Don't Be Salty: How Irrigation, Soil Health and Climate Affect Vineyard Salinity

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In agriculture there are many compounds that we might call "salts," most of which contain calcium or magnesium. However, these are often not concerning if present in viticultural soils; it is sodium chloride (NaCl) that is most concerning when growing grapes. While chloride is an essential nutrient for plants, it's required in such small quantities that it is rarely, if ever, applied to a field or vine on its own. Sodium is not considered an essential nutrient for plant growth and can be very problematic if present in large amounts.

Sodium may be thought of as an unintentional imposter. The size and charge of a sodium ion are comparable to those of a potassium ion. Potassium is used as the basis of many processes in plant physiology and is essential in large quantities for plant growth. It is so essential that some plants (including grapevines) have created specialized sodium entry pathways in their root systems for only potassium ions.[1] Unfortunately, due to the similarity in size and charge between sodium and potassium, these pathways often also let sodium ions enter the vascular system of the grapevine and can lead to sodium accumulation in the fruits of grapevines.[4,5,6]

Some vineyards that experience NaCl-toxicity problems may be forced to utilize dwindling sources of groundwater for irrigation; this practice can concentrate what salts already exist in the water source and allow sodium chloride to accumulate in the vineyard under driplines. Other issues with salinity in vineyards may be the result of seawater intrusion into the soils of those sites.

In any situation, when sodium chloride concentrations exceed 40 mMol, or about 4 dS/m in the soil, the site can be considered sodic or saline.[11] This is equivalent to around 5% of the average salt concentration in seawater, not particularly common in agricultural settings. However, salt levels underneath drip emitters may be higher than surrounding soils due to an evaporative concentration of NaCl from irrigation water.[12]

Impacts of Heat and Drought on Salinity

Salinity problems in vineyards are often directly related to drought and high temperatures, both of which are in abundance in California. As temperatures rise, evapotranspiration in vineyards increases, resulting in high water demand. Under drought conditions, water is less available to growers and may not be available to meet the increased vineyard water demand during heatwaves.

Additionally, it may also be the case that the water that's available is of worse "quality" and laden with salts or other compounds from agricultural runoff. During droughts, regions that rely on groundwater for irrigation may not experience adequate recharge of groundwater reserves via winter precipitation. These consequences of drought and high evapotranspiration can concentrate the salts already present in the groundwater through depletion of water for irrigation usage. Improperly recycled water may also contain high NaCl concentrations, which will be introduced to a vineyard if used as irrigation water.

Salinity in vineyards used to be less of a concern. During the era of flood irrigation for grapevines the high volume of water applied during an irrigation event, would leach the accumulated sodium chloride downward in the soil profile, past the grapevine's root zone. As an industry, vineyard management has moved away from this method of irrigation because of how inefficiently water is utilized in a flood-irrigated vineyard system.[12,13]

In California, water scarcity and developments in irrigation technologies have led to the adoption of drip or micro sprinkler irrigation systems which have a higher water use efficiency than flood irrigation. In turn, because this new irrigation system is low-input relative to flood irrigation, NaCl is no longer leached by mass influxes of irrigation water during spring and summer, leading to accumulation in the upper layers of the soil.

PHOTO BY CHRIS CHEN

In severely impacted plants, leaves will experience extreme necrosis and begin to senesce from the vine. This is one way grapevines are able to sequester and then remove salts from their tissues

Avoidance of salt buildup in soils is the first approach growers should take if they are worried about sodium chloride at a site. One way to avoid salt buildup is by irrigating with only high-quality irrigation water. High-quality water has little to no NaCl in the water itself. This may be recycled water (if treated properly), surface water or water from a groundwater source that is regularly recharged in winter. In some locations, growers cannot choose their irrigation source and cannot be picky about the water they're using for irrigation.

Soil Health to Reduce Salt Toxicity

Another approach is to improve the health of your soil. Soil health can be defined in many ways, depending on the objective. To improve soil health for NaCl tolerance in a vineyard, it would be beneficial to improve soil structure, limit compaction, increase cation exchange capacity and utilize cover crops to build soil organic matter.

Improving soil structure and limiting compaction serve similar purposes with NaCl management in soils. With good soil structure, low compaction, and a higher water infiltration and percolation rates, NaCl may be leached past the root zone naturally during winter rain events. California's Mediterranean climate results in hot, dry summers and cool, wet winters.

If a grower's goal is to leach NaCl from the upper layers of the soil in a vineyard and flood irrigation is not an option during the summer, that site will rely on sufficient winter precipitation to leach those salts downwards into the soil profile. Good soil structure, low compaction, and a higher water infiltration and percolation rates will encourage rapid absorption of precipitation into and movement throughout the soil profile to help leach salts.

Increasing soil cation exchange capacity is also important as it provides more binding sites for mineral nutrients. Sodium, like most plant nutrients, is a cation and requires a negatively charged binding site in the soil to stick around. Sodium will compete with other nutrients for these binding sites. A high number of cation exchange sites allows even a highly sodic soil to retain nutrients needed for plant growth and prevents nutrient problems from worsening in saline soils. Higher soil cation exchange capacity in soils can allow sodium ions to adsorb to soil particle surfaces and effectively take them out of the soil solution. This results in lower sodium availability to grapevine roots.

Cover Crops

Cover crops can be used to improve soil structure, increase cation exchange sites and sequester some of the NaCl already present in the soils. Currently, there are no useful plant species that preferentially take up sodium or chloride and can be grown in an agricultural setting. However, most plant species will absorb some of the NaCl around their roots. Some plants, such as sunflower and mustards, have been shown to have a higher uptake of sodium than other commonly grown crops.[14] If mowed and removed, cover crops can remove a small fraction of the salts in the soils. While not a solution to salt accumulation in vineyards, cover crops can help improve the situation. In years of heavy rainfall, cover crops may also improve leaching of various salt compounds from the soil profile and reduce the rate of salt accumulation in soils of irrigated cropping systems.[15]

As average temperatures increase and precipitation patterns become less predictable in California, it's likely that sodium chloride accumulation in vineyards will become more prevalent. Overuse of groundwater for irrigation can exacerbate NaCl loading introduced via a depleting water source with high salts concentrations.

Takeaways

Short-term solutions, such as salt-tolerant grapevine rootstocks, are under development; however, all plants have a limit to the amount of salt they can tolerate. If soil NaCl concentrations continue to increase, solutions related to rootstock selection and vine phenotypes will become less effective. Given the continued popularity of drip irrigation strategies, proper groundwater management, sufficient recharge rates and well-structured soils remain important tools for addressing sodium chloride accumulation in vineyard soils. WBM

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