Use of Soil and Water Amendments in Orchard Management

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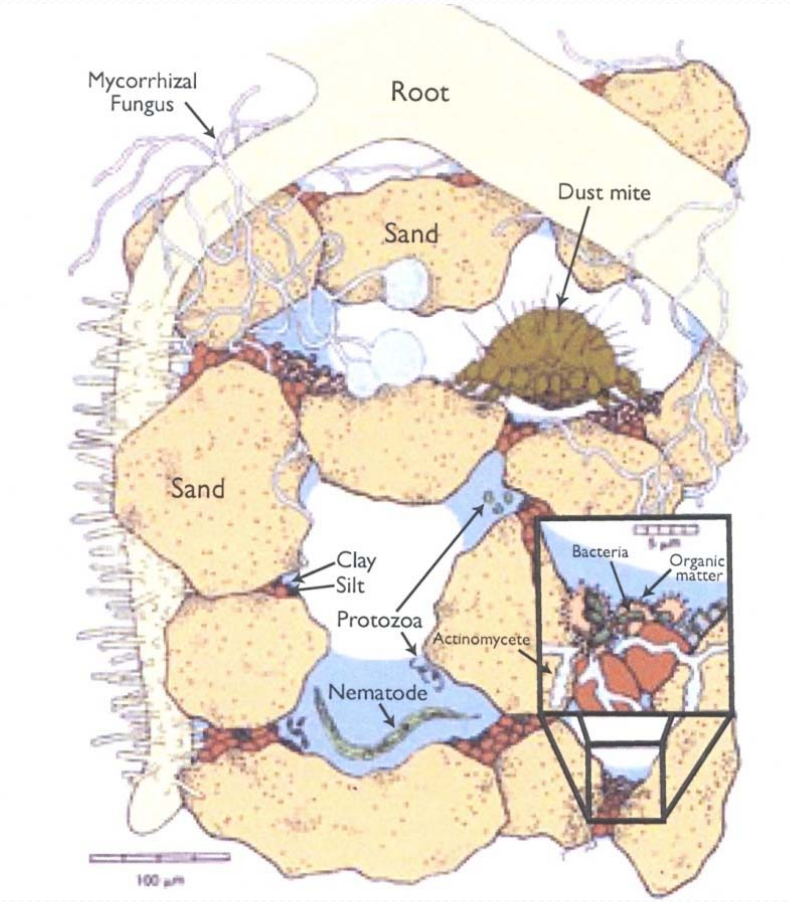
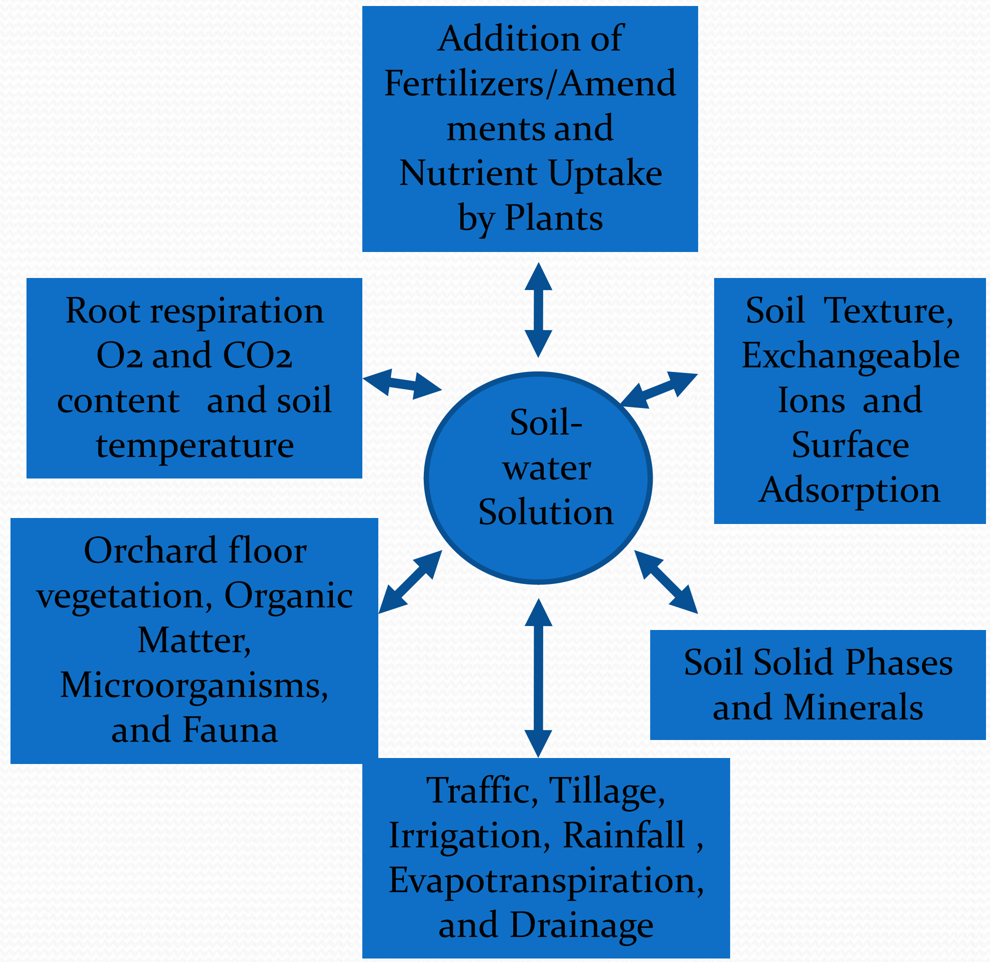
Topics

