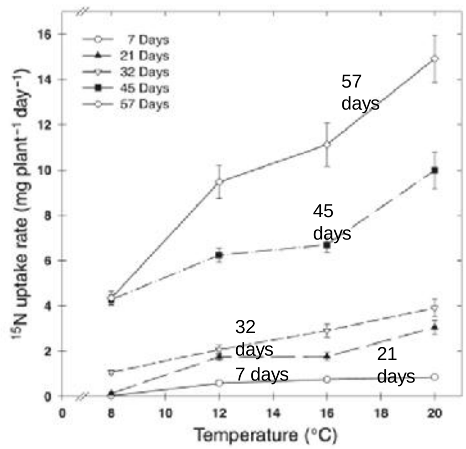


After Bravo and Uribe, 1981 In Marschner, 1986



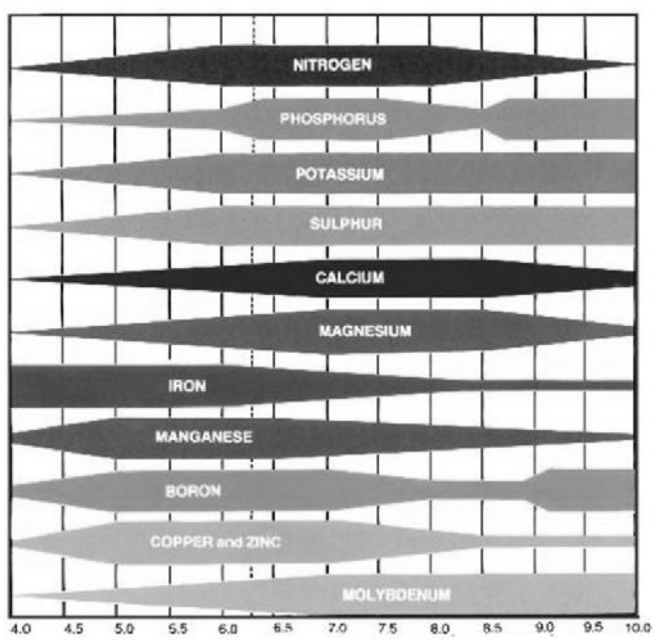


Influence of temperature on ^{15}N uptake rate of 'Fuji'/M26 apple trees 7, 21, 32, 45 and 57 days after planting.

