

Bicarbonate bad guy in Western soil, water

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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 and sprinkler heads. It is toxic to plants - in some cases more toxic than chloride. And in the soil, it ties up some nutrients and makes them unavailable to plants, and it is a leading cause of surface crusting.

Whew! That's quite a laundry list of negatives. Isn't there anything good that can be said about bicarbonate?

"Not really," says Larry Schwankl, irrigation specialist with the University of California, Davis' Department of Land, Air and Water Resources (LAWR).

Schwankl recommends growers test their irrigation water for bicarbonate. "In the water, we recommend levels of less than two milliequivalents per liter (mq/l)," he says. "Above that level, bicarbonate will react with calcium to form calcium carbonate, or lime. Those particulates can drop out of the water and plug emitters and microsprinklers."

Growers should also test their water for pH and calcium content, suggests Schwankl.

"A water pH above 7.5 is usually associated with high bicarbonates." As for calcium, it can't form precipitates if it isn't available. "Only if it's available will it be able to react with bicarbonate," explains Schwankl, "so a grower with high bicarbonate levels but no available calcium in the water might be OK."

However, he notes, "if that same grower decides to use his irrigation system to deliver a calcium fertilizer to his crops, he'll have to do something about his bicarbonate levels or some of that calcium will get tied up and won't get to his plants."

A telltale sign of high bicarbonate levels in irrigation water, says Schwankl, "is a white, chalky precipitate building up on the outside of emitters or on the irrigation pumps or faucets."

Water treatments

The standard treatment is to lower the water's pH by adding an acid. Lowering the pH to 6.5 neutralizes about half the bicarbonate in the water, explains Steve Petrie, supervisor of agronomic services for Unocal Agriproducts.

"In the past," reports Schwankl, "growers used sulfuric acid, or in some cases, phosphoric acid. Sulfuric acid has to be handled with specialized equipment and will burn right into a person's skin if it touches bare flesh. Even so, it's still used quite a bit. Phosphoric acid is a good source of phosphorous and it is acidic, although it's a weaker acid than sulfuric acid.

There is a product that's been out for a while called N-pHuric. It's an acid fertilizer produced by reacting urea and sulfuric acid. "It has all the

acidity of sulfuric acid, but is much less corrosive and dangerous to handle than sulfuric acid," Schwankl says.

Bicarbonate in soil

In the soil, bicarbonate again becomes a bad actor.

This was illustrated by an experiment with radish seedlings that compared equal concentrations of sodium chloride and sodium bicarbonate. The sodium bicarbonate proved more toxic. "Chloride is usually considered the most toxic anion to plants," notes Joe Traynor, a private consultant in Bakersfield, Calif. "But this data indicates that bicarbonate is more toxic to some species."

Traynor says bicarbonate also is strongly implicated in iron chlorosis, a yellowing of leaves due to an iron deficiency. One theory is that bicarbonate makes phosphorous more available by tying up calcium and thus increasing the solubility of calcium phosphates. "High phosphorous levels in plant tissue are often associated with iron deficiency," Traynor points out.

Even more troublesome is bicarbonate's eagerness to tie up a soil's calcium and form lime.

Calcium is important in building cell walls and membranes in plants, and increasingly is being identified as a leading determinant of crop quality.

Blossom end rot in tomatoes, tip burn in lettuce and cabbage, brown pit in apples, and internal brown spot in potatoes all are examples of calcium deficiencies.

What's more, by tying up calcium, bicarbonate becomes the leading cause of crusting and sealing of soils. Calcium is a divalent cation, meaning it has two positive charges, explains Petrie. Sodium is a monovalent cation. Calcium is preferred over sodium on a soil particle's exchange site, and will displace sodium if calcium is available in sufficient amounts in the soil. The sodium then becomes soluble and eventually leaches from the root zone. But by tying up calcium, bicarbonate makes it unavailable to a soil particle and gives sodium a change to alight.

Sodium discourages aggregation and leads to silting. Clay soils are particularly susceptible. "Clay particles are flat and tend to lie on top of each other," explains Schwankl. "Calcium discourages that process, while sodium encourages it. The result of high sodium is poor water infiltration."

A lab can test for bicarbonate by measuring bicarbonate levels in a saturated soil paste extract. But more and more growers are turning to an SAR (Sodium Adsorption Ratio) test, reports J.D. Oster, soil and water specialist at UC Riverside. SAR is the ratio of sodium to calcium and magnesium in the soil solution. The ratio is more important than the levels of nutrients themselves, explains Oster.

"If calcium and magnesium are plentiful, a grower can tolerate a higher level of sodium in

his soil," he explains.

No matter which test a grower uses, a high SAR or a high bicarbonate level indicates time for action.

Soil Treatments

The options for treating high bicarbonate levels in soil are more numerous and more unclear than they are for water.

In some cases, a grower can simply treat the results of high bicarbonate levels by adding calcium or gypsum (calcium sulfate). That increases the availability of calcium to both plants and to soil particles, and it lowers SAR by increasing the level of calcium.

Elemental sulfur is another possibility. In calcareous soils (defined as soils with free lime), sulfur produces acidity as it is oxidized into sulfate. This acidity reacts with lime to release calcium, again making it available and lowering the soil's SAR.

The final, and most common treatment, is application of an acid or acid fertilizer. Again, sulfuric acid and phosphoric acid are the likely acids. N-pHuric fertilizer is a common acid fertilizer. Sulfuric acid - applied on its own or as a component of N-pHuric fertilizer - reacts with bicarbonate to form calcium sulfate (gypsum) and H₂CO₃, an unstable and short-lived compound that rapidly converts to H₂O (water) and CO₂ (carbon dioxide).

Because sulfuric acid results in a release of gypsum, growers might wonder why not simply apply gypsum? The advantage of an acid or acid fertilizer is two fold: nutrition (phosphoric acid provides P, and N-pHuric fertilizer supplies N and S), and philosophy (an acid neutralizes bicarbonate, thereby attacking the problem at its core, while adding gypsum merely treats the symptom.)

In addition, gypsum is usually applied over an entire area. An acid or acid fertilizer can be applied precisely where it is needed. In most western soils, bicarbonate levels are so high that it is cost-prohibitive to lower them throughout the soil profile. In these cases, growers are having success by applying a strong acid such as sulfuric acid or N-pHuric fertilizer in a band, either above the surface or by shanking it in.

The acid reacts with the bicarbonate to free up calcium, which reduces sealing on the soil surface and creates a window of time for water and nutrients to get down to the root zone.

"We have some soils where the top inch can be as hard as pavement, and our tomatoes really have a problem with emergence," reports Gary Hughes, a tomato and cotton grower in Kernan, Calif. "In the past, we've just tried to keep the soil moist with sprinklers, but this year we used a 50/50 mix of N-pHuric fertilizer and phosphoric acid. The soil turned nice and crumbly and we got a full stand."



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