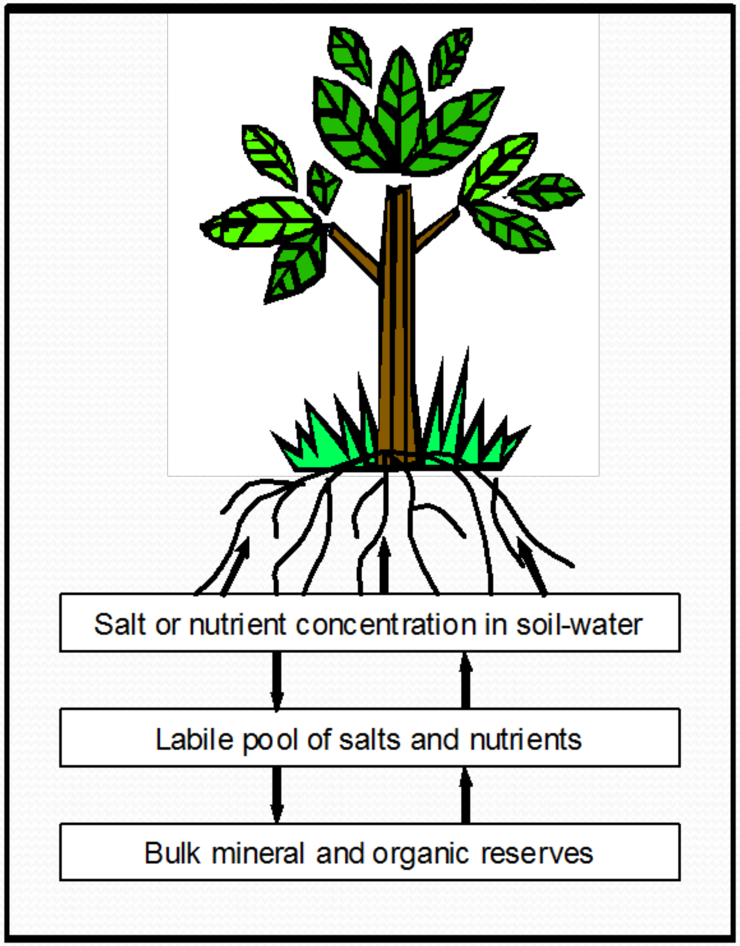
- Role of soil and water amendments in sustaining soil quality
- Classes of amendments and their chemical properties
- Questions to ask when considering amendments and choosing among the different types
- Future workshops? Soil and tissue testing, etc…

