University of Nebraska Lincoln
Cooperative Extension in Lancaster County
Educational Resource

Answers to Questions About Liming Acid Soils

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Tom Dorn, UNL Extension Educator – Lancaster County Extension

Question #1: My soil test report shows a number for pH and another number for buffer pH. What does pH measure and what is the difference between pH and buffer pH?

Answer: pH is a measure of the acidity or alkalinity of a soil. When the soil solution (the water in the soil) contains equal numbers of hydrogen ions (H^+) ions as hydroxyl (OH^-) ions, the soil is neutral and the pH of the soil is 7.0. When there are more H^+ than OH^- ions, the soil is acidic, and when there are more OH^- ions than H^+ ions, the soil is alkaline. The scale is logarithmic. That is to say a soil with a pH of 6.0 is 10 times more acidic than a soil with a pH of 7.0. A soil with a pH of 5.0 is 10 times more acidic than a soil with a pH of 6.0 and 100 times more acidic than a soil with a pH of 7.0.

Soil acidity can be thought of as two types: active or soil solution acidity and reserve or exchangeable acidity. The active acidity of a soil is measured directly by a pH meter in the lab.

Reserve acidity depends on several factors, such as amount and type of clay, amount of organic matter and soluble aluminum concentration in the soil. Therefore, two soils can have the same measured pH, but will require different amounts of lime to change the pH value and correct it back to a more neutral pH.

A chemical test using a buffer, is performed in the laboratory to determine the amount of calcium carbonate equivalent (CCE) necessary to raise the soil pH to a desired level. This buffer solution reacts with the soil to neutralize both the active and reserve acidity. The change in the pH of the buffer can be measured and correlated to the amount of lime needed per acre to obtain the same results in the field. This is reported on the soil test report as buffer pH. A rule of thumb for buffer pH values is, for every 0.1 point below pH 7.0, it takes about 1,000 pounds of ag lime (60% CCE) to bring the top seven inches of soil (about two million pounds of soil) up to a measured pH value of 6.5 (6.5 is considered the ideal pH for most crops).

For example a soil with a buffer pH of 6.3 would require (7.0 - 6.3) x 1,000 = 7,000 pounds of ag lime per acre to bring the pH value up to 6.5. If the lime is incorporated deeper than seven inches, larger amounts of lime are required to neutralize the acidity because you are affecting a greater mass of soil.

Question #2: Does liming really make sense economically?

Answer: Nutrient availability is affected by the pH of the soil in two ways. Clay and organic matter carry negative charges. Positively charged particles called cations (pronounced "kat-I-on") are attracted to, and held by, the negatively charged sites on the clay and organic matter particles until the plant roots exchange a hydrogen ion (H^+) for the plant nutrient which is taken into the plant and used.

There are a finite number of cation exchange sites in a soil. This can be measured in the laboratory and is reported on some laboratory reports as the cation exchange capacity (CEC) of the soil. As the cation exchange sites get filled up with hydrogen ions, fewer sites can be occupied by the cations that are needed for the metabolic processes in the plant. The essential plant nutrients that are held as cations in the soil include: K^+, Mg^{2+}, Ca^{2+}, Cu^+, Cu^{2+}, Zn^{2+}, Mn^{2+}, Fe^{2+} and Fe^{3+}. Nitrogen, when it is in the ammonium form (NH_4^+) is held as a cation in the soil and is obtained through the cation exchange process as well.

The pH also affects the availability of the nutrients which are present in the soil. A pH range of 6.0 to 7.0 is ideal because in this range, the major plant nutrients are most available for use by plants. Nutrients less available to plants as pH drops below 6.0 are P, K, Ca, Mg, S and Mo.

Conversely, at very low pH values (below 5.2), aluminum enters the exchangeable ion complex. Aluminum is toxic to plants and further depresses yields if pH is allowed to get this low.

Besides the effect pH has on the purely chemical processes in the soil, pH also affects the microbiological processes as well. Bacteria in the soil are more active between pH 6.0 and 7.0, thus mineralization of organic matter is better (increasing the availability of nitrogen and other nutrients such as phosphorus, sulfur and other nutrients). Also, the bacteria associated with nodulation and nitrogen fixation by legumes function better in the 6.0 to 7.0 pH range.

