Irrigation Water: A Correlation to Soil Structure And Crop Quality?

By: Brent Rouppet, Ph.D.

Part 1: Irrigation Water Quality Problems

Irrigation water quality is becoming progressively more important since many growers today are either irrigating with snow-melt runoff from the Sierra Nevada, Cascade or other mountains, or poor quality subsurface water. Therefore, one of our most important current issues with growing crops in the West is the issue of water quality and how it relates to soil structure, crop quality, and crop production.

For irrigation water to be effective it needs to penetrate into the soil supplying enough water to sustain the crops until the next irrigation. Yet, most irrigation water used in California and the West is harmful to good soil structure, and eventually to plant growth and crop quality. Because infiltration problems develop slowly they are often overlooked and even go unnoticed. However, in many cases it takes just a few years or less for plants to begin to die or for the soils to become increasingly less productive.

Slow Water Penetration

The most important factor for water penetration is salts (or lack thereof) present in the water and/or soil. While all water used for irrigation contains some dissolved salts, the suitability of water for irrigation depends on the kinds and amounts of salts present. The salts of concern for irrigation and water penetration are primarily compounds of positively charged cations (calcium, magnesium, potassium and sodium), and negatively charged anions (bicarbonate, carbonate, chloride and sulfate). Many people don't realize that as irrigation water moves down into the soil profile, it is always doing one of two things. It is either depositing salts in the soil, or it is stripping or removing essential elements or constituents from the root zone.

Salinity (electrical conductivity of water [ECw]) and sodium content or sodicity (exchangeable sodium percent [ESP]) of irrigation water, especially influence to what extent soil particles remain together or separate (flocculate and deflocculate). The higher the sodium content (and ESP) and lower the total salt content of irrigation water, the more likely soil particles will become separated and disorganized. This is caused by a chemical imbalance between calcium and (sodium + magnesium [both villains to good soil structure]). Since both salinity and the amount of sodium and magnesium in irrigation water influences aggregate stability, all must be considered when determining the likelihood that water quality can reduce water infiltration. Snow-melt runoff from the Sierra Nevada, Cascade and other mountains contains very little salts.

Danyal Kasapligil, Agronomist with Dellavalle Laboratory, Fresno recently told me: "A lack of calcium in the majority of soils due to snow-melt irrigation water, or poor quality subsurface water, is leading to serious problems in California. What we are seeing in the field is, not only are there more and more water penetration problems, but crop quality is also rapidly declining because of a lack of calcium in our irrigation water."

It has been field proven: for irrigation water to penetrate deeply into the soil, the electrical conductivity of the water needs to be greater than approximately 0.60 dS/m (decisiemens per meter). Irrigation water with less than 0.60 dS/m conductivity will contribute to loss of soil structure and increased water penetration problems. Many don't realize it, but the electrical conductivity of snow-melt runoff from the Sierra Nevada Mountains typically can have a reading of 0.02 dS/m or less. The real problem with this water is it is too pure:

1. The water lacks calcium, essential for good soil structure; and
2. Any calcium existing in the soil profile is over time leached below the root zone or used by the crops, and is typically not being replaced in quantities required.

Figure 1: Water Penetration Problems in Grapes Near Lodi Due to Low Salts in the Irrigation Water and Soil

Also, for optimum soil structure there should be approximately 16 times more calcium than sodium, and 8 times more calcium than magnesium in the soil.

Another major problem with irrigation water that contributes to poor soil structure is the presence of bicarbonate (HCO3-) salts. The problem with bicarbonate present in irrigation water is it will combine with any calcium in the water or soil to form lime (CaCO3) when the water evaporates. Also, bicarbonate itself is the most toxic anion that exists in relation to plant health. Irrigation water that has bicarbonate present in excessive amounts should be treated with an acid which will eliminate the potential for lime precipitation.

Correcting Water Penetration Problems

There are several ways to help improve water infiltration problems including:

1. Physically breaking surface crusts and compacted soils with use of chisels, rippers, etc.
2. The addition and use of organic matter such as composts and manures to improve the stability of soil aggregates.
3. The use of wetting agents and related products that can greatly help with soil hydrophobicity.

However, since the problem of water quality and penetration is for the most part one of chemistry and not physics or mechanics, a chemical solution to the problem using soil amendments containing calcium is usually required. With its addition, calcium's availability is increased in the soil while sodium and magnesium are decreased. The result is increased total salt concentration (ECw) of the soil water and decreased exchangeable sodium concentration (ESP). Poor water penetration is directly caused by a chemical imbalance in the soil and irrigation water between calcium and (sodium + magnesium).

