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Understanding Water Quality

By Bill Argo and Paul Fisher

What are the common nutritional problems in your greenhouse? Do you have problems like those shown in Figure 1 with crops like petunias or calibrachoa, or are the problems like those shown in Figure 2 with crops like marigolds or geraniums? Often, pH-related problems like these are due to misunderstanding and mismanagement of water quality.

Water quality is a key factor affecting pH management in container-grown crops. Understanding a few technical terms about water quality will help you improve pH management appropriate for your own greenhouse.

Differences Between Water pH and Alkalinity

There is a great deal of confusion when it comes to understanding the difference between water pH and water alkalinity, and why they are important to the management of your crop.

The term "pH" is a direct measurement of the concentration of acidic hydrogen ions (H^+) contained in a solution. The pH of a solution can be directly measured with a pH meter, and can range between 0 (very acidic) and 14 (very basic). At a pH of 7.0, the solution is said to be neutral. When the pH is above 7.0, and the solution is said to be basic or alkaline (not to be confused with alkalinity). When the solution is below 7.0, the solution is said to be acidic.

Alkalinity (also called acid-buffering capacity) is a measure of all the chemical bases contained in a water. Alkalinity is not a specific ion, but rather includes the concentration of several ions that affect acid-buffering capacity. Under most conditions, the ions that have the greatest effect on alkalinity are bicarbonates like calcium, magnesium or sodium bicarbonate and, to a lesser extent, carbonates like calcium or sodium.

In a water sample, the concentration of all of the ions that makes up the alkalinity term are combined and reported as equivalents of calcium carbonate ($CaCO_3$, the main component of lime), or total alkalinity. Alkalinity can therefore be thought of as the "liming content" of the water.

The units used to report alkalinity can be parts per million (ppm), mg/liter or milliequivalents (mEq).

Alkalinity can't be measured with a pH meter. Instead, you have to use a meter or test kit specifically designed to measure alkalinity. The cheapest and easiest to use are colormetric test kits where an indicator dye is added to the water, then a dilute acid is added until a color change occurs at a specific pH (usually at a pH of 4.5). The alkalinity concentration correlates with the amount of acid in the water.

Water Alkalinity Affects Media pH

When it comes to managing the pH of a container media, the alkalinity concentration has a much greater effect than does water pH. Alkalinity (calcium bicarbonate, magnesium bicarbonate and sodium bicarbonate) and limestone (calcium and magnesium carbonate) react very similarly when added to a root medium. And just like too much limestone, the use of irrigation water containing high levels of alkalinity can cause the pH of the root media to increase above acceptable levels for plant growth.

To compare the effect of water pH or alkalinity on the ability to raise pH (or neutralize acid) in a medium, 50-ppm alkalinity (which is a low alkalinity) would be similar to using a water with pH 11. Irrigation water with a pH of 8.0 would have the same effect on media pH as an alkalinity concentration of only 0.05 ppm.

Importance of Water pH

Water pH is still important for crop management. Even though it has little impact on the root media, water pH does affect the solubility of fertilizers, and the efficacy of insecticides, fungicides and growth regulators before you apply it to the crop. Generally, the higher the water pH, the lower the solubility of these materials.

Minimizing Effects of High Alkalinity

The most common method for minimizing the "liming effect" of high alkalinity is to add a strong mineral acid (sulfuric, phosphoric or nitric acid) directly to the irrigation water. As the pH of the water decreases, some of the alkalinity is neutralized. All of the alkalinity has been neutralized when the pH of the water reaches 4.5.

It is commonly recommended to add a sufficient amount of acid to decrease the alkalinity concentration to between 50- and 120-ppm $CaCO_3$, depending on the crop. The amount of acid that you need to add to your water depends on the type of acid used and the amount of alkalinity that needs to be neutralized, not the water pH. The easiest way to calculate the acid requirement of your water is to download the "acid addition calculator" from Purdue University and North Carolina State University at www.ces.ncsu.edu/depts/hort/ floriculture/software/alk.html.

With most acid injectors, it is difficult or impossible to figure out how much acid is being added. Instead, most growers will "dial in" the acid injector by measuring the pH of the water coming out of the end of the hose. This method can give you a rough estimate on the amount of alkalinity left in the water. For example, a solution pH of 5.2 should have about 40-ppm alkalinity, a pH of 5.8 at 80-ppm alkalinity, and a pH of 6.2 at 120-ppm alkalinity. However, this relationship between pH and alkalinity levels is prone to large amounts of error. The only way to know the exact amount of alkalinity that remains after acid injection is to measure it by using an alkalinity test.

