Last Class

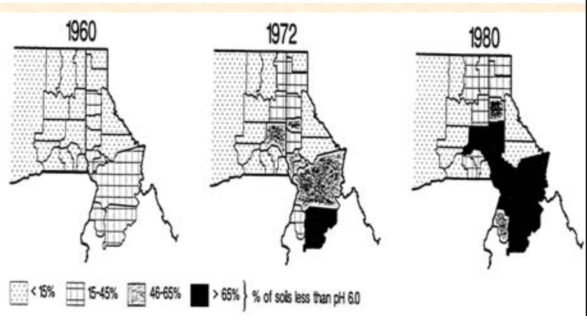
- *pH-dependent charge*: OM, oxides, crystal edges
- *Anion Exchange Capacity (AEC)*
- "*Non-acid cation*" is new phrase for "*base cation*"
  = Ca++, Mg2+, K+, Na+ (in your homework, you calculated % BS. New term is "*non-acid cation saturation*")
- Soil pH
  - Definition (recall from chemistry classes)
  - pH scale: Soils generally pH 4 to 9
  - Acidity & Alkalinity affect plants directly and indirectly
  - Factors that promote alkalinity – non-leaching environs
  - Factors that promote acidity – leaching environments, added acids (acid rain, NH4 fertilizers)

Ammonium Acidification

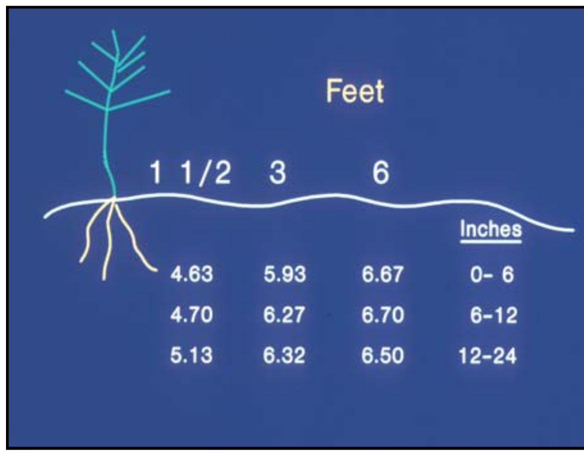
Ammonia or ammonium fertilizer

$$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 2H_2O + 4H^+$$

Soil pH Shifts in Northern Idaho and Eastern Washington



(Mahler et al. 1981)

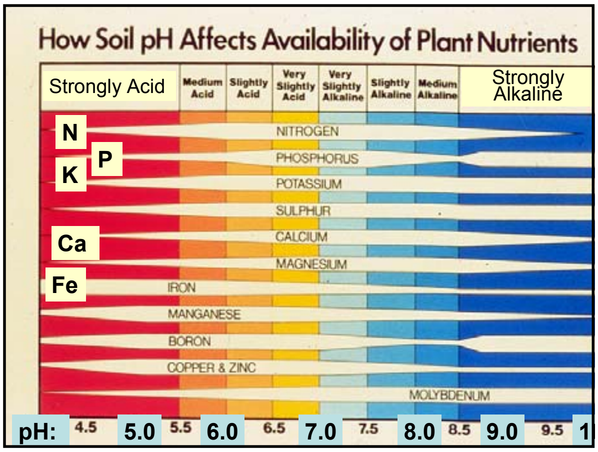


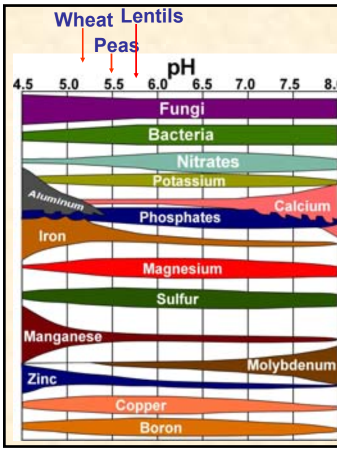
FERTILIZER ACIDITY

Material	Lbs Lime/Lbs N
Ammonia (anhydrous)	1.8
Ammonium Nitrate	1.8
Urea	1.8
AN solution (20-0-0)	1.8
UAN solution (32-0-0)	1.8
Ammonium Sulfate	5.2
DAP (18-46-0)	3.9
MAP (11-48-0)	4.9
UNIPEL (16-16-16)	2.8

Why is soil pH important?