It is best to maintain the soil pH at values above 6.0. A pH of 6.5 is considered ideal. However, because it is expensive to apply lime and because it takes several years for the lime to fully react in the soil, liming should be considered an eight-year investment. Remember also that the same things that made the soil acidic in the first place are going to continue to occur, requiring periodic applications of lime in the future.

Question #3: My soil has a pH of 5.9 and a buffer pH of 6.3, could I wait another year or two to apply lime, given tight finances?

Answer: Yes. A pH of 5.9 is below the ideal range but

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probably not low enough to have much affect on yield in most years. However, the pH of this soil is at the point where nutrient availability is beginning to decline. Lower pH values will reduce nutrient availability even more and will have yield consequences.

Remember, the longer one waits, the more lime it will take to correct the pH. Also, due to the high cation exchange capacity of our soils in eastern Nebraska, the buffer pH is already quite low, requiring rather large amounts of lime to correct the problem. It would be good not to get much further behind, because it will require even more lime to correct pH levels in the future.

Question #4: Are there differences in lime quality?

Answer: There are differences in lime quality due to the chemistry and particle size distribution of the product used. The ag lime that is commonly available in eastern Nebraska is a mixture of calcium carbonate and magnesium carbonate plus impurities. Both calcium carbonate and magnesium carbonate are effective in neutralizing pH.

Limestone is not very soluble and, therefore, needs to have a small particle size to dissolve into the soil solution quickly enough to be considered effective. NebGuide (G84-714) *Estimating Ag Lime Quality* indicates limestone held on an eight-mesh screen (the size of gravel) is less than 10% effective, whereas that passing an eight-mesh screen and held on a 60-mesh screen (like course to fine sand) is about 40% effective, and that passing through a 60-mesh screen (like gritty flour) is 100% effective.

Lime is tested and the neutralizing effectiveness is expressed as calcium carbonate equivalent (CCE). Most labs will recommend lime requirement as pounds per acre of CCE. Lime suppliers in Nebraska must register with the State Department of Ag and the minimum CCE value must be specified. Most ag lime in Nebraska runs between 60 to 65% CCE. Therefore, if a lab recommends 3,000 pounds of CCE to raise the pH to 6.5, and a lime source having 60% CCE is used, it would take: 3,000 ÷ 0.60 = 5,000 pounds of that particular lime to meet the recommendation.

Question # 5: Could I apply less than the recommended amount of lime and still do some good?

Answer: University of Nebraska lime recommendations are for the amount of lime required to bring the top seven inches of soil up to a pH of 6.5. Less lime will not bring the pH level up as much but will prevent it from going lower for a time and may raise it some (depending on the amount applied). An analogy would be the decision to fill the gas tank on the pickup which might take $25 or only to put $10 worth of gas in the tank. Either decision will help you get down the road, but you won't go as far on $10. Remember also, operators charge by the acre to spread lime. If, for example, one applies one-third of the recommended amount but then must do it three times as often, the total cost will be higher than if it were applied in one operation.

Basically, there is no way around the laws of chemistry. It takes a given amount of lime to neutralize the active and reserve acidity in the soil and bring the measured pH up to an acceptable level.

Question #6: I am in a no-till system where the soil is never mixed by mechanical means. Will lime be effective if it is spread on top and left there?

Answer: Soil scientists say lime applied in a no-till system does eventually neutralize the top three to six inches of soil. While lime's solubility is low, it *is* soluble and will move into the soil with the water over time. Also, earthworms and other forces tend to mix the soil. Would the lime work quicker if it were incorporated? The answer is definitely yes, it would react quicker if it were incorporated, but if it is not possible to incorporate the lime, it will eventually work anyway.

References:

Liming Acid Soils — *Kansas State University (MF-1065)*
http://www.oznet.ksu.edu/library/CRPSL2/MF1065.PDF

Estimating Ag Lime Quality — *NebGuide (G84-714)*
http://www.ianr.unl.edu/pubs/soil/g714.htm