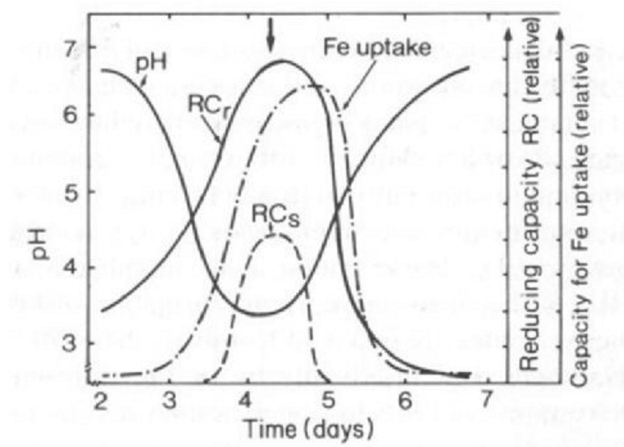


Bars on data points represent standard errors of the mean of four replicates

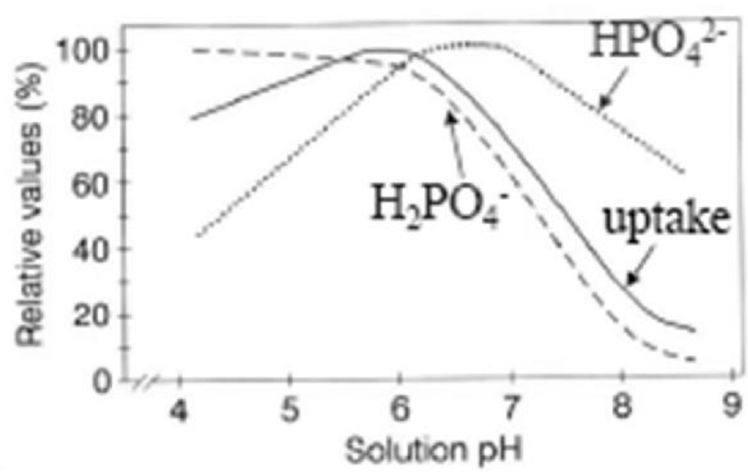
6. pH



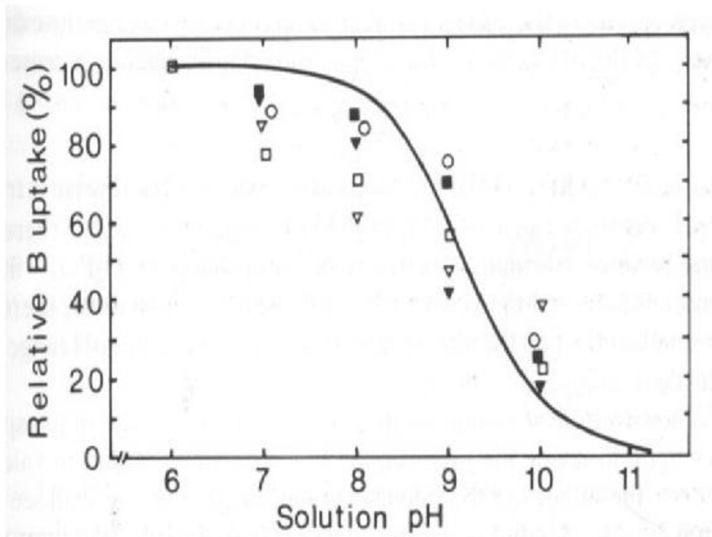
Iron deficiency   Iron resupply



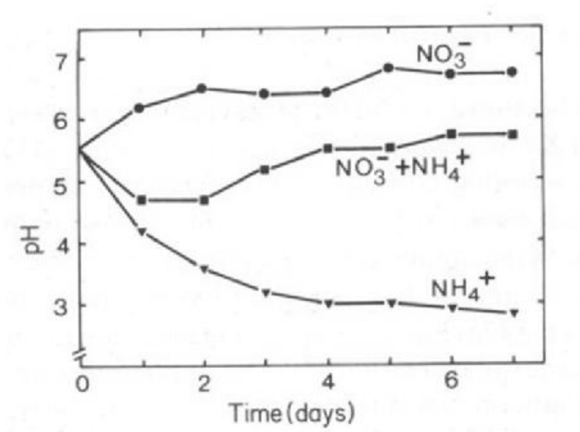
Root-induced changes in the external solution (pH; reducing substances, RCs) and in root properties (reducing capacity, RCr; capacity for iron uptake) in sunflower in response to iron deficiency and resupply (↓)) (Marschner, 1986)



(Marschner, 1986)



(Oertli & Grgurevic, 1975 In Marschner, 1986)



Pemberian pupuk N dalam bentuk atau yang menghasilkan NH_4^+ akan cenderung membuat pH media perakaran berkurang

(Marschner, 1986)

7. Oxygen

Effect of oxygen partial pressure around roots on uptake of potassium and phosphorus by barley

Oxygen partial pressure (%)	Uptake	
	Potassium	Phosphate
0.5	37	30
5	75	56
20	100	100

From Hopkins et al (1950)

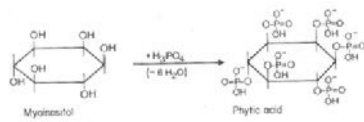
8. CO_2 concentration

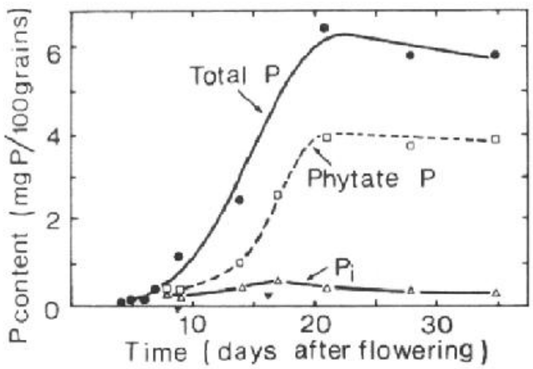
Table. Responses of root NH_4^+ and NO_3^- uptake capacity and whole-plant growth to elevated CO_2

Species	Uptake rates		Growth	Ref.
	$NH4^+$	$NO3^-$		
Acer saccharum	nc	nc	nd	1
A. rubrum Increase	nc	nd		1
Glycine max	nc	nc	nd	1
Sorghum bicolor	nc	nc	nd	1
Avena fatua	nc	nc	nd	2
Bromus hordeaceus	nc	Decrease	nd	2
Lolium multi¯orum	nc	nc	nd	2
Vulpia microstachys	nc	nc	nd	2
Lasthenia californica	nc	Decrease	nd	2
Plantago erecta	nc	Decrease	nd	2
Mixed-species community	nc	nc	nd	2
Ceratonia siliqua	nc	nc	Increase	3
Agrostis capillaris	nc	nd	nc	4
Pinus taeda	Decrease	nd	Increase	5
P. ponderosa	Decrease	nd	Increase	5
P. taeda	nc	Increase	Increase	6
P. ponderosa	Decrease	Increase	Increase	7
P. taeda	nc	Increase	nd	7
Bouteloua eriopoda	nd	Increase	Increase	8
Prosopis glandulosa	nd	nc	Increase	8
Larrea tridentata	nd	Decrease	Increase	8
Populus tremuloides	nc	nc	Increase	9

7. Plant metabolism

- Phytates are salts of phytic acids, which is hexainositol phosphoric acid.





Time course of content of inorganic phosphorus (Pi) and phytate phosphorus in rice grains during development (Ogawa et al., 1979)

- Phytic acid is synthesized from the cyclic alcohol myoinositol by esterification of the hydroxyl groups with phosphoryl groups
- The amount of phosphorus being supplied to a plant affects the various phosphorus fractions in a typical manner.
- With an increase in the supply from a suboptimal to an optimal level, all the phosphorus fractions in the leaves increase. Above this level, only the Pi increases, reflecting the storage function of Pi in highly vacuolated tissues.
- In grains and seeds, however, the level of Pi at maturity is very low and most of the phosphate is present as phvtate.
- In these organs, phytate is usually the only phosphorus fraction to be affected by a change in phosphate supply.
- During the early stages of development, the phytate level is low, but it rises sharply during the period of rapid starch synthesis.
- In contrast, the level of Pi during this period is generally low and further declines during rapid phytate formation.

- The sparringly soluble calcium-magnesium salt of phytic acid is term phytin. Phytic acid also has high affinity for zinc and iton
- In legume seeds and cereal grains the main phytates are the potassium-magnesium salts, phytin being virtually absent, Phytate phosphorus makes up ~50% of the total phosphorus in legume seeds, 60-70% in cereal grains, and 86% in wheat mill bran
- Most of the phytate is localized in the aleurone layer in cereals, in the germ in maize, or in the cotyledons in legumes. The phytates are incorporated as discrete particles ("globoid crystals") in the protein matrix of large protein bodies.
- The occurrence of phytates is not restricted to grains and seeds but can also be demonstrated, for example, in potato tubers, where it accounts for 15-30% of the total phosphorus.