

What Influences Soil pH and How Do We Modify It?

Dan Nelson

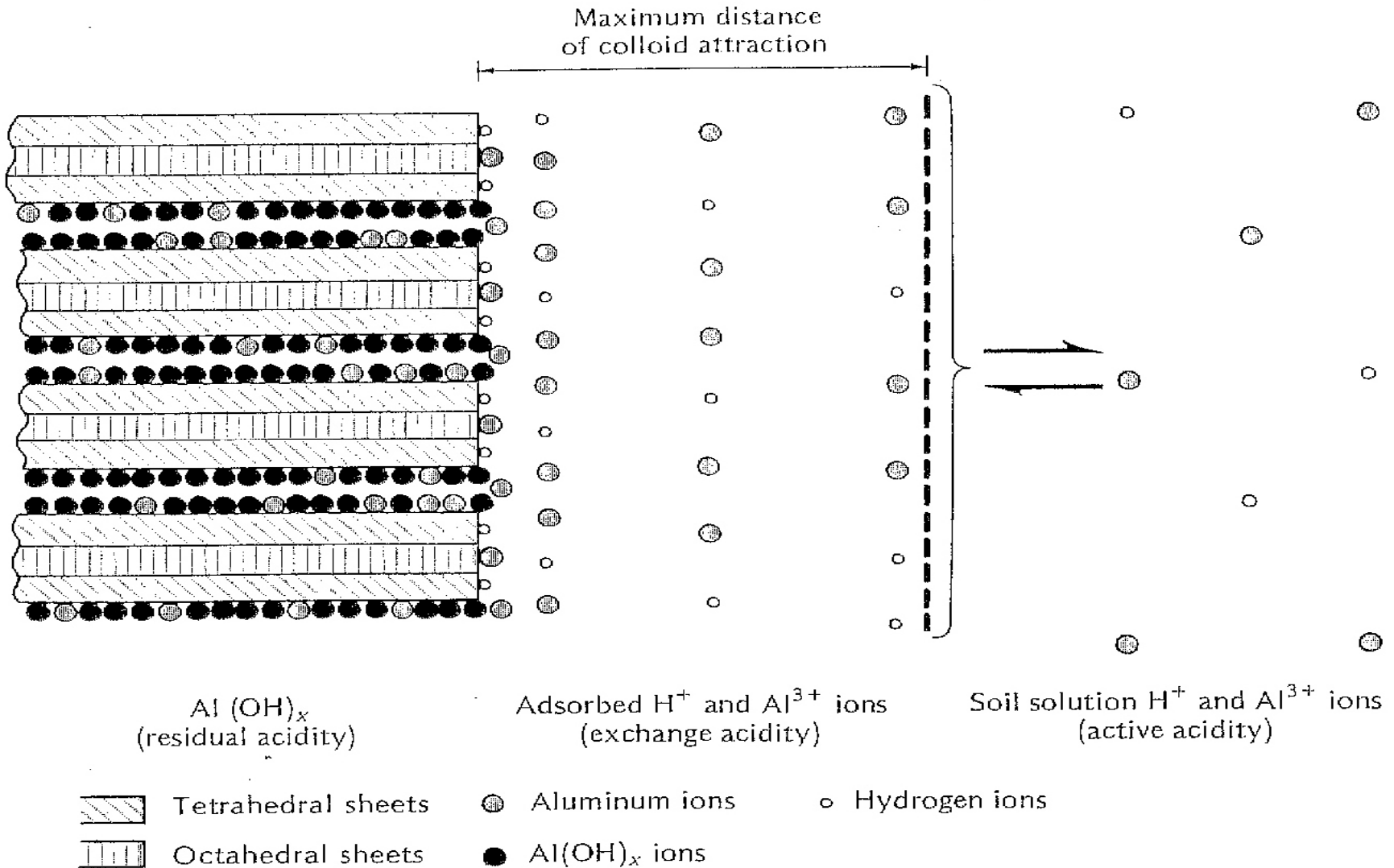
soiltest farm consultants, inc.