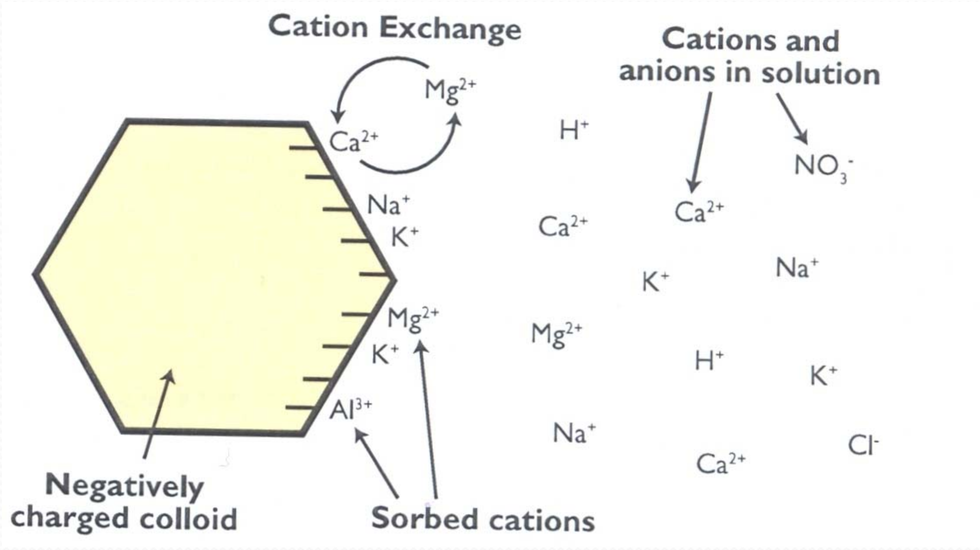
Visual and conceptual portrayal of the dynamics affecting soil quality.





Today's Focus – Chemical amendments and their effect on soil and water chemistry





General classes of chemical amendments

- Calcium salts (direct calcium suppliers)
- Acid forming amendments (indirect calcium suppliers)
- Soil and water conditioners (polymers)
- Surfactants

Calcium salts and related properties

Salt	Formulation	Solubility (distilled water @20°C, at ph=7)		Soil Rxn and effect on pH
		(g/100 mls)	General rating	
Calcium nitrate	$Ca(NO_3)_2$	121	Highly soluble	Gradual, Neutral
Calcium chloride dihydrate	$CaCl_2 \cdot 2H_2O$	98	Highly soluble	Gradual, Neutral
Calcium chloride	CaCl2	74	Highly soluble	Gradual, Neutral
Calcium acetate	$C_4H_6CaO_4$	34.7	Highly soluble	Increase pH of acid soils
Gypsum	$CaSO_4 \cdot 2H_2O$	0.26	Moderately soluble	Gradual, Neutral
Dolomite	$CaMg(CO_3)_2$	0.03 (depends on soil ph)	Low solubility	Increase pH of acid soils
Lime	CaCO3	0.005 (depends on soil ph)	Very low solubility	Increase pH of acid soils
By-product ash	CaO or $Ca(OH)_2$	Variable (depends on soil pH)	Very low solubility	Increase pH of acid soils

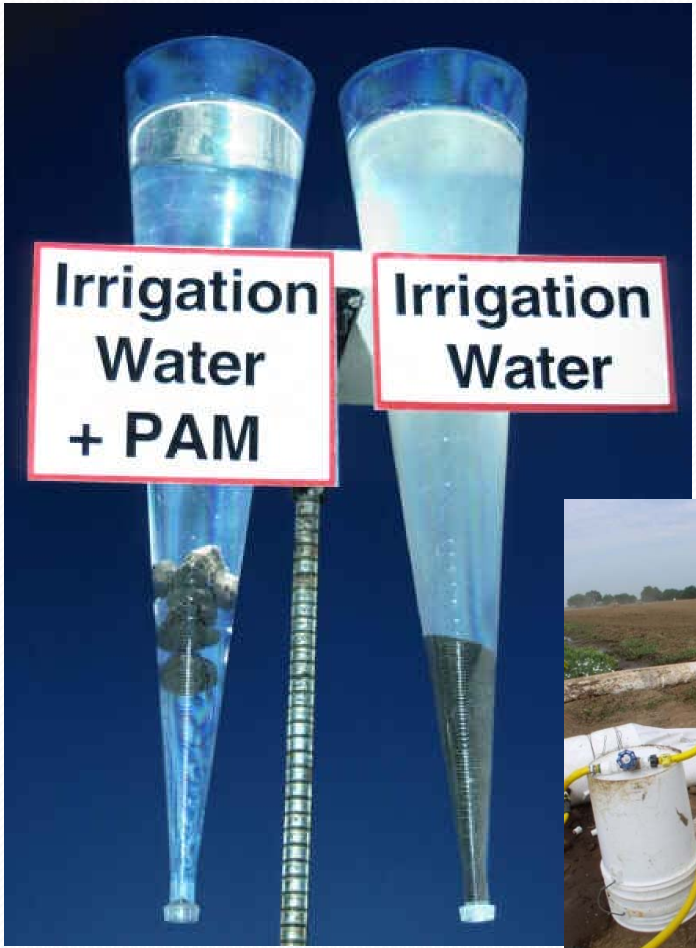
Source: CRC Handbook of Chemistry and Physics, 56th Edition

