

Soil Nutrients

Two Types of Nutrients:

- Macronutrients
- Micronutrients

Soil Nutrients

Two Types of Nutrients:

- Macronutrients – required in large amounts
- Micronutrients – required in small amounts

Soil Nutrients

Two Types of Nutrients:

- Macronutrients
 - Air: C, H, O
 - Soil: N, P, K, Ca, Mg, S

Soil Nutrients

Two Types of Nutrients:

- Micronutrients
 - Soil: Fe, Mn, Cu, Zn, B, Mo, Cl, Co
- Corn consumes:
36 kg (80 lbs) of N acre/year
0.05 kg (0.1 lbs) B acre/year

Soil Nutrients

Two Issues Related to Nutrients:

- What is the total quantity of a nutrient in the soil?
- What is the quantity available to plants?

Soil Nutrients

Two Types of Nutrients:

- Availability is determined by dissolution of soil in HFI and H_2SO_4 . Mass spec can then be used along with other methods.

Soil Nutrients

Representative Quantities of Nutrients:

Organic Matter	4.10 %
N	0.15 %
P	0.04 %
K	1.70 %
Ca	0.40 %
Mg	0.30 %
S	0.04 %

Soil Nutrients

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Soil Nutrients

Representative Available of Nutrients:

Organic Matter	4.10 %	2.00 %
N	0.15 %	0.12 %
P	0.04 %	0.07 %
K	1.70 %	2.00 %
Ca	0.40 %	1.00 %
Mg	0.30 %	0.60 %
S	0.04 %	0.08 %

Soil Nutrients

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Why is N availability lower?

Soil Nutrients

Representative Available of Nutrients:

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Why are available% > quantities%?

Soil Nutrients

Most Soils Have Enough Nutrients:

- Exception is coarse-grained soils where total amounts are important.

Why?

Soil Nutrients

Most Soils Have Enough Nutrients:

- Exception is coarse-grained soils where total amounts are important.

1. Few minerals
2. Leached
3. Low CEC

- In either case, total available is the important quantity.

Soil Nutrients

Nutrients:

- Of the nutrients present, we can summarize their presence as...

1. Unavailable
2. On exchange sites
3. In solution

Soil Nutrients

Nutrients:

- **Unavailable** elements in...

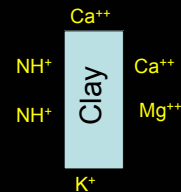
1. Clays
2. Soil Minerals
3. Organic Matter

Soil K usually dominates unavailable fraction (present in mica).

Soil Nutrients

Nutrients:

- **Available** nutrients on exchange sites...



Soil Nutrients

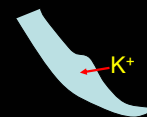
Nutrients:

- In general,
 - Ca > Mg > K on exchange sites
 - P and S not on exchange sites because they are anions!
 - N present as NO₃⁻ rather than NH⁺

Soil Nutrients

Solution Nutrients:

- In general,
 - Source of osmotic pressure difference between organism membranes and soil waters.



Soil Nutrients

Summary

kg present per hectare w/ 15 cm of surface
 Framework Exchange Solution

Ca	8000	2000	50-200
Mg	6600	400	10-30
K	33,800	200	10-30
P	800	-	0.5-1.0
S	800	-	3-15
N	3,000	-	5-25

(1 hectare = 2.47 acres)

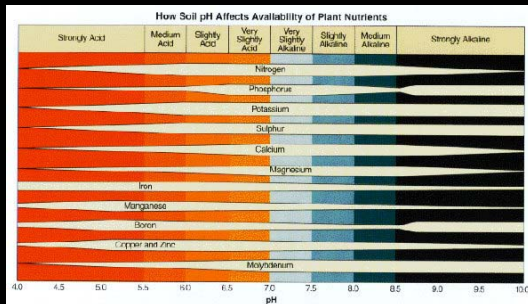
Soil Nutrients

Nutrients:

- Soil pH effects nutrient availability...
 - Changes solubility of nutrients
 - Changes amounts held on exchange sites
 - Effects microbe populations (organic matter decomposition)

Soil Nutrients

Nutrients:



Soil Nutrients

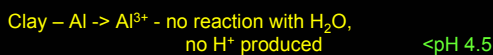
Nutrients:

- Availability of Fe, Cu, Zn, Mn, and Al are similar.
- Availability increase with increasing acidity.