Unfortunately, We Must Visit Chemistry: What is Soil pH?

- Soil Solution proton activity or concentration (H^+)
- Exchangeable Acidity (H^+ , Al^{+++} , Fe^{+++})
 - $3H_2O + Al^{+++} = Al(OH)_3 + 3H^+$
 - Basic cations: Ca, Mg, K, Na, act to lower acidity
- Residual Acidity
 - Tends to minimize change in pH (buffer)
 - Organic Matter
 - Clay Edges
 - Precipitates such as Carbonates, Phosphates, Oxides

Soil is a Complex System



What Changes Soil pH?

- Weathering w/water (Geologic Processes)
 - Gradually wash away K, Ca, Mg (bases)
 - End up with Al, Fe Oxides (red soils) & acid
- Weathering w/o water makes alkaline and saline soils like Eastern Washington (basic cations not removed)
- By Man's activity
 - Acid rain -- accidentally
 - Elemental Sulphur -- intentionally
 - Ammonium Fertilizers – incidentally
 - Irrigation (additions of bicarbonate, cations)
 - Harvest of cations

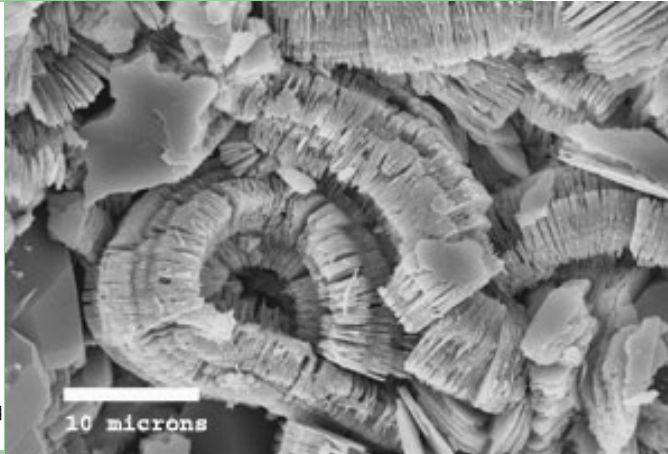
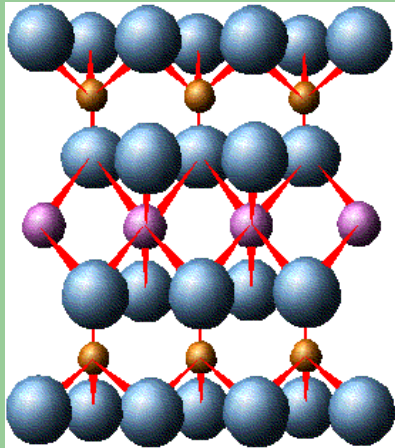
Native Conditions in the Columbia Basin

- Glacial Outwash, Lacustrine Sediments, Aeolian Deposits
- Rock Flour: Low Clay Content, Mostly Sand and Silt
- Arid Environment, Low Rainfall, Hot Summer
- Little Vegetation, Low Organic Matter
- Calcium Carbonate Accumulation
- Neutral to High pH
- 2:1 Alumino-Silicate Clays

Clay Mineralogy

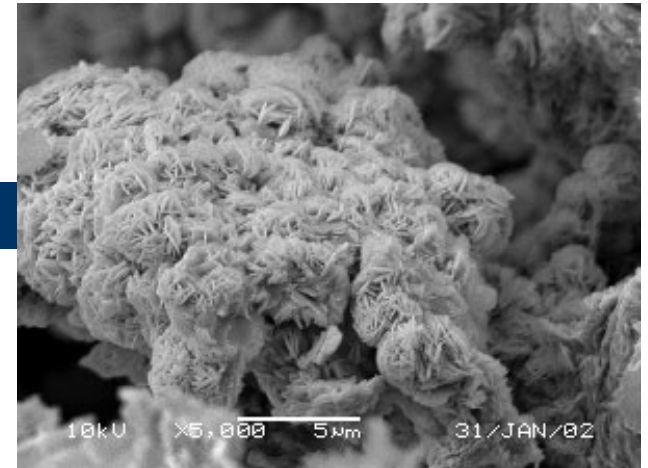
Alkaline Soils

Alumino-Silicate Minerals
Silica Tetrahedra
Aluminum Octahedra
“Crystalline”