Acid forming amendments

- Sulfur (100 %S)
- Sulfuric acid (100 % H_2SO4)
- Urea-sulfuric acid (N-phuric 10/55 or US 10, 10% N, 55% sulfuric acid)
- Nitro-sul (20 % N, 40 % S)
- Lime-sulfur (6% Ca, 23 % S)
- Thio-sul (12 % N, 26 % S)

Soil and Water Conditioners

Soil Gluing Polyacrylamides (PAM)



Water Absorbing Cross-linked Polymers

Illustration of different PAM formulations and their effect on soil stability and turbidity in irrigation runoff.

Surfactants

- Some of the earliest uses of surfactants originated on lands following wild fires
- By reducing the surface tension between the soil and water surfactants runoff and erosion was reduced
- Research has shown benefits to golf courses, particularly greens with high silica-sand soils
- Agricultural research as a whole has not shown too much benefit

Questions to consider when choosing amendments

- Is soil and/or water quality among the weaker links in the production system? Relative to:
  - Irrigation management
  - Orchard floor and traffic management
  - Nutrient management
  - Other horticultural and pest management practices
- What is the soil or water quality characteristics and associated field problem and does the choice of amendment and application method seem to match it?
- When purchasing an amendment are competing products being compared on an equivalent basis?

Common soil and water quality problems

- Low pH soils
- Hardsetting soils
- Soil crusting and slow water infiltration
- Bicarbonate in irrigation water
- Other possibilities or opportunities

Amending Low pH Soils

- Soil pH influences the availability of nutrients to orchards. A soil pH of 6.8 represents a level where all of the essential plant nutrients are optimal. Although, orchard production can be economically viable across a wider range of soil pH, conservatively pH of 6 to 8.
- Soils with pH< 5.5 are more likely to respond to liming.
- Fertigation through drip and micro irrigation with acid forming fertilizers can further increase the need for liming.

Available or potential liming materials

- Lime
- Dolomite
- By-product ash
- Calcium acetate

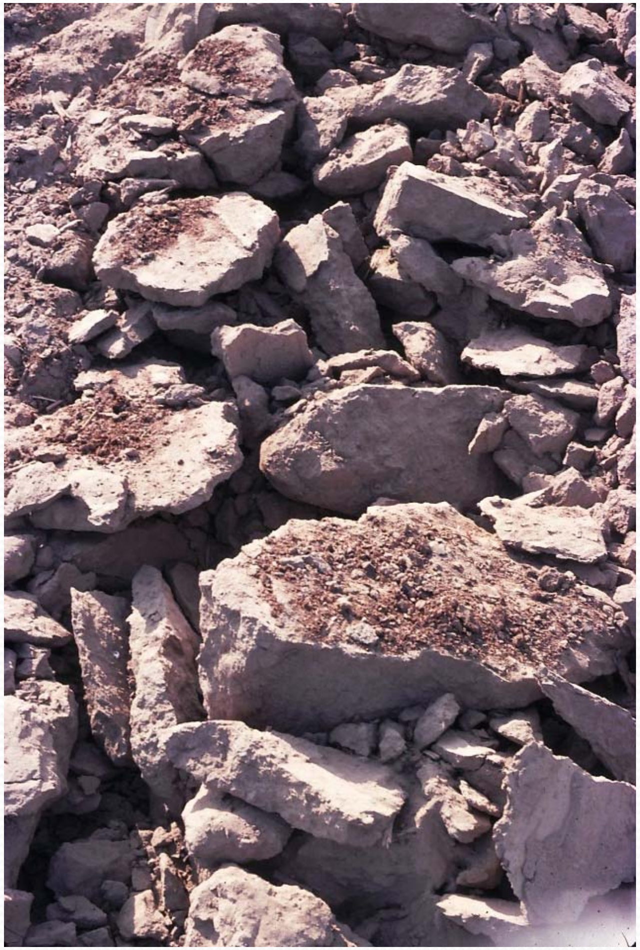
- Liming rates are dependent on initial pH and soil texture, often rates are 2 to 5 tons of lime equivalent product per acre.
- Specific soil tests can be performed to prescribe liming rates for specific soil conditions.

