The effect of soil pH on nutrient availability

By Chris Oswalt

Soil pH influences nutrient availability. This article considers the specific fate of nitrogen, phosphorus and potassium in soils with elevated pH values. The discussion also assumes that these effects would be similar to conditions in the wetted zone where micro-sprinkler irrigation has raised soil pH.

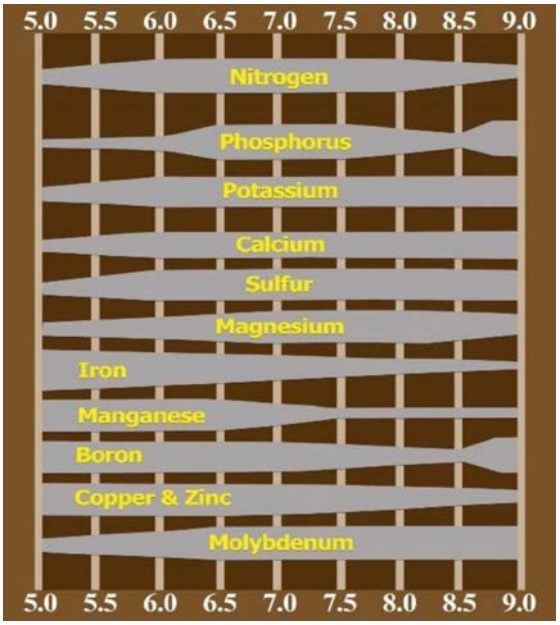
NITROGEN

Soil pH can affect several reactions involving nitrogen in the soil solution and the efficient use of this nitrogen by plants. Nitrification, the conversion of ammonium to nitrite and nitrate, is done by soil bacteria and is most rapid in soils with a pH between 7 and 8. The process of nitrification in the soil slows down at a soil pH of 5 or less. If a grower is using ammonium nitrate as a nitrogen source, then at a pH between 7 and 8, this ammonium nitrate would be rapidly converted to nitrate.

This would make the nitrogen applied significantly susceptible to leaching due to the quick conversion of the ammoniacal nitrogen to the more soluble nitrate form. At a lower soil pH, the ammonium in this ammonium nitrate would be more slowly converted to nitrate due to the reduced activity of soil bacteria. This reduction in the ammonium-to-nitrate conversion rate results in more nitrogen remaining in the ammonium form, which is less susceptible to leaching.

Also, soils with elevated pH values can cause nitrogen loss due to the atmosphere's volatilization of ammonia. This nitrogen volatilization loss occurs when ammoniacal nitrogen sources are applied to a soil surface with pH values greater than 7. In the management of nitrogen applied to soils, when pH values are above 7, there is a more significant loss of nitrogen when ammonium forms of nitrogen are used.

Growers can better manage these potential ammoniacal nitrogen losses by lowering the soil pH to slow the conversion to nitrate and reduce volatilization. Volatilization can also be reduced by incorporating this ammoniacal nitrogen in the soil by cultivation or irrigation. Using irrigation to incorporate ammonium forms of nitrogen in high-pH soil can result in additional leaching due to faster conversion of this ammonium to nitrate or nitrite by soil bacteria.



The effect of soil pH on nutrient availability as expressed by relative bar width.

Source: Nutrition of Florida Citrus Trees, 3rd Edition by Kelly T. Morgan and Davie M. Kadyampakeni

PHOSPHORUS

The availability of phosphorus in calcareous soils is also limited. The amount of phosphorus in soil is closely related to the availability of this phosphorus to plants. In high-pH soils, phosphorus reacts with soil calcium, resulting in a decreased solubility and availability of phosphorus (a process called phosphorus fixation). In this situation, phosphorus availability is determined by the amount of soluble phosphorus applied and any phosphorus released from that fixed phosphorus. Application of soluble phosphorus in these soils will only be available to plants for a short time due to the rapid phosphorus fixation at high soil pH. Lowering the soil pH to a range of about 6.5 to 7.2 will decrease the amount of fixed phosphorus, resulting in the availability of previously insoluble phosphorus.

POTASSIUM

Availability of potassium in high-pH soils is difficult to achieve due to the occupation of the nutrient-holding sites of the soil particle surface by excessive calcium. The occupation of these exchangeable soil particle sites will suppress potassium uptake by citrus trees due to competition

between calcium and potassium for the exchangeable soil particle sites. Although potassium would typically be available for plant uptake at a higher soil pH, the competition with soil calcium can negate this availability. Lowering the soil pH in this situation will reduce the exchangeable sites of the soil particle that could be occupied by potassium or other basic cations (calcium and magnesium). This would result in the release of potassium and other basic cations, making it more likely that leaching could affect the soil levels of these nutrients.

HLB-AFFECTED TREES

Huanglongbing (HLB)-affected trees tend to have smaller and weaker root systems when compared with healthy trees. Even though this increases nutrient deficiency and stress on the plant, the roots are still functional. Nutrient uptake and soil pH are of utmost importance to ensure tree health.

The optimal soil pH for effective Florida citrus production ranges from 5.8 to 6.5. Research suggests that pH ranging between 6 and 6.5 can help increase the availability of potassium, phosphorus, calcium, manganese, zinc and iron in the soil. Even though a lower pH seems to benefit HLB-affected trees more than healthy trees, the pH of your soil should not be lower than 5.

COPPER CONSIDERATIONS

One caveat to consider when determining the best soil pH level for your groves is the presence and amount of soil copper. Copper toxicity can become a problem in soils with high levels of copper or when the soil pH is lowered, making this soil copper more available. A case in point would be soil pH ranges of 6.5 to 7. These higher levels of soil copper are biologically nonreactive and tied up by the soil. When the soil pH is reduced, it can release bound copper, causing copper toxicity problems without a change in the amount of copper in the soil.

Remember, the measure of soil pH is the negative log of the hydrogen ion concentration and is a logarithmic function. Hence, a decrease of one pH unit is a 10-fold increase in acidity, and a 2-unit drop would be a 100-fold increase in soil acidity.