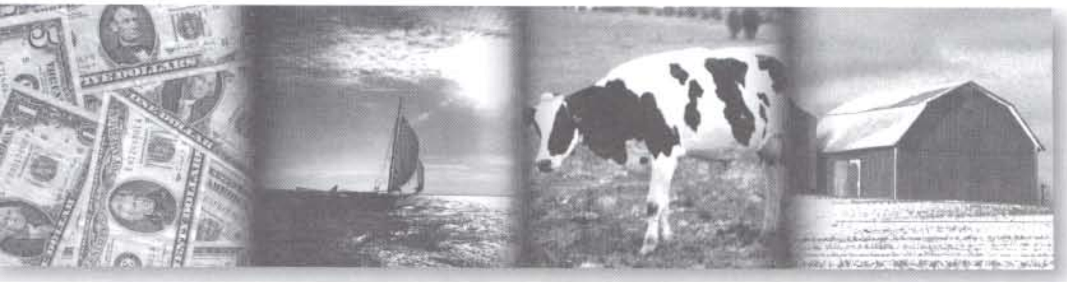

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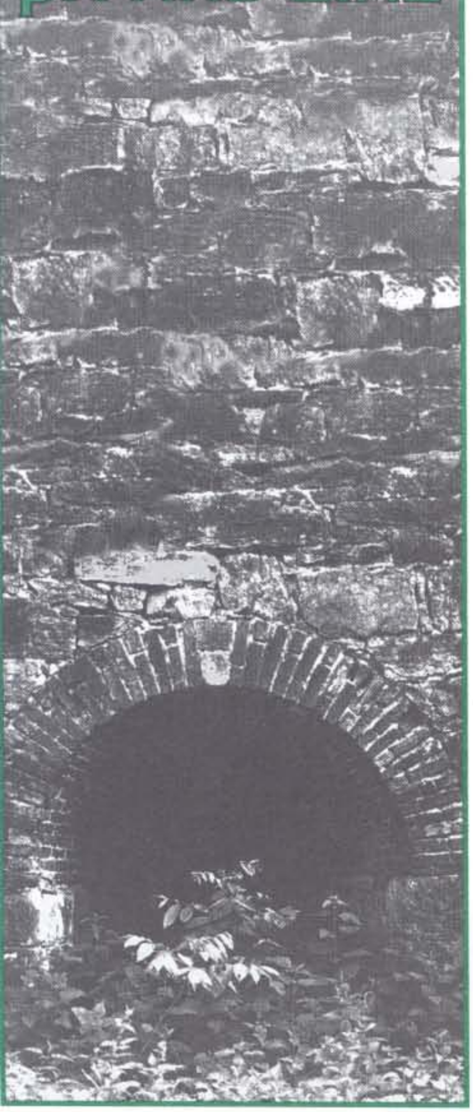
NUTRIENT MANAGER

Newsletter of the Maryland Cooperative Extension Agricultural Nutrient Management Program

FOCUS ON pH AND LIME



For over two millennia farmers have added materials with liming properties to some soils. The Roman scholar, Pliny the Elder, writing in the first century A.D., described how limestone, marl, and the ashes of limekilns could be used to increase the yield of some crops. He provided detailed information on their use and which soils and crops benefited from such applications.

