The pH Factor: Beneficial or Bologna
Part 2: In Containers, pH is Mostly Bologna

(See Previous Issue for "Part 1: In Field Soils, pH Provides Beneficial Information")

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Container growth media are different from field soils, very different. Unlike most soils, as water moves down through a container it contacts the bottom and begins to accumulate. Only when water builds to the point where weight of water at the top of the column forces water out at the bottom does drainage begin. Considerable water is retained by capillarity after drainage stops. If growth medium components are finer in texture, more water is retained, if components are coarser, less water is retained, but the saturated zone at the bottom is ever present. The frequent bathing of the growth medium with water and high water retention increases calcium accumulation. Evaporation of water from containers is high relative to field soils. As water evaporates, dissolved minerals are left behind and accumulate.

As part of my curiosity and search for the truth about pH and nutrient availability in soilless container growth media, I did a study using pine bark, Canadian peat and sand mix. No calcium or phosphorus or other nutrients were added. The mix was used to fill 30 containers with a volume of 0.67 gallons (trade one gallons). One third of the containers were watered with deionized water that was pH 7.0. One third was watered with deionized water that had been treated with acetic acid so that the pH was 3.0. One third was watered with deionized water that had been treated with lithium hydroxide to raise the pH to 11.0. The quantity of water applied to each container was adjusted so that only a few drops exited with each application. It required 26 days and 16 applications for the water at pH 3 and 11 to shift the pH of the mix in the containers to about pH levels of the water. At that time, samples were removed from five containers with each treatment, made into 2: 1 slurry of distilled water and mix by volume and allowed to sit for 24 hours. The solution was separated by filtration and analyzed for micronutrients. The differences between treatments were minimal and statically not different one from the other. My conclusion; pH did not play a role in micronutrient availability from soilless mix components in containers.

The pH of soilless growth media in containers reflect only the fact that something was added or is accumulating either from fertilizers or the irrigation water that is either acidic or basic, nothing more. Pine bark typically has a pH of 4.0 to 4.5. Canadian peat typically has a pH of 3.0 to 4.0. Sand is more variable, but the washed concrete sand available in north central Oklahoma typically has a pH of 6.0 to 6.8. A mix of three parts by volume of ground pine bark, one part peat and one part sand typically has a pH of 4.0 to 4.5 before the addition of any fertilizer materials. If you do not add a calcium source to the mix and there is little or no calcium or other bases in the irrigation water, the pH of the mix will soon reflect the pH of the irrigation water. On the other hand if you have little calcium in your irrigation water and add dolomite (which is calcium and magnesium carbonates in approx. a 2: 1 ratio) at a rate of 8 pounds per cubic yard, the pH of the mix will generally be in the range of 5.0 to 5.5. The reason the dolomite does not cause a more rapid increase in pH is because of the slow release of calcium and magnesium into the growth medium from the particles.

After many failed attempts to show cause and affect relationships with pH, I took a different approach. To try to determine effects of pH more clearly and directly on plant growth, I did a study that proved most interesting. Plants were grown in a mix of 80% washed sand and 20% peat, with 1.5 pounds of Micromax, 12 pounds Osmocote 18-6-12 and 4.0 pounds dolomite. Water was pH 7.0 (+ or –) after being run through resin exchange columns to remove most calcium and other chemicals and divided into three tanks. Water in tank one was adjusted to pH 4.0 using acetic acid, tank two was left at pH 7.0 and tank three was raised to pH 10.0 using lithium hydroxide. [Acetic acid and lithium hydroxide contain no elements that affect plant growth. Lithium is not absorbed by plants.] After using the water for four months, pH of the growth medium approached pH of the irrigation water. All species of plants in the mix with pH in the low 4 range were just as green and vigorous as those at 7.0 or approaching pH 10.0.

This study convinced me that pH is not directly responsible for plant problems. It is a fictional scapegoat. The plant growth problems result from the accumulation or leaching of element(s) directly or the interaction of accumulated elements with micronutrients which reduces micronutrient availability. The focus should be on what element(s) have accumulated or leached to cause pH to go up or down. The element having the greatest influence on pH of the growth medium and micronutrient availability is calcium. Consider this point: It is common to find mix pH in the "optimum" range but nutrient levels far from optimum. On the other hand, if the focus is on proper nutrient levels, pH of most container growth media typically falls in the ideal range of 4.5 to 5.5.