Interest in Calcium Acetate as a Liming Material

Treatment	Soil pH 0-6 inches , 3 wks after treatment began
Calcium acetate, daily, disturbed	7.30 a
Calcium acetate, daily, undisturbed	6.87 ab
Calcium nitrate, single app	6.73 bc
Calcium chloride, daily	6.73 bc
Calcium nitrate, bi-weekly	6.70 bc
Control	6.33 c
CAN-17, daily	5.80 d
CAN 17, biweekly	5.30 e
CAN 17, single app	5.03 e

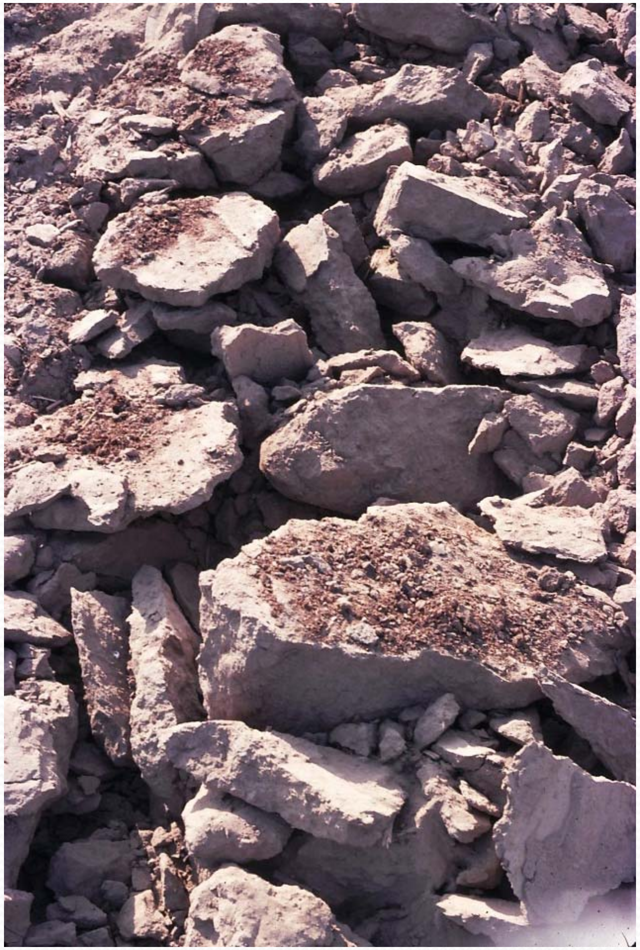
Source: W. Wildman, California Agriculture, Nov-Dec, 1988, pp. 7-9.

Hardsetting Soils



- Hardsetting soils show a massive, compact, and hard surface when dry and then tilled.
- After irrigation the soil aggregates are unstable and breakdown. Clay movement within the wetted depth of soil occurs, plugging the pores between the larger sand and silt grains, creating the massive soil structure.
- Associated with low salt content in irrigation water supplies, sodic soils and water supplies, or low calcium to magnesium ratios (Ca:Mg)

Hardsetting Soils



- Sodic soils less common in northern Sacramento Valley than other areas.
- Quote:

"Taking as a whole the controlled studies of the effect of magnesium in soil and water(Mg) on water infiltration rates and hydraulic conductivity and applying them to conditions in California leads one to suspect that Mg effects on infiltration can occur at Ca/Mg ratios in the soil-water less than 3 and on hydraulic conductivity at Ca/Mg ratios less than 2."

James D. Oster , UC Irrigation and Water Quality Extension Specialist, Emeritus. 1995. SLPYHCHM Note #3.