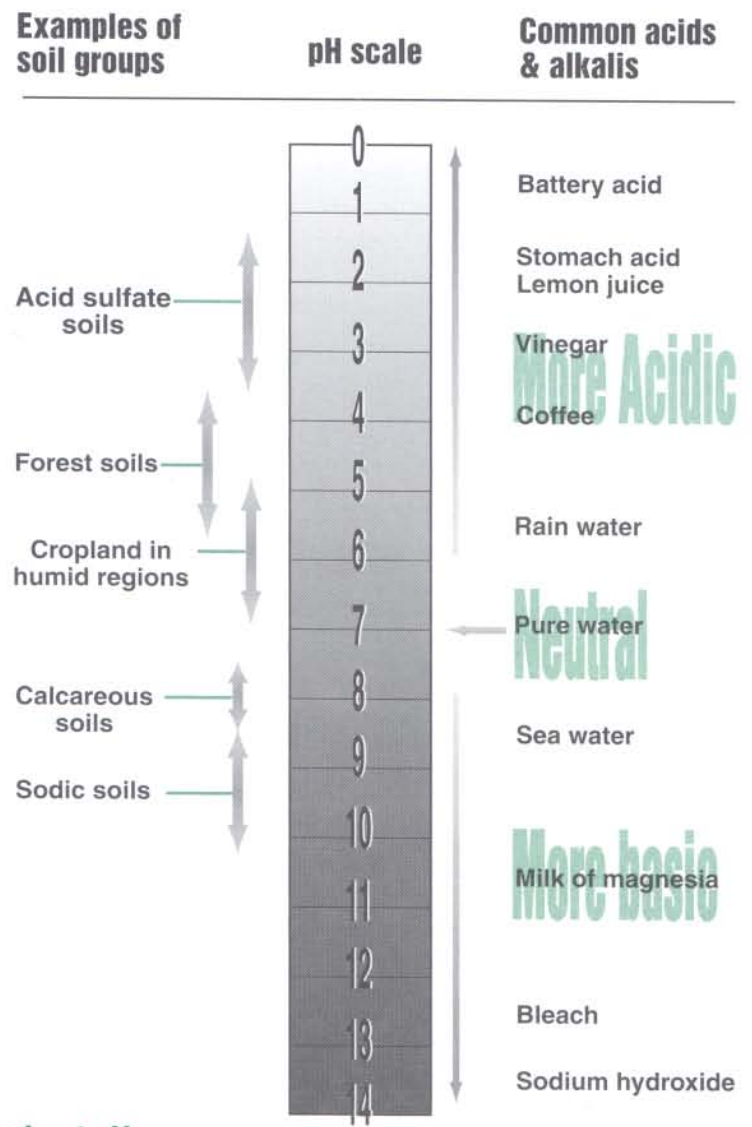
The use of liming materials increases the productivity of many soils because of their ability to neutralize soil acidity. Soil pH, a measure of a soil's acidity or alkalinity, has an impact on crop yield through its effect on nutrient availability and other aspects of crop production. Careful management of soil pH is an essential part of managing soils to obtain high crop yields.

WHAT IS pH?

The pH scale is used to measure acidity and alkalinity. On the pH scale pure water has a pH of 7. **Acids** have pH values below 7 and **alkalis** (also called **bases**) have pH values above 7. The stronger the acid, the lower the pH value; the stronger the alkali, the higher the pH value. Figure 1 gives a more detailed description of how this scale works.

THE EFFECT OF pH ON SOIL

Soil pH affects a wide range of processes that take place in the soil. For example, pH levels below 5 favor the production of soluble aluminum, manganese and iron compounds. At high concentrations these are toxic to some crops. The activity of many beneficial soil bacteria is also affected by soil pH. In very acidic soil, the activity and numbers of some of these bacteria are very low. The effective and safe use of many herbicides also relies on maintaining certain ranges of pH.



More about pH

Water has the chemical formula H_2O. In pure water a small number of the H_2O molecules split to form equal numbers of hydrogen (H^+) and hydroxide (OH^-) ions. In 1 liter of pure water there are 0.0000001g or 10^{-7} grams of hydrogen ions. On the pH scale this becomes simply pH 7. Strong acids, for example battery acid, contain much greater concentrations of hydrogen ions, approximately 0.1 grams or 10^{-1} grams per liter. Battery acid therefore has a pH of 1. A strong alkali such as lye (sodium hydroxide) has very few hydrogen ions, 10^{-14} per liter. It therefore has a pH of 14. Acids have more H^+ than OH^- ions. Alkalis have more OH^- than H^+. Because pure water has an equal balance of both H^+ and OH^- ions it is said to be **neutral.** Generally, soil pH varies from between pH 4 and 10. Many crops grow best when between pH 5.5 to 6.5.

Figure 1: The pH scale giving the pH of common substances and the range of pH common in soils.

pH and Plant Nutrient Availability

Soil pH affects the availability of many plant nutrients.