Acid Soils

“Amorphous” Iron & Aluminum Oxides
Highly Weathered
Si leached
Higher Organic Matter



Different Aluminum Chemistry

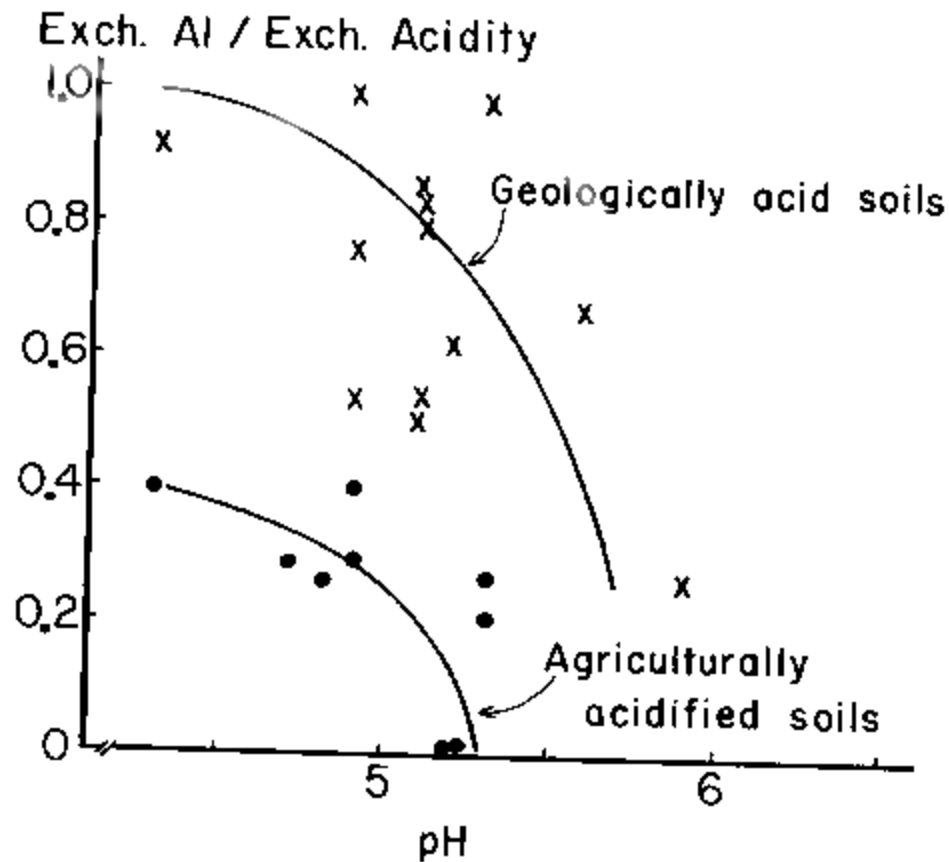
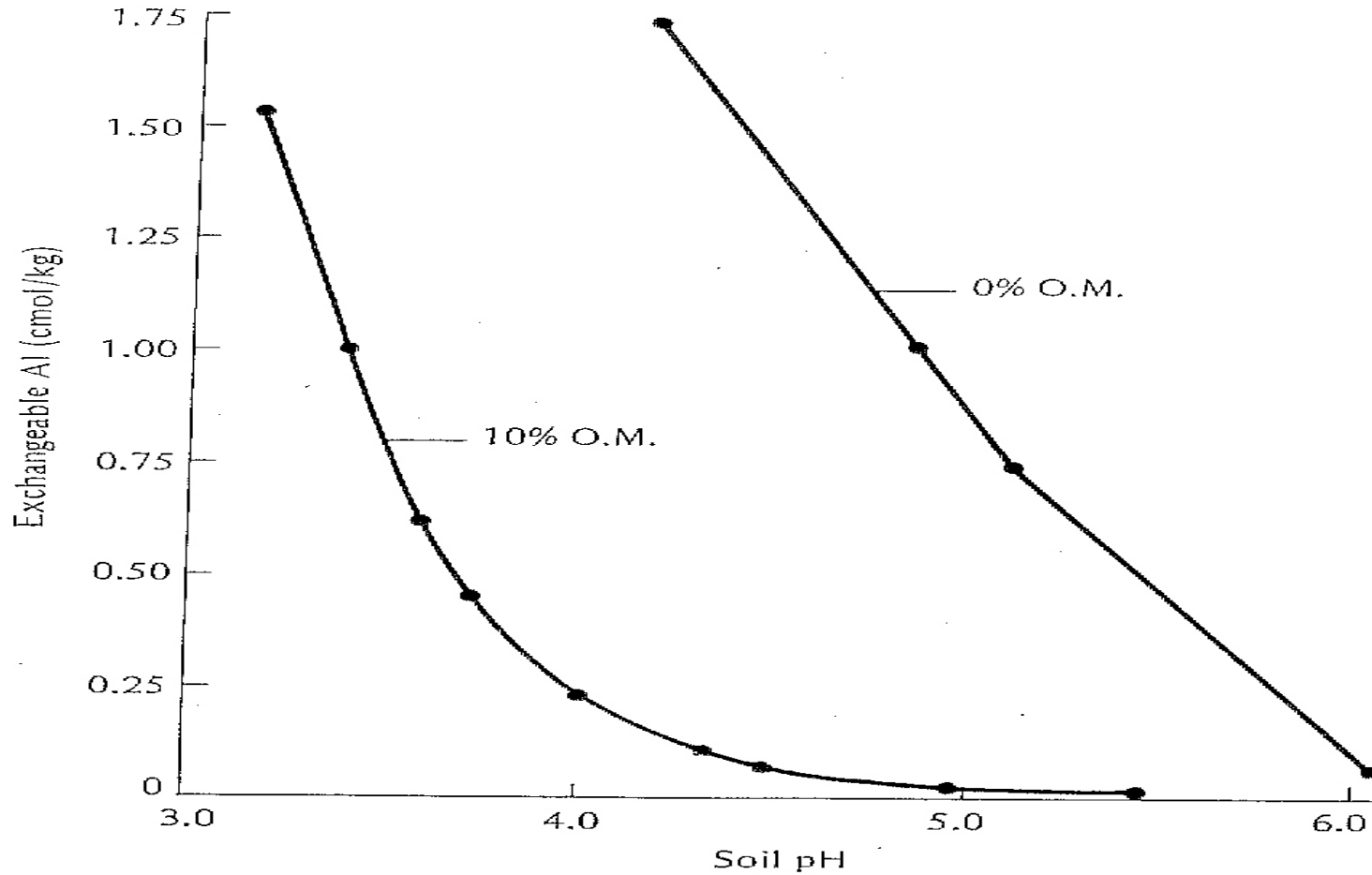