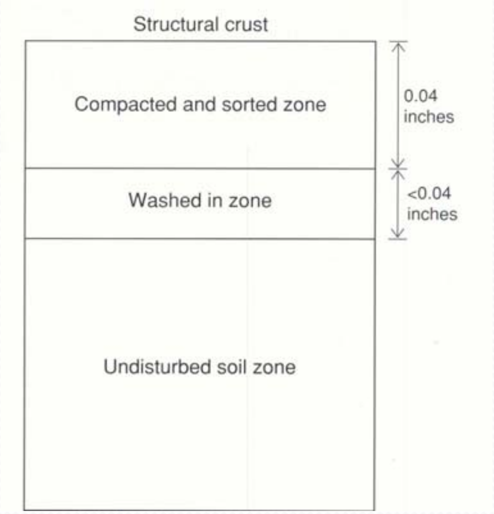
Managing hardsetting soils

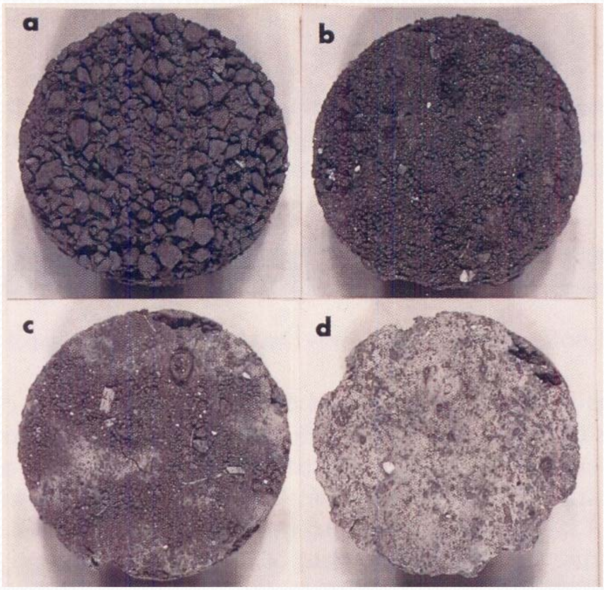
- Preplant – land applications of lime or gypsum depending upon soil pH.
- Soil testing can help evaluate the rate.
- Rate is partly an economic decision as well as an agronomic decision.
- Rates may be on the order of 2-5 tons per acre.
- Water applications may also fit into management after orchard establishment.

Effect of soil and water pH (acidity) on lime ($CaCO_3$) solubility

pH of water saturated with $CaCO_3$	Solubility of lime ($CaCO_3$)		
	ppm (mg/l)	lbs/acre-foot	(meq/l)
6.2	965	2618	19.3
6.5	720	1953	14.4
7.1	355	963	7.1
7.9	135	366	2.7
8.6	55	149	1.1
9.2	41	111	0.82
10.1	20	54	0.36
Source: Agricultural Handbook 60. pp 48. 1954			

Structural Soil Crusts and Slow Water Infiltration





- Structural soil crusts are caused by the same mechanisms as hardsetting soils, only the movement of clay particles is limited to the top few millimeters of soil.

Managing structural crusts

- Preplant – land applications of lime or gypsum will lose effectiveness as first and subsequent irrigation seasons progress.
- Water treatments or frequent mid-summer applications of gypsum or alternative amendment at equivalent rate shown to be effective
  - 250 to 500 lbs solution grade gypsum per acre-foot of water
  - About 1000 lbs of land grade gypsum per acre per month in summer

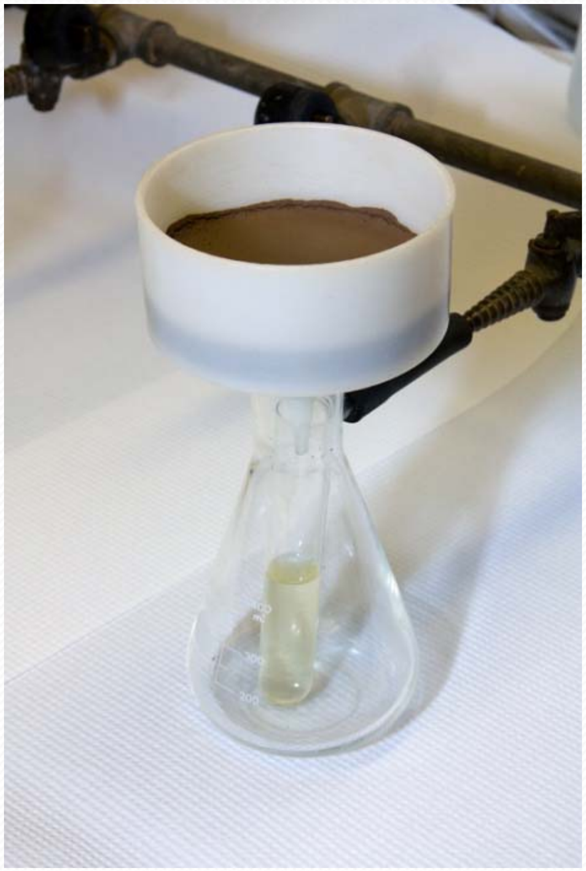
High Bicarbonate (HCO_3) in Soil and Water