- Types of vegetation
- Microbial activity
- Fate of nutrients
- Fate of pollutants





The effect of soil pH on:

•availability of plant nutrients

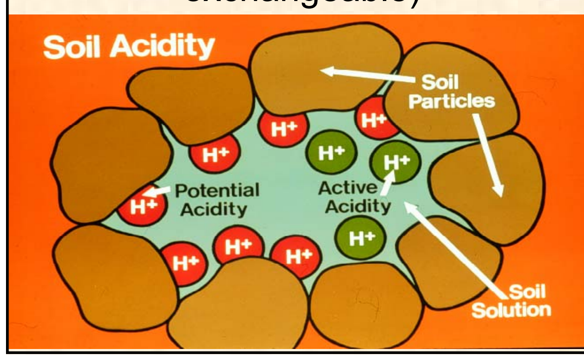
•activity of soil microorganisms,

occurrence of toxic elements

Fractions ("pools") of soil acidity

Active acidity	**Reserve acidity**
• **H^+ in soil solution**	• **H^+ & Al^{3+} on exchange sites and bound**
• small fraction of total soil acidity • measured by pH • immediate root environment	• dominant fraction of total acidity • represented by *% acid saturation* • bulk of neutralizable acidity
• Need a few lb/ac lime to neutralize	• Need several TONS/ac lime to neutralize

Active vs. Reserve (potential, exchangeable)



More terms related to pH status of soils

- **Calcareous** = soils that have calcium carbonates ($CaCO_3$)in them (incl. "caliche")
  - Presence of free $CaCO_3$ buffers soil at pH = 8.3

Eastern Montana, a chalky white calcic horizon

More terms related to pH status of soils

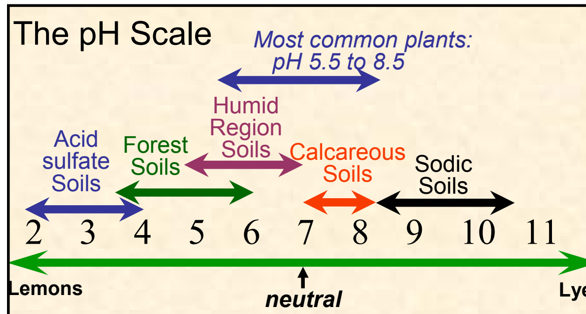
- **Saline soils** – contain enough soluble salts to impair productivity

Salt crust near the Great Salt Lake in Utah

More terms related to pH status of soils

- **Sodic Soils** = soils that have high exchangeable sodium (Na+) – poor soil structure, pH > 8.3
  - Have "columnar" soil structure
  - "black alkali" soils
- **Acid-sulfate soils** = soils that have reduced sulfur – when oxidized (exposed to air and water) they produce H_2SO_4 – can be VERY acid
  - Ex. Drained swamps, mine spoils

The pH Scale



highly *acid* | highly *alkaline*

high (H+) | high (OH^-)

low pH | high pH

Changing soil pH

- **Alkaline soils:** add acid (Sulfur) to decrease pH
  - e.g. Al sulfate, ammonium sulfate
  - In saline soils: need to remove excess salts (with high quality irrigation water)
  - In sodic soils
    - must first remove sodium (use gypsum)
    - Then leach out salts

Changing soil pH

Acid soils: Add "lime"

- Lime = carbonates, oxides or hydroxides of Ca (or Ca & Mg) - there are many types!
- How?
  - The Ca^{2+} (or Mg^{2+}) replaces H+ on exch. sites
  - The carbonate (CO_3^{2-}) or OH- reacts with H^+ to form H_2O & CO_2
  - Ex: $Ca(OH)_2 + 2H^+ \rightarrow Ca^{2+} + H_2O$

The pH will increase when there is a net decrease in solution H^+.