Fig. 2—Exchangeable Al as a fraction of “exchangeable acidity” for geologically acid and agriculturally acidified soils (Janghorbani et al., 1975; Brown, 1975).

Al, pH and OM



Note: wood chips is not soil organic matter

Changing Soil pH

- Raising pH with Lime or Dolomite
 - SMP or A&E lime requirement test
 - Not exactly calibrated for our soils
 - Lime Score (% lime & surface area) and time
- Reducing pH
 - Elemental S
 - Microbial process (surface area, moisture & heat)
 - 6.4 t/ac S for each 1% free lime!
- Nothing happens fast!
 - Don't try to force it w/ excessive applications
 - You will mess up something else
 - Soils tend to be well buffered—Kyle Bair's study

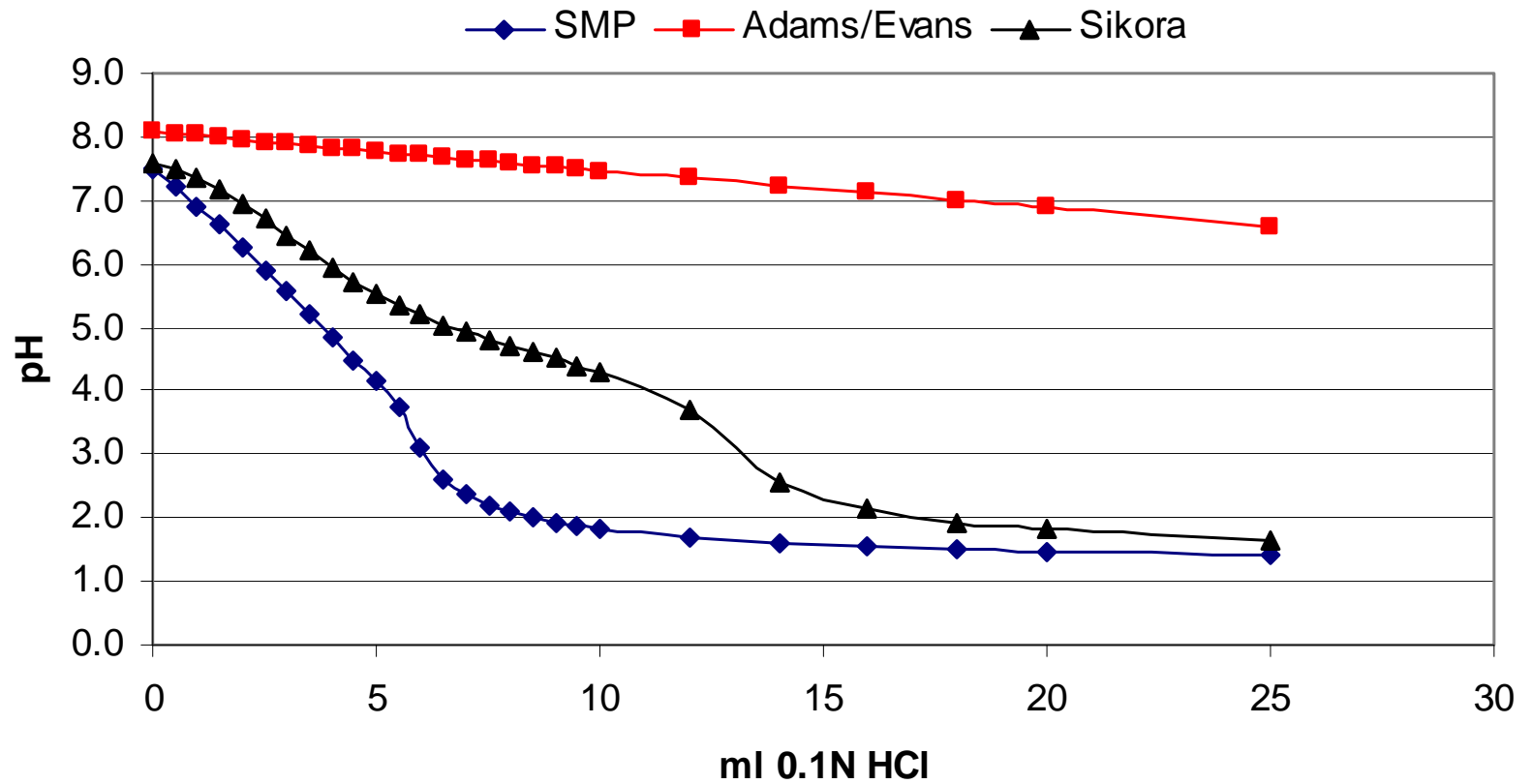
Raising the soil pH: Lime Response Curves from Quincy