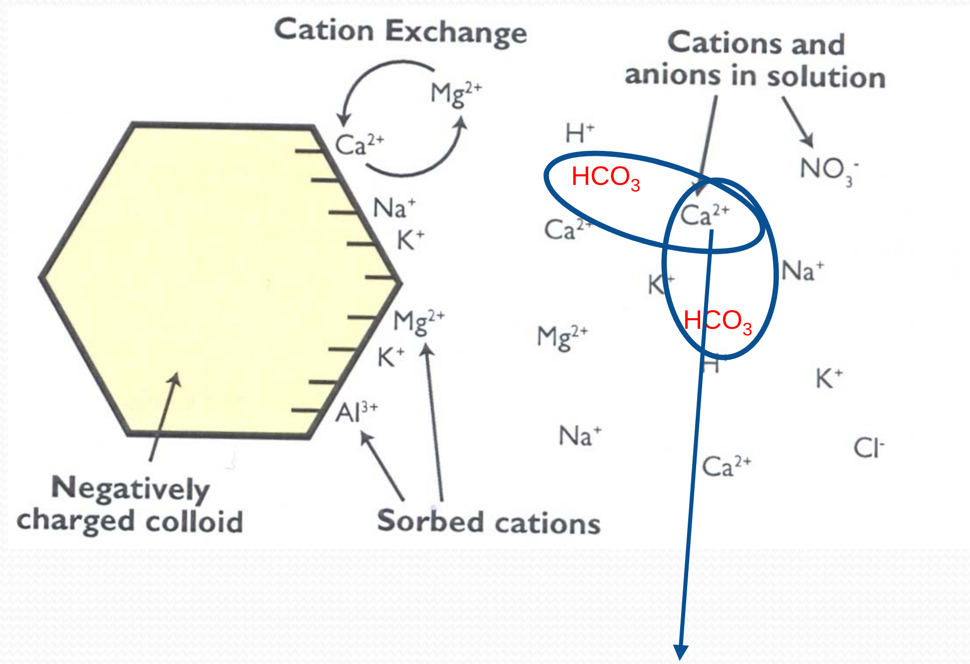
"If bicarbonate is ever cast in a Western movie, it'll be the guy in the black hat. For it – and its cousin carbonate – are among the leading villains in poor quality Western soils and poor quality irrigation water."

"Bicarbonate is a negatively charged ion that is the leading cause of plugging in drip emitters, microsprinkler heads, and it is a leading cause of surface crusting"

California – Arizona Farm Press, June 20, 1998

High Bicarbonate (HCO_3) in soil and water





Lime ($CaCO_3$)
Precipitates out
of solution

Managing high bicarbonate (HCO_3) in water

- More than 2.0 meq HCO3/l need to be detected in water test to be worthwhile
- Acid forming amendments (indirect calcium suppliers) are effective for treating high bicarbonate waters if calcium is in the water
- The rate will be specific for the water supply
- General rule – neutralize about 75 percent of bicarbonate shown in a water quality test (about 9 gallons sulfuric acid per acre-foot per neutralizes 1.0 meq/l of bicarbonate in water)

Other possibilities and opportunities to achieve benefits with amendments

- Calcium salts (gypsum) in K-fixing soils
- Peer-reviewed studies in other crops (avocado, blueberries, etc…) showing calcium from an amendment such as gypsum suppresses Phytophthora root rot
- Grower reports of higher leaf tissue N with less N fertilizer when gypsum has been applied

Interest in future workshops?

- Smaller group focus with classroom style
  - those who could then reach out to help others with technical support
  - more in-depth look at applying soil, water, and plant tissue testing

Thank You!