Soil Nutrients

Nutrients:

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Soil Nutrients



acids

Fe⁺⁺⁺ (soluble)

Fe(OH)_xⁿ (less soluble)

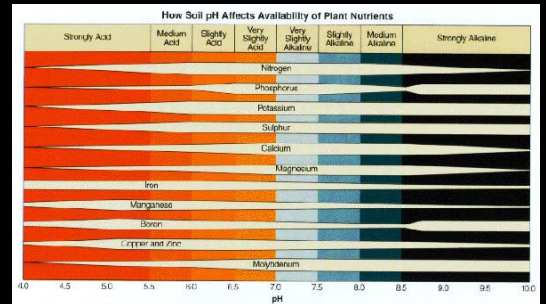
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Nutrients:

- Micronutrients are more available at higher pHs.
- Example: $\text{Fe}^{3+}(\text{HMoO}_4^-)_3$ has low solubility at low pHs.

Soil Nutrients

Nutrients:



Soil Nutrients

Nutrients:

- Micronutrients are often deficient in...
 - Organic Soils
 - Sands
 - High pH soils

Why high pH soils if they are more available at these pHs???

Soil Nutrients

Nutrients:

- Micronutrients are often deficient in...
 - Organic Soils
 - Sands
 - High pH soils

Why high pH soils if they are more available at these pHs???

Are leached from soils!

Soil Nutrients

Nutrients:

- Availability of P...
 - Present as PO_4^{3-}
 - Often limited availability
- Why? Reacts with other species to form immobile compounds.

Soil Nutrients

Nutrients:

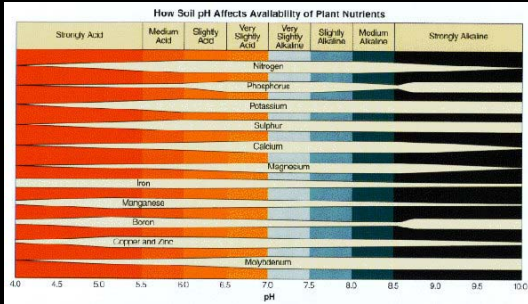
- Availability of P...
 - Present as PO_4^{3-}
 - Often limited availability
- Why? Reacts with other species to form immobile compounds.

FePO_4 and AlPO_4 low pH, insoluble
 $\text{Ca}_3(\text{PO}_4)_2$ high pH, insoluble
 Na_3PO_4 v. high pH, insoluble

Optimum pH is 6-7*

Soil Nutrients

Nutrients:



Soil Nutrients

Nutrients:

- In general, 25% of P is available.
- Considerable P must be added to soil to reduce P fixation.
- P is largely lost through physical erosion rather than chemical.
Example: Erosion after plowing.

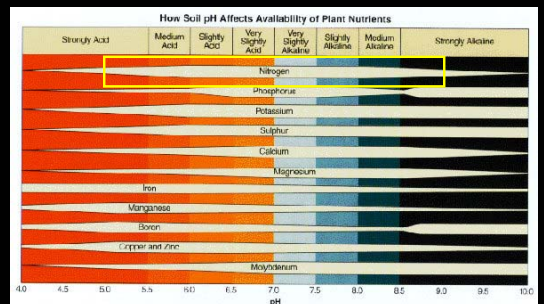
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Nutrients:

- Availability of N...
 - Present as NO_3^- and NH_4^+
 - Most in organic matter
 - Availability depends on organic matter decomposition
- Why? N fixation is a limiting factor.

Soil Nutrients

Acidity effects soil microorganisms.



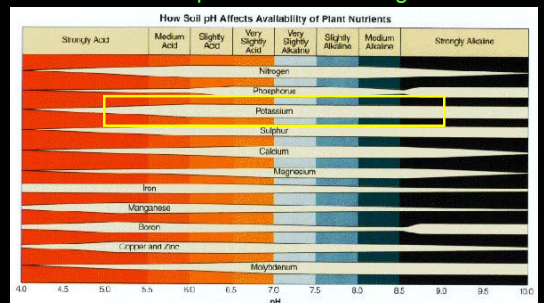
Soil Nutrients

Nutrients:

- Availability of K...
 - Present in solution (1-2%), exchange sites (1-10%), in minerals (90-99%)
 - Amount in minerals is ~170 times more than on exchange sites.
- Why so little on exchange sites?
Easily leached.

