Soil Acidity; What It Is, How It Is Measured, Why It Is Important

Source: Drs. John Grove & Edwin Ritchey; UK Soil Scientists

The chemical health of the soil supporting your crop is strongly related to soil pH and fall is the best time to correct excess soil acidity. Soils are usually dry and application traffic compaction is less likely. Lime takes time to react, to neutralize soil acids, and fall application allows greater acidity reduction prior to spring planting. Soil samples may be a bit difficult to take when the soil is dry (as is the case in much of Kentucky right now), but the benefits of early detection and correction of acid soils in your crop production fields can be very significant.

Soil acidity consists of acid cations, hydrogen (H+), aluminum (Al3+), and in some soils, manganese (Mn2+). These acids are neutralized by basic anions, carbonate (CO3 2-), hydroxyl (OH-), and oxide (O2-) provided by materials like agricultural, hydrated/slaked, and quick/burnt limes, respectively. Agricultural (ag) lime, consisting of different proportions of calcium and magnesium carbonates and crushed/ground to smaller particle sizes to speed acidity correction, is the material most often used to correct soil acidity in crop production fields. Rates of ag lime are found from measurements of acidity in your soil sample.

Figure 1. Measurement of soil pH (photo: UK Regulatory Services)

One important measure of soil acidity is soil pH, which is measured by electrodes placed in suspensions (Figure 1) of a portion of the soil sample in water or a simple salt solution (calcium chloride, CaCl2, or potassium chloride, KCl). Salt solutions are more appropriate when drought results in fertilizer salt residues in fall soil samples, as is true this fall. This summer's drought was not uniform, statewide, and the resulting fertilizer salt carryover is both significant and variable, causing lower and noisier than usual pH values in the soil plus water suspensions. The University of Kentucky (UK) soil test lab determines soil pH in a suspension of soil and KCl solution that 'swamps' salt carryover differences in our samples. The KCl pH values are converted to water pH values using an equation: water pH = (0.91 x KCl pH) + 1.34.

The pH measured these suspensions is related to the hydrogen ion (H+) activity of the soil-water system. The chemical definition of pH is that pH = - log(H+). In other words, for a pH drop of 1 unit (e.g., from pH 6 to pH 5) there will be a ten-fold increase in H+ activity in the soil solution. If pH rises by 1 unit, only one-tenth as much acidity will be present in the solution. As such, these pH measurements only determine the active acidity in the soil water solution bathing plant roots. This fraction of total soil acidity is extremely small. It would take less than a half-pound of calcitic lime per acre to neutralize the active acidity contained in the soil solution of 8 inches of pH 5 silt loam topsoil at field moisture.

The much, much larger portion of total soil acidity, termed potential (reserve) acidity, resides on the surface of soil clay and organic matter particles. This particle surface acidity is in equilibrium with the solution active acidity, and the greater the clay or organic matter content, the greater the soil's ability to resist solution pH changes by either releasing or adsorbing H+. This resistance is the soil's buffer capacity. Soils with different textures (sandy vs. silty vs. clayey) can have the same level of active acidity, the same pH in soil plus water/ simple salt suspensions, but these soils will have very different quantities of potential/reserve acidity. This causes soil test labs to use another measurement approach to get at potential/reserve acidity, the buffer pH/ lime requirement test. Measurement of the soil potential/reserve acidity is done by suspending a portion of the soil sample in a chemical buffer solution that competes with the soil's buffer capacity and reacts with the particle surface acidity. The UK soil test lab uses the Sikora II buffer, which has a preset pH of 7.5. The lower the pH of the soil plus Sikora II buffer suspension, the greater the soil's potential/reserve acidity and the greater the lime requirement needed to neutralize that acidity.

Understanding your soil's acidity status is important. Soil pH can serve as a general indicator of soil nutrient availability, much like body temperature indicates general animal health. Soil pH values between 6.4 and 7.0 promote nodulation of legumes and the biological nitrogen fixation that sustains these crops. Low pH can slow biological mineralization of organic matter and crop residues, slowing release of organic nitrogen, phosphorus, and sulfur.

As soil acidity rises, soil pH falls and potentially toxic elements like manganese and aluminum become more soluble and available for plant uptake. Acid soils reduce the solubility and uptake of other nutrients, especially phosphorus and molybdenum. Surface soil acidity can reduce the effectiveness of triazine herbicides. Alkaline soils with excessively high soil pH values also often exhibit potential for nutrient stress. Deficiencies of zinc, manganese, and phosphorus have been observed on high pH soils in Kentucky. Boron, copper, and iron deficiencies have been reported in other states. Over-liming, whether due to excessive application rates or improper spreader operation, should be avoided.