Raising soil pH above 5.5 increases the conversion of ammonium into nitrate. This increases nitrogen availability to many crop plants which prefer nitrate as a nitrogen source.

The root nodules of legumes contain bacteria which convert nitrogen in the air into a form plants can use. The best pH for the activity of these bacteria varies according to the crop in which they live. For example, those living in alfalfa work best at about pH 6.8-7, while those in soybeans are more effective at pH 5.8-6.5.

Maximum availability of phosphorus occurs between pH 6 and 7. Outside this range the formation of insoluble phosphorus compounds reduces its availability to plants.

All crops have a range of pH at which they grow best. Examples of optimum pH ranges for various crops are given in Figure 2.

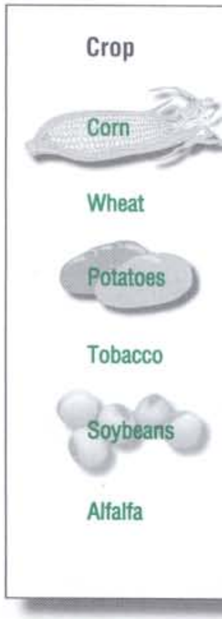
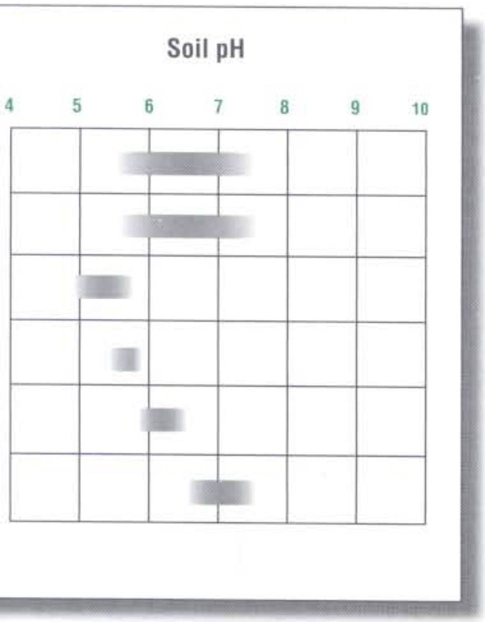


Figure 2: Optimum pH

Herbicides And pH

The effectiveness and breakdown of some herbicides differ across the range of pH encountered in soils. Below pH 5.8, triazine herbicides are held by the soil and cannot be absorbed by plants. This may reduce their effectiveness against weeds. Raising the pH above 6.5 makes the herbicide available to plants and effective at weed control. However, this may cause problems. For instance, if you limed a soil to which triazines had been applied for many years the herbicide may be released. If small grains were then planted in the field they may be damaged or killed by the herbicide.

Many sulphonylurea herbicides are only quickly broken down at a pH below 7. If a soil is limed above this pH the breakdown process slows and may stop altogether. The herbicide remains in the soil and can damage future crops planted in the field.



ranges of some crop plants.

Liming Soils

To prevent soils from becoming too acidic for optimum crop growth, it may be necessary to apply liming material.

A small adjustment in a soil's pH may require the addition of a large quantity of lime. This is because soil has the ability to resist changes in pH. Although soil may contain relatively few **active** hydrogen ions, in solution it contains large numbers held in **reserve** which are chemically bound to soil particles. In order to change the pH of a soil it is necessary to neutralize both the active and the reserve soil acidity.

Liming Materials

Liming materials react with acids in the soil. This is called **neutralization.** Liming materials usually contain the oxides or carbonates of calcium and magnesium. Crushed limestone is the most widely used liming material because of its low cost. Limestone is composed mainly of calcium carbonate. Some limestones, particularly dolomitic limestone, also contain magnesium.

Other forms of liming materials do exist. Examples are quicklime (burnt lime) and slaked lime (hydrated lime), marl, water treatment lime waste, fly ash, biolime and liquid lime (finely ground limestone suspended in water).

The Effectiveness of Liming Materials

When comparing different liming materials, it is important to know the **neutralizing value** and the lime **particle size.** These two characteristics can be combined to determine the **"effective neutralizing value."** When comparing the cost of liming materials, make sure you determine **the cost per ton of effective neutralizing value**. Consult SFM-5 (available from your local Extension office) for more information and examples.

