Gypsum: Essential for Maximized Water Use Efficiency and 40 Other Purposes

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Water Penetration Problems in Walnuts Where Snowmelt Runoff is the Primary Source of Irrigation Water

There really cannot be enough said about the benefits and advantages of using high-quality gypsum to orchards, vineyards, and other crops, as well as to irrigation water. I have worked with agriculture from Mexico to Canada, and from China to the Outback of Australia and I am still impressed at how entire crops have not only benefited with the use of gypsum, but often have been saved from failure. Gypsum is such an essential amendment that its routine and frequent use is actually necessary for the sustainability of all irrigated soils. However, every year about this time I am consulted about the applications and uses of gypsum. Some growers also have questions pertaining to the uses of agricultural lime vs. gypsum which I will also address in a minute.

It wasn't that long ago when gypsum was primarily used to help reclaim soils with especially high amounts of sodium. For example, many of these soils are found in certain areas in the southern San Joaquin Valley. High sodium soils typically have water penetration/soil compaction problems due to the sodium's ability to destroy good soil structure. However, we now know that there are as many as 40 additional agronomic benefits from the use of gypsum and other calcium sulfate products.

Gypsum is a naturally occurring mineral found in many parts of the United States and the world. Gypsum is also often available as a by-product material. The actual chemical name of gypsum is "calcium sulfate dihydrate", and the chemical formula for pure gypsum is $CaSO_4 \bullet 2(H_2O)$. In the chemically pure form, gypsum contains 23.28% calcium (Ca) and 18.62% sulfur (S) in the readily available sulfate form (SO_4). By nature gypsum also contains 21% water. There is also another calcium sulfate mineral used in agriculture and horticulture in the West and that is anhydrite [$CaSO_4$]. Anhydrite is almost identical to gypsum, but by nature doesn't contain the two water molecules. All gypsum is hydrated calcium sulfate and actually forms from anhydrite. The word "anhydrite" of course means "without water."

Worldwide, there is much more of the mineral anhydrite than there is gypsum. For many growers in California, Nevada, Oregon, and the rest of the West, when they buy and apply agricultural gypsum, they are actually purchasing anhydrite, and are getting more active ingredients than other forms of calcium sulfate and less water. Obviously, every source of gypsum or gypsum-like products contain different amounts of calcium and sulfate, so growers should be aware of the source and purity of the product that he or she is purchasing. The typical gypsum sources that are commercially available for agriculture and horticulture often contain impurities which result in a calcium level between 18%-23%, and 15%-19% sulfur. Gypsum is also available as a byproduct material. Some of the more common byproduct gypsum sources are waste wallboard (also known as sheetrock or drywall). A few locations may have access to byproduct phosphogypsum from the production of phosphorus fertilizer, and some locations may have access to byproduct gypsum sources related to other industrial processes.

Gypsum should not be confused with agricultural lime or limestone. The chemical formula for limestone is $CaCO_3$, very similar to anhydrite, $CaSO_4$. However, anhydrite and gypsum are basically neutral pH-wise where the carbonate in limestone is very alkaline. Agricultural lime, therefore, is used to treat acidic soils…those soils where the pH is lower than optimum for nutrient availability. For most soils in California and the West, the optimum soil pH is about 6.4. So agricultural lime is used to amend acidic soils and supply some calcium (limestone is approximately 150 times less soluble than gypsum). Gypsum is used as a soil amendment or soil conditioner other than for amending acidic soils.[1]

Dr. Arthur Wallace of Wallace Laboratories, El Segundo, California, has spent a lifetime working with problem soils and irrigation water worldwide. Now into his 90's, Dr. Wallace is more convinced than ever that the use of calcium sulfate is essential in optimizing production with agriculture in many significant ways. In an article entitled "Gypsum is Almost a Universal Soil Amendment," Dr. Arthur Wallace and his son, Dr. Garn Wallace, explain that almost 40 benefits from gypsum's use have been documented.

We now know that gypsum helps in many more situations that just high sodium problem soils. For example, in areas where snowmelt runoff has been the principle water source, (much of the San Joaquin and Sacramento Valleys) water penetration problems occur greatly limiting water penetration, oxygen and carbon dioxide movement, and of course, root development and growth. This is because the "pure" water over time leaches calcium (necessary for optimum soil structure) from the root zone. When it is not replaced the water penetration problems begin to occur as magnesium and sodium become the dominant cations in the soil.

I've listed below the major benefits of using high-quality gypsum materials that have been field documented:

- Enhances water use efficiency. Twenty-five to 100 percent more water is available to crops depending on the soil type and soil management practices while simultaneously improving drainage through particle flocculation. Always important in California and the West where water supplies are decreasing and shrinking while costs are escalating
- Improves soil structure and compacted soils. Calcium provided to the root zone flocculates (or combines) sand, silt, clay and humus particles together thus improving water and air movement and plant root growth in the soil medium. Water penetration problems cause ponding and runoff, depriving root systems of needed moisture and oxygen, and wastes irrigation water
- An excellent fertilizer source for calcium and sulfur. There are 16 nutrients required or essential for plants. Calcium and sulfur are two of them. With calcium and sulfur deficiencies appearing more and more frequently gypsum is a practical and economical source for these two nutrients
- Amends and reclaims soils high in destructive sodium and magnesium. Sodium and magnesium (to a lesser extent) act the opposite as calcium in soils by destroying structure and reducing water and air movement, and root growth. [There should to be 16 times more calcium in the soil than sodium, and eight times more calcium than magnesium]
- Replaces harmful salts. Sodium, chlorine, boron and many other salts in higher levels in irrigation water and soil are detrimental to plant growth and development since they rupture and destroy plant cells
- Is necessary when irrigation water is "too pure" and when soils are low in total salts. When the electrical conductivity of soils and water is low [~0.75 dS/m or less], surface soil sealing and water penetration problems occur if irrigation water does not contain adequate calcium
- Helps with high bicarbonate irrigation water. Bicarbonates form free lime when water evaporates resulting in reduced available calcium and increased soil pH. The reduction of available calcium also leads to loss of soil structure and reduced water infiltration
- Reduces runoff, erosion and soil crusting. Erosion begins when rain or irrigation drops strike bare soil detaching soil particles. Aggregates stabilized by gypsum are less prone to crusting and erosion since there is limited runoff due to larger, more stable aggregates
- Counteracts acidity in subsurface soils. Gypsum leaches into the subsoil replacing aluminum and other acid forming ions, thus allowing roots to penetrate the hostile subsoil more readily
- Along with composts, manures and other plant materials, use of gypsum helps rebuild the supply of soil organic matter and is a major means for increasing the efficiency of its accumulation

From the standpoint of plant nutrition and as a soil conditioner or soil amendment gypsum uniquely helps soils be more productive and more fruitful than any other single product on earth. Working with soils and crops worldwide I have witnessed gypsum's use being largely underutilized, yet know that routine and frequent application of this essential amendment is required for the sustainability of all irrigated soils.

[1] Gypsum has many uses in addition to agriculture. A partial list of products and processes that use gypsum includes blackboard chalk, cement, wallboard, Plaster-of-Paris, dental molds, paint filler, toothpaste, molds for casting metals, tofu coagulation, improving mineral content of brewing water, dietary calcium additives in breads and cereals, and pharmaceuticals.

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