The primary factors responsible for an increase in pH of container growth media are dissolved minerals in the irrigation water. Calcium, magnesium, sodium, potassium, carbonates and bicarbonates are all basic and as they accumulate over time, cause the pH of the growth medium to increase. As the pH of the mix increases from the original 5.0 to 5.5, availability of micronutrients decreases and crop growth typically slows and leaves become more and more yellowed. The crop response is NOT due to pH, but rather to the accumulating basic material(s) that react with the micronutrients creating complexes that are less and less soluble. Calcium is the dominant element, or bully, in containers. Calcium has two strong positive electrical charges, whereas sodium, potassium and bicarbonates only have one. Magnesium does have two positive electrical charges but is typically associated with tightly bound water, reducing the strength of the electrical charge.

It is commonly stated that high pH causes chlorosis and stunting. This is incorrect. High pH (pH above 7.0) means that there is more hydroxyl (OH^-) ions present compared to hydrogen ions (H^+). In fact it is primarily the accumulation in the growth medium of calcium that slowly renders micronutrients unavailable and that causes chlorosis and stunting. Hydroxyl (OH^-) ions themselves have little or no adverse effect on plant growth, likewise for hydrogen ions. Change in pH is simply an indicator that other elements are accumulating, leaching or are being used up.

When growth medium pH drops below 4.5, analysis should be done to be sure deficiency of calcium or magnesium does not occur. Likewise, when pH climbs above 5.5 to 5.7, something basic is accumulating and should be identified. Source of the responsible element (s) (Ca, Mg, or Na) should be located. However, once the optimum calcium level is determined for a particular growth medium and irrigation water source you can set the pH meter on the shelf.

Most container growth media components contain few micronutrients available to plants. Some micronutrients are released with decomposition of growth media components, but this is minimal. Since few micronutrients are there to begin with, unlike field soils, raising or lowering pH has little influence on availability. In short, if you add micronutrients to the growth medium they are present, if you do not they are absent and growth is likely to be restricted by micronutrient deficiencies whether pH is 4.0 or 8.0.

When micronutrients are added in soluble sulfate forms they attach strongly to the growth medium, like nails to a magnet, and little or none is lost by leaching. Availability of micronutrients for plant growth and for how long is primarily a function of the quantity of calcium present either intentionally added to the growth medium or deposited over time by the irrigation water or a combination of the two. (Figure 1.) NOTE: Always check sources of micronutrients. Most sulfate forms work well. However, oxides of iron, manganese, copper and zinc are worthless. Both the Handbook of Chemistry and Merck Index list these oxide forms as "practically insoluble".

Four examples:

1.When excess calcium is not added to the mix initially and where irrigation water contains low levels of calcium, magnesium, and bicarbonates, micronutrients from 1.5 pounds of Micromax per cubic yard remain available and provide optimum micronutrients for plant growth and good foliage color for two years or more. The amount of dolomite to add depends on the level of calcium in the irrigation water and is therefore site specific. This can only be determined with a complete irrigation water analysis.

2. When excess calcium is added to the growth medium stunted growth and chlorosis can occur after three or four months or less, even when 1.5 pounds Micromax was added initially. Excess calcium added initially quickly forms complexes with micronutrients, rendering them unavailable for plant use. The micronutrients are still present but their availability has declined to the point where growth and foliage color is no longer at optimum. In this respect, what happens in a soil-less container growth medium and field soils is similar. However, a major difference is that adding sulfur or other acidifying agent provides few benefits. The pH of the growth medium can be lowered over time with sulfur applications, but unlike in field soils, a drop of a full point or two in pH has only a slight influence on micronutrient availability because of the dominance of calcium. Further, any increase in micronutrient availability is too little, too late in the case of most crops in containers.

3. When irrigation water contains 65 to 85 ppm of calcium, and no dolomite or other calcium source is added to the growth medium and 1.5 lbs of Micromax is added, micronutrient availability typically remains for the life of the crop and growth and color is good.

4. When irrigation water contains in excess of 85 ppm calcium, slowly more calcium is applied than is needed for plant growth and the excess accumulates in the growth medium. As calcium accumulates, complexes with micronutrients occur and availability, particularly of iron, manganese, copper and zinc decrease. The higher the level of calcium in the water, the faster calcium accumulates and causes problems.

Figure 1. These nandina show severe chlorosis and leaf bleaching. A common diagnosis would be high pH. In fact, the problem is the result of excess calcium and phosphorus applied in the mix. Yes, the pH is high, but the true cause of the problem is excess Ca and P.

Place your focus on nutrient elements supplied by the mix components and irrigation water. Then add only the amounts of calcium and magnesium needed for crop growth. Once nutrient contributions from mix and water are identified and proper adjustments made in terms of dolomite added, you can throw the pH meter away. Or at least place it on a shelf with the 8-track player, three pound cell phone and other museum pieces.

*Adapted from Plant Production in Containers II.
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