8-WEEK INCUBATION STUDY OF 3 COLUMBIA BASIN SOILS

Soil	INITIAL pH		LIME APPLICATION, TONS / ACRE					LIME REQUIREMENT T/AC Target pH = 6.5	
	CaCl ₂	1:1	0	1.6	4.4	9.4	14.5	A&E	SMP
1	5.4	5.6	5.4	6.5	7.7	7.8	7.8	1.54	0
2	5.6	6.1	5.8	6.5	7.7	7.8	7.8	0.72	0
3	5.5	5.8	5.4	6.7	7.8	7.8	7.9	1.30	0

For reference: 1% in an acre-6in = 10 tons of lime; low effervescence; would require 6.4 tons of S⁰ to neutralize

Lime Requirement Buffer Titration Curves



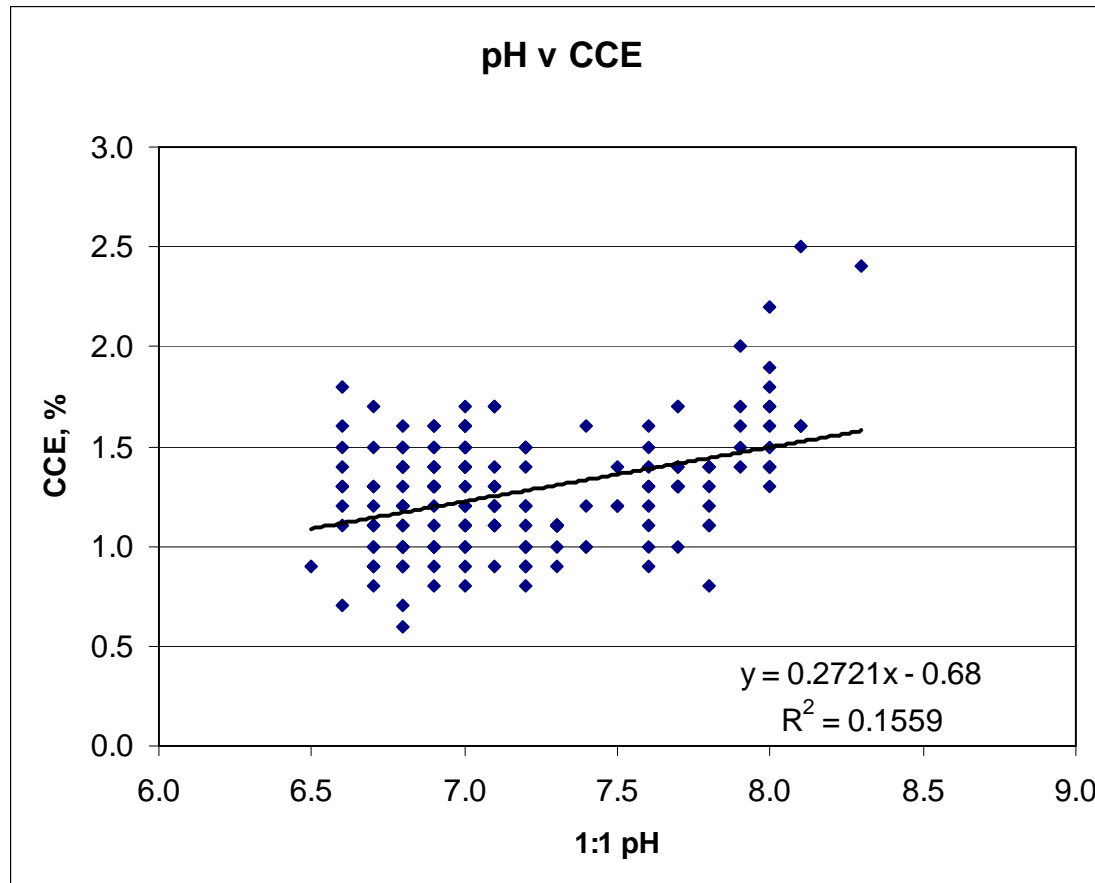
What if you apply too much LIME?