Simply put: Balancing both the soil and irrigation water using additional calcium can correct nearly all water penetration problems

Chemically, calcium counterbalances sodium and/or magnesium, thus increasing both macro- and micro-pore formation in the soil. The result is a reduction in:

1. Soil aggregate degradation
2. Surface crusting, and
3. Any deflocculation or cementing problems

There is now a major improvement in overall soil porosity, aeration (oxygenation) and water penetration.

This is what occurs in the soil with the addition of calcium:

Ca^{2+} + Na^{+} -[soil particles] → Ca^{2+}-[soil particles] + Na_2SO_4 (now leachable)

When calcium is applied to the soil and/or irrigation water, the detrimental sodium and magnesium are removed from the soil system. The chemical reaction and positive effect is immediate and dramatic, but not permanent. Therefore, a routine calcium application maintenance program is generally required.

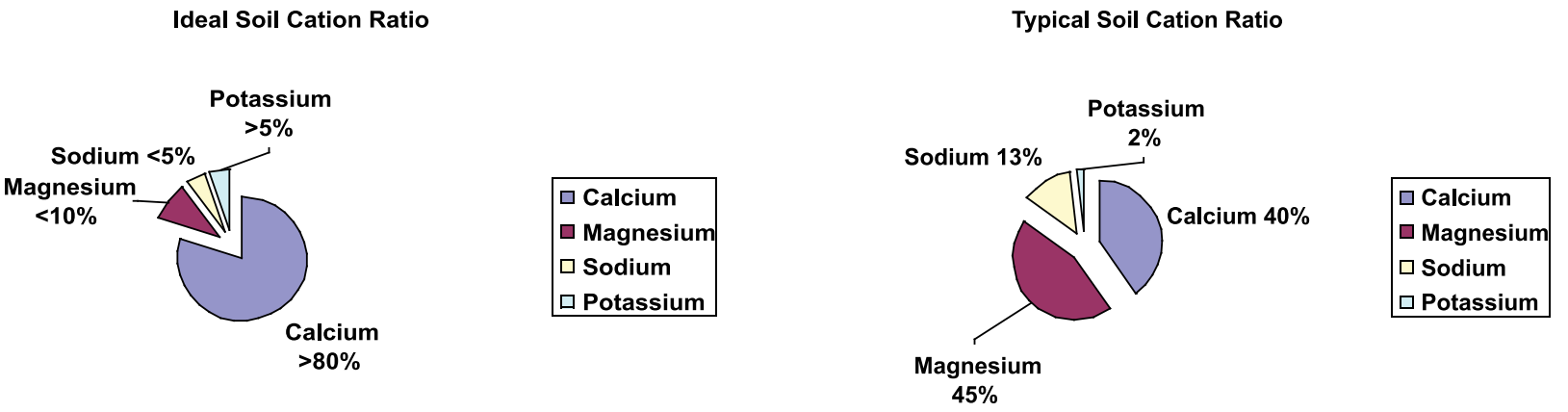

Figure 2. Ideal and Typical Base Saturation of Cation Percentages Found in Soils of the Western United States

Major Benefits of Applying Calcium to Soils and Irrigation Water

- Water now penetrates deeper into the soil profile due to a more flocculated or organized soil condition
- Less water is wasted due to runoff or "ponding" on the soil surface, thus reducing both wet and dry areas and erosion
- Less irrigation water is required to achieve the same results
- There is an improvement in water use efficiency. Twenty-five to 100% more water is available in calcium treated soils versus untreated soils
- There is increased oxygenation in the root zone
- Calcium is an essential plant nutrient, generally found in deficient quantities in most soils. [Calcium is often required by crops in amounts comparable to nitrogen and potassium]. Bitter pit in apples, blossom-end rot in tomatoes, peppers and watermelons; blackheart of celery, club-root in cole crops, are all calcium deficiency related. Calcium deficiency also reduces fruit quality and seed formation and quality in all crops.

John Witzske owner of Water Right Technologies, Modesto, recently told me: "I have been working with a lot of growers in the coastal valleys, especially berry and grape growers, where they are experiencing more water penetration and crop quality problems than ever before. The problem is directly related to a lack of calcium, plus high bicarbonate and sodium in the irrigation water and soil, along with high soil magnesium in many areas. With the use of organic soil amendments along with a balanced calcium and acid program, we are correcting many of the associated water penetration and crop quality problems in those areas."

Having worked with problem soils and irrigation water around the world, there cannot be enough said about the occurrence and difficulties associated with water penetration problems. But these problems are easily corrected by well-informed professionals. We have witnessed fields and crops that have not only benefited from precise and accurate water and soil treatment for water penetration problems, but often the crops themselves have been saved from failure. Perhaps the treatment of irrigation water and soils in regard to water penetration should be considered a vital component and necessary "first step" to all successful soil and water management programs in the agriculture industry.

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