One option is to make a chart of measured water pH versus alkalinity concentration for your own water source. That way, "dialing in" the acid injector is more precise because it is based on measured values for your greenhouse or nursery rather than rough estimates.

Be extremely careful about adding enough acid to neutralize all the alkalinity. Once you reach a water pH of 4.5, the alkalinity concentration is zero and, at that point, even small additions of acid can cause the pH of the water to decrease rapidly to levels that are potentially toxic to plants (and people).

In addition, strong mineral acids are caustic and should be handled with extreme care. Always wear proper eye, face and skin protection when working with acid. Avoid diluting acids by hand, but if you have to, always add acid to water, not water to acid. Some acids may be incompatible with fertilizers, especially if mixed in the same stock tank, or may corrode pipes over time. If possible, always inject acid separately from the fertilizer.

Another option for alkalinity control is to use acidic fertilizers. Fertilizers high in ammoniacal nitrogen produce an acidic reaction when added to the root medium, which can be used to neutralize the liming effect of water alkalinity. For example, 20-20-20 (69 percent NH4-N) has enough acidity to be used with 200- to 300-ppm alkalinity water without further acidification.

There are several drawbacks to using fertilizer for alkalinity control. Fertilizers high in ammoniacal nitrogen may cause excessive growth. In addition, the effectiveness of the ammoniacal nitrogenÐbased acidification is greatly reduced when the temperature of the media is less than 60¡ F.

Effects of Low Alkalinity

Not everybody in North America has irrigation water with high alkalinity. The primary problem associated with low alkalinity water is a tendency for media pH to drop over time. Growers often run into low pH problems when low water alkalinity is combined with a fertilizer high in ammoniacal nitrogen. Fertilizers high in ammoniacal nitrogen are acidic, and without any alkalinity in the water to balance the reaction (resist lowering of pH), acidic fertilizers will tend to drive the media pH down over time.

Fertilizers that are high in nitrate nitrogen often do not cause the media pH to increase when combined with low-alkalinity water. In fact, it is often recommended that growers with low alkalinity water use fertilizers high in nitrate nitrogen simply to maintain a stable media pH. When low media pH does occur in conjunction with a low-alkalinity water source, raising media pH with high-nitrate fertilizers may be difficult or impossible. Growers with low alkalinity should stock potassium bicarbonate or liquid lime, which raise media pH.

Ideal Alkalinity Versus Manageable Alkalinity

It is commonly recommended that the ideal alkalinity of irrigation water should be between 40- and 120-ppm CaCO3, depending on the crop, its stage of development and the size of the pot. However, these recommendations do not take into account the type of fertilizer that is being used. Always remember that irrigation water and water-soluble fertilizer are inseparable when discussing pH management or plant nutrition. In the case of pH management, the reaction produced by the fertilizer solution is a combination of the alkalinity concentration in the water and the ammoniacal nitrogen concentration in the fertilizers. To get a fertilizer solution that does not increase or decrease the media pH over time ("neutral" fertilizer solution), the acidity produced by the ammoniacal nitrogen in the fertilizer should be balanced by the liming effect of the alkalinity in the water.

For example, a "neutral" fertilizer solution can be produced by using an irrigation water with 150-ppm alkalinity balanced with a fertilizer containing between 30 to 40 percent of the nitrogen in the ammoniacal form (example: 20-10-20). Lowering the water alkalinity to 40 ppm would require a fertilizer with less acidity (lower ammoniacal nitrogen levels) to produce a neutral fertilizer solution (example: 13-2-13 with 5 percent ammoniacal nitrogen). Therefore, there is not a single optimal alkalinity. Instead, you should adapt your pH-management program to the water source using fertilizer selection and, if needed, acidification.

Conclusion

So how would a grower with high-alkalinity water differ in nutrient management for petunias from a grower with low-alkalinity water? The Midwest grower may consider acidification to lower alkalinity or use a fertilizer high in ammonium content. In contrast, the East Coast grower with low alkalinity would not acidify the water and would select a fertilizer high in nitrate content, using only a fertilizer containing high levels of ammoniacal nitrogen as a corrective measure if media pH was too high. In this way, each grower would balance their water quality to achieve a stable media pH over time.

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