Neutralizing value is expressed in two ways, **calcium carbonate equivalent** or **percentage oxides**. In Maryland, all agricultural liming products should bear a statement of the total "percent of oxides of calcium and oxides of magnesium." It is possible to convert between these two methods of measuring the neutralizing value (see Figure 3).

The size of lime particles in a liming material will effect how quickly pH is adjusted. Fine particles react quickly, large particles react more slowly. Liming materials are often a mixture of particles of various sizes. The size of lime particles is expressed as the percentage of the material that passes through several sieve sizes. Information on fineness is given for liming materials and includes the proportion of different particle sizes present. In Maryland, fineness of liming materials must be expressed as the percentage passing through 20 mesh (i.e., a 20 mesh screen has 20 wires to the inch), 60 mesh and 100 mesh screens.

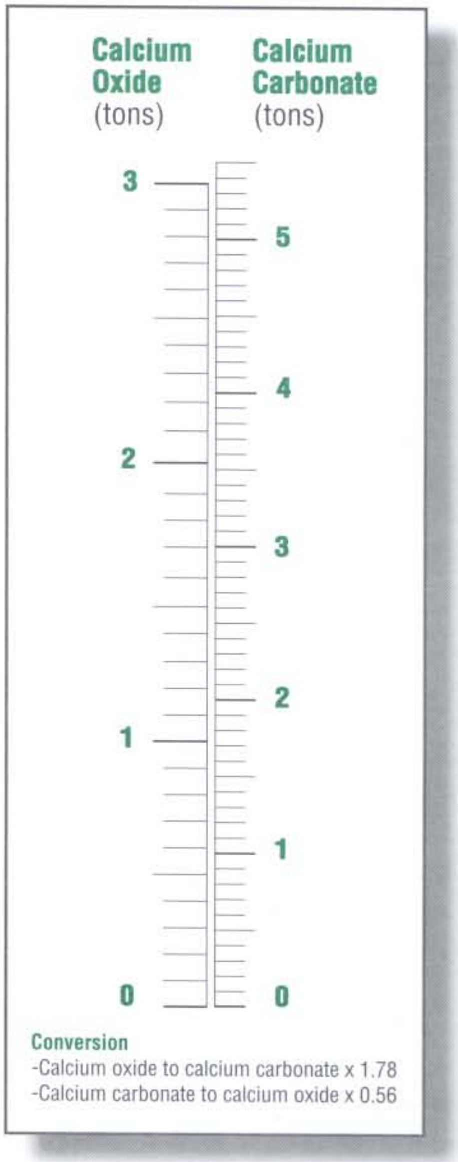
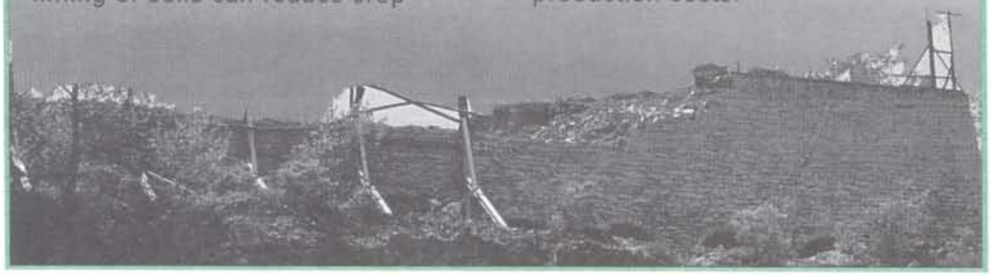


Figure 3: A conversion scale comparing Calcium Oxide and Calcium Carbonate neutralizing values.

Dangers of Overliming

Optimal lime application rate can only be determined by soil testing for lime requirement. Both the underliming and overliming of soils can reduce crop yields. Overliming can cause micronutrient deficiencies and may delay herbicide breakdown. Purchase of unneeded liming material increases production costs.



For nutrient management planning services, call your Cooperative Extension educator at the county Extension office.

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