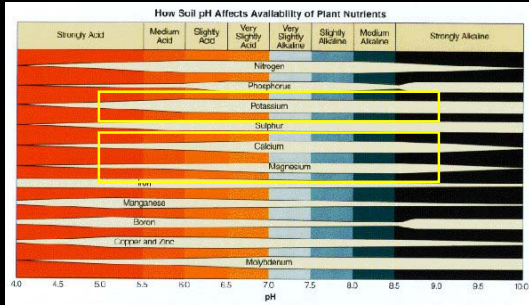
Soil Nutrients

K is less available at low pH. Why?
 H^+ and Al^{+++} displace K^+ on exchange sites.



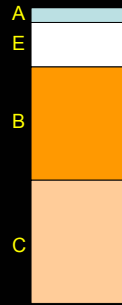
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Ca and Mg are less available at low pH. Why?
 H^+ and Al^{+++} displace them on exchange sites.



Soil Nutrients

Random Thoughts:

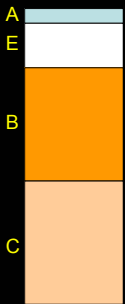


• Which horizon would have the highest amount of Ca?

• Which horizon would have the highest percent Ca on exchange sites?

Soil Nutrients

Random Thoughts:



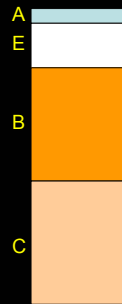
• Which horizon would have the highest amount of Ca?
 A horizon (more exchange sites)

• Which horizon would have the highest percent Ca on exchange sites?
 C horizon (higher pH, high base saturation)

Soil Nutrients

Fertilizers

- Mineral
- Organic



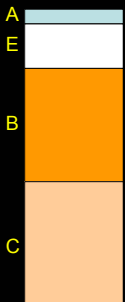
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Mineral Fertilizers

• Percentages of bulk are listed in order of N, P, K

• Example: 20-10-10 (20% N, 10% phosphates, 10% potassium).

• Can be given as ratios... 2-1-1



Soil Nutrients

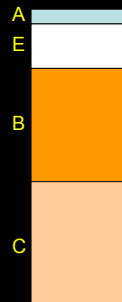
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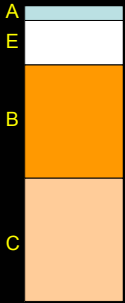
• Example: 20-10-10 (20% N, 10% phosphates, 10% potassium).

• Can be given as ratios... 2-1-1

- Trees like 2-1-1
- Grasses like 3-1-2



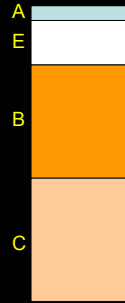
Soil Nutrients



Mineral Fertilizers

- P as P_2O_3 (phosphoric acid), so 24 lbs in 6-24-24 yields only 10.8 lbs of P.
- K as K_2O , so 24 lbs in 6-24-24 yields 19.2 lbs of K.

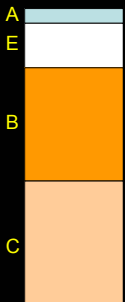
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Organic Fertilizers

- Cow manure is one form
 - 500 lbs dry manure is...
 - 2.4% N, 0.7% P, and 2.1% K.
 - 12 lb N
 - 3.5 lb P
 - 10.5 lb K
- 100 lb of mineral fertilizer (6-24-24) yields...
- 6 lb N
 - 10.8 P
 - 19.2 K

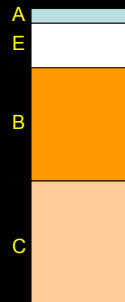
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Organic Fertilizers

- One ton of fresh manure is equivalent to a 100 lb bag of 12-3.5-10.5 mineral fertilizer.
- ### Organic Fertilizers
- Municipal waste is a 14-4-5 fertilizer.
 - Sewage sludge is an 18-8-1 fertilizer.

Soil Nutrients



Advantages of Organic Fert.

- Adds organic matter to soil
 1. Increases CEC
 2. Increase H_2O holding capacity
 3. Adds structure to A horizon
- Slower release of nutrients
 1. Lessens leaching
 2. Sustained benefit