Soil pH Buffering Capacity

- Soils are resistant to pH changes due to their pH buffering capacity.

Remember: *Although pH is the indicator of soil acidity, exchangeable acidity makes up the bulk of the neutralizable acidity. To raise pH exchangeable acidity must be neutralized.*

Soil pH Buffering Capacity

- Ability of a soil to resist pH changes during inputs of acid or base.
- Factors include:
  - texture:
  - organic matter:
  - exchangeable Al^{3+}

Methods of Determining Lime Requirement

- Methods must evaluate the amount of neutralizable acidity in soils.

That is – <u>both</u> active and reserve acidity
  - soil titration
  - chemical buffer
  - % base saturation
  - % Al saturation

Benefits of Liming

- Neutralize toxic elements: Al, Mn, H.
- Improve overall nutrient availability.
- Increase microbial activity.

- Increase % non-acid cations (% BS)
- Improve Ca, Mg availability
- Improve soil structure with Ca
  - Ca^{2+} <u>flocculates</u> clay particles – attracts layer silicate particles together

Lime Requirement Determined by:

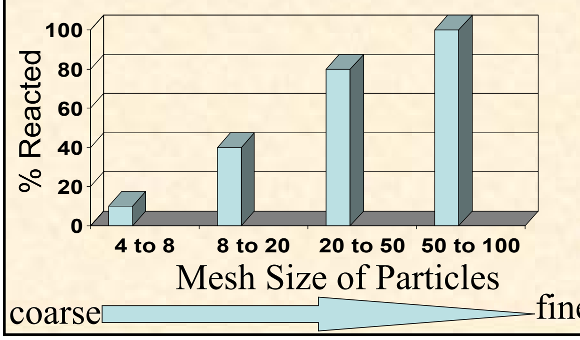
- Liming goal:
  - pH goal or tolerable level of exchangeable Al.

- Soil buffering capacity

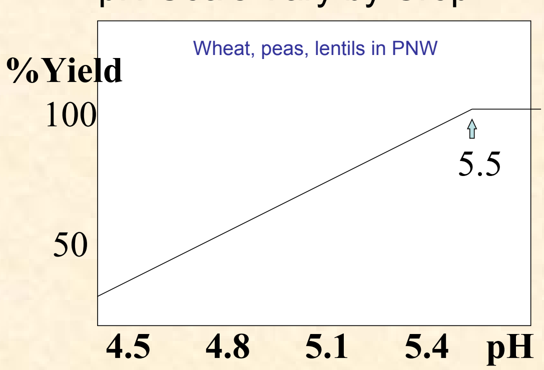
- Neutralization value of liming material
- Fineness of liming material

- Depth of tillage

Lime Reacted in 1 to 3 years



pH Goals Vary by Crop



pH Goals Vary by Crop

<u>>6.5</u>
- alfalfa
- sweetclover
- sugar beets
- beans
- peas
- asparagus

<u>5.5-6.5</u>
- corn
- grasses
- wheat
- barley

pH Goals Vary by Crop

5.0-5.5
- blueberries
- cranberries
- strawberries
- potatoes
- tobacco
- rye
- oats

<5.0
- azalea
- hydrangea
- rhododendron

Lime Neutralizing Value (Calcium Carbonate Equiv.)

MATERIAL	*MW*	*Calcium Carbonate Equivalent*
calcite	100	100%
dolomite $CaMg(CO_3)_2$	184	2(100)/184= 109%
burned lime CaO	56	100/56= 179%
hydrated lime $Ca(OH)_2$	74	100/74=136%

2000 Lime Trial

March 2000 (following fall lime incorporation)

	Lime Rate (tons / ac)		
Depth (inches)	0	1	2
0-6	5.20 c	5.83 b	6.23 a
6-12	5.10 b	5.16 b	5.33 a
0-12	5.17 b	5.33 b	5.63 a