Different crops have different soil pH needs. UK publication AGR-1 provides pH and lime information for many crops (AGR-1 Lime and Fertilizer Recommendations). Blueberries, potato, and azaleas grow well at lower soil pH values, tolerating the greater acidity and related chemical conditions. Corn and soybean require greater pH values and UK recommends lime to reach a target pH of 6.4 when the soil pH falls below 6.2 (see Table 6 from AGR-1).

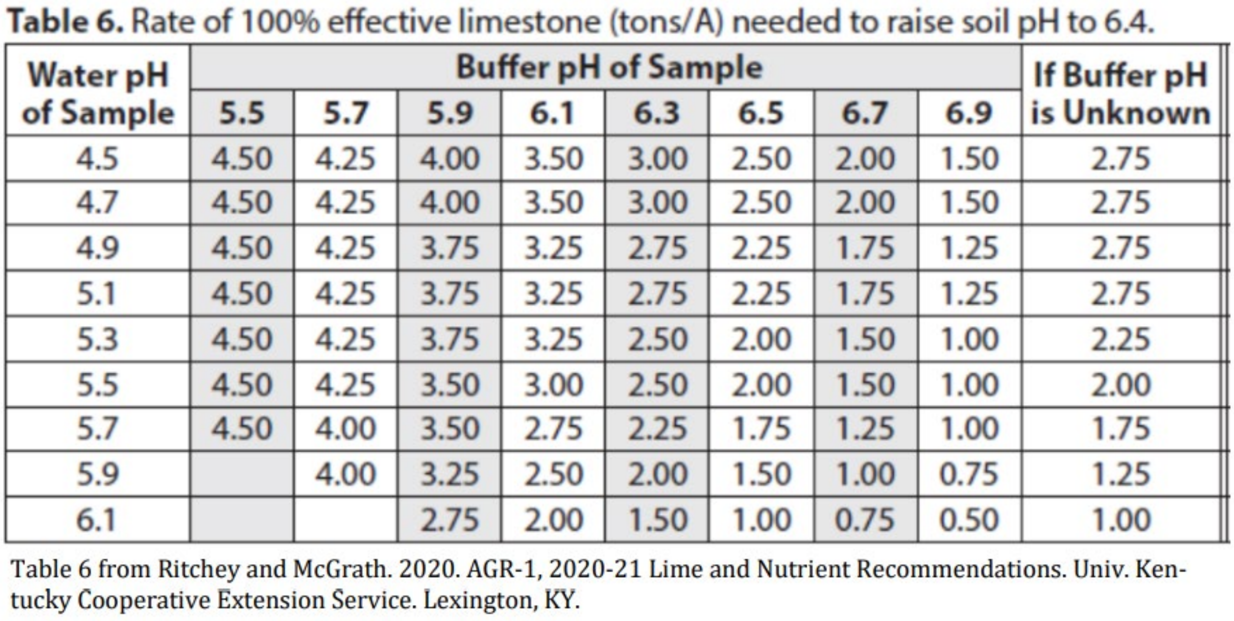

Table 6. Rate of 100% effective limestone (tons/A) needed to raise soil pH to 6.4.

Water pH of Sample	Buffer pH of Sample								If Buffer pH is Unknown
	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	
4.5	4.50	4.25	4.00	3.50	3.00	2.50	2.00	1.50	2.75
4.7	4.50	4.25	4.00	3.50	3.00	2.50	2.00	1.50	2.75
4.9	4.50	4.25	3.75	3.25	2.75	2.25	1.75	1.25	2.75
5.1	4.50	4.25	3.75	3.25	2.75	2.25	1.75	1.25	2.75
5.3	4.50	4.25	3.75	3.25	2.50	2.00	1.50	1.00	2.25
5.5	4.50	4.25	3.50	3.00	2.50	2.00	1.50	1.00	2.00
5.7	4.50	4.00	3.50	2.75	2.25	1.75	1.25	1.00	1.75
5.9		4.00	3.25	2.50	2.00	1.50	1.00	0.75	1.25
6.1			2.75	2.00	1.50	1.00	0.75	0.50	1.00

Table 6 from Ritchey and McGrath. 2020. AGR-1, 2020-21 Lime and Nutrient Recommendations. Univ. Kentucky Cooperative Extension Service. Lexington, KY.

Finally, soil pH is rather slow to change, either up or down in our silt loam/silty clay loam soils. Don’t expect soil pH to reach your target pH 6 months after application – it may take over a year. That said, taking soil samples every 2 to 3 years is adequate for monitoring this important soil health parameter.