- Geologically acid soils have acid subsoils
 - Plowing and deep tillage will bring pH down
 - Not usually an option in E WA
 - Watch P, Zn, Mn and Fe in plant testing
- Elemental S can be used to bring pH down
 - Expensive
 - Start chasing your tail..... Just don't over-lime in the first place!

Calcium Carbonate Equivalent (CCE)

- Test to measure the “basicity” of a soil
 - React soil with excess acid
 - Back-titrate to 8.2 with sodium hydroxide
- Get an idea of how much acid to apply to neutralize all free lime and all basic functional groups in OM and clays
- 6.4 t elemental S is required to neutralize 1 % CCE in 1 acre-ft

pH relationship to CCE



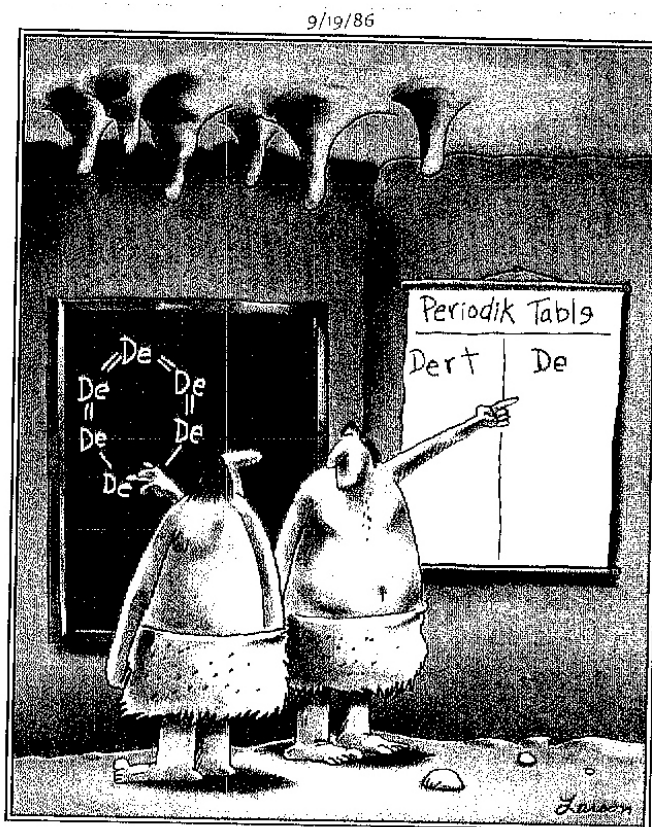
What if you apply too much SULFUR?

- pH starts dropping too low?
 - Plowing will help in E WA soils
 - Legumes may not perform well w/o Rhizobium; onions do poorly w/o mycorrhizae
- Excess Sulfate will accumulate
 - Increase Soluble Salts—shouldn't be harmful
 - Competitive inhibition of nitrate uptake
 - Will require leaching to remove and/or grow forage crops to enhance removal
- The soil will equilibrate to normal over time

