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Soil pH: "The Master Soil Variable"

Though harvest continues, many growers have planted next year's crop; small grains, cover-crop, and even pasture seedings are getting in the ground. With this, we again begin considering crop fertility options to get these newly established crops off to the best start possible. However, one aspect that can be overlooked in our fertilizer decision making process is soil pH. Often referred to as "The Master Soil Variable", soil pH plays an outsized role in nutrient availability, root formation, and microbial activity (just to name a few). An understanding of pH and its relation to soil chemical and biological processes can be phenomenally powerful to management decisions on the farm. This article will hopefully provide a brief, yet composed overview of soil pH and its relationship to nutrient availability.

pH, or potential hydrogen, is defined by the equation:

$$pH = -log[H+]$$

The equation may be read as "pH is the negative logarithm of the concentration of hydrogen ions in a solution". Plainly, the more hydrogen ions in a solution, the *lower* the pH value. It is a logarithmic expression so that we can evaluate the values effectively. A quick review of our high school chemistry textbook would describe that pH values range from 0-14 where solutions below neutral (7) would be acidic, while solutions above pH 7 are basic.

As farmers, we need to operate in a tighter pH range. Our soils here in central Maryland are mildly acidic and commonly range from about pH 5.0 to 6.5. For agronomic purposes, we generally like to see values between 6.0 and 6.5, this is where macro-and micronutrients are optimally plant-available. For example, plants uptake the macronutrient phosphorus in the chemical form orthophosphate ($H_2PO_4^-$). This form of phosphorus exists in the soil solution at maximum concentration between pH values 5.5 and 6.5. In the pH values above and below this range, the phosphate anion (PO_4^{3-}) is bound by either calcium or aluminum/iron oxides respectively, and is not plant-available. Phosphorus is a vital nutrient for this time of year; it ensures effective germination and is a key component of the plant energy metabolism.

Soil pH also affects a soil's cation exchange capacity (CEC). Without getting too in-the-weeds about CEC, we can recognize this chemical property as the extent to which a soil retains positively charged nutrient ions (cations) like potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). As pH increases (becomes less acidic) CEC increases as the soil reveals more locations for cation nutrients to be held. These nutrients are therefore less likely to be lost, and more likely for root-uptake.

Since our soils are naturally acidic, we raise the pH by applying "liming" materials–or those materials that contain a form of calcium carbonate ($CaCO_3$). It's important to note that the calcium does not do the work, rather it is the carbonate ions (CO_3) that react with the hydrogen ions in the acidic soil solution, to create hydroxyl ions (OH^-) that raise pH.

Relatively speaking, liming materials are one of the cheaper forms of fertilizer. What I mean to say is that given how soil pH plays an incredibly important role in determining plant nutrient availability, properly timed and applied liming materials can provide a significant “bang-for-your-buck”. Maintaining optimal soil pH is a key component of any fall fertility plan.

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