Summary

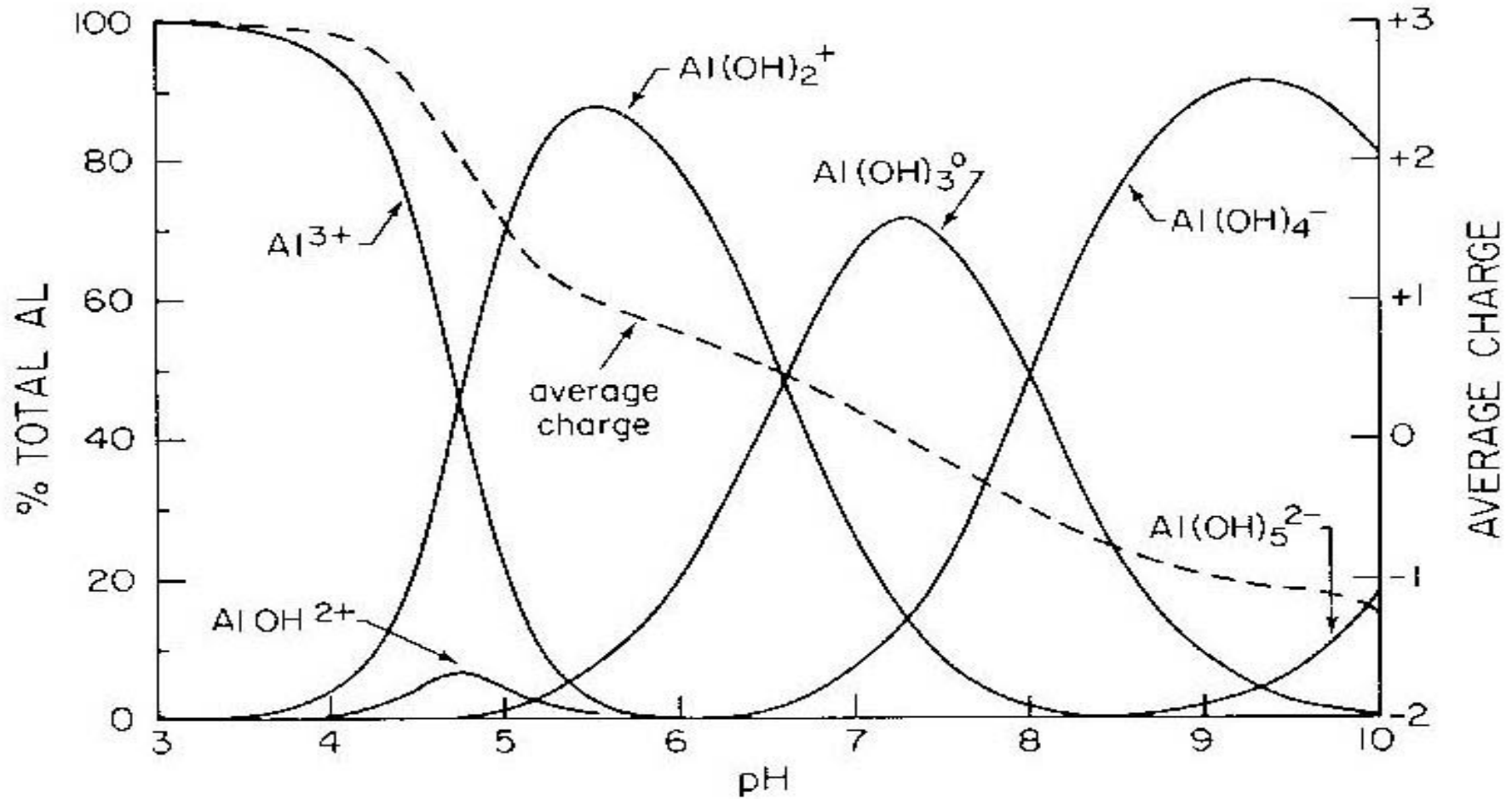
- E WA soils do not behave like W WA soils even if the pH is low
- Soil test to determine Lime or Sulfur requirement
 - SMP buffer method is not calibrated for this region
 - A&E seems to work OK; Sikora shows promise but needs calibration
 - CCE is better a indicator than pH for S application
- Be Patient. The soil system is complex and buffered. Changes do not happen rapidly

Questions ?



Early chemists describe the first dirt molecule.

Aluminum Chemistry and pH



What Can Change When We Fertilize?

- **Texture—No**
 - We can change the pH relatively quickly, but we cannot change the clay minerals. (thermodynamics v. kinetics)
- **We form lots of acid**
 - $\text{NH}_4^+ \rightarrow \text{NO}_3^- + 2 \text{H}_2\text{O} + 2 \text{H}^+$
 - 100 lbs/ac ammonium = 225 lbs/ac elemental S \rightarrow 14 lbs/ac H^+
 - 575 lbs H^+ minimum over 40 years!
- **Greater Plant Production**
 - Increased Organic Matter
 - Increased Microbial Activity