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Soil pH – Its not a real substance

By Dr. Terrence Fullerton

Just about anyone involved in crop production knows that it is important to check the soil pH. But if we get a value of 6.0 exactly what does that mean? Many people are surprised to find out that there is no substance called "pH" and the value 6.0 does not mean that there are six of anything in the soil.

To understand pH, let us look at some basic chemistry. Everywhere there is water there are hydrogen ions (H^+) and hydroxide ions (OH^-). The higher the concentration of hydrogen ions the more acidic the solution is. The level of acidity affects how fast food spoils or metal rusts, it determines if your pool is safe for swimming and if your food will digest properly. Acidity affects just about anything that contains water.

Because acidity is so important, chemists have to find a way to measure and report the concentration of H^+ ions. The traditional way is to express the concentration in "moles per liter". Using this method, acidity can be expressed as follows:

Acidity of orange juice	0.000251 moles/liter H^+
Acidity of milk	0.000000398 moles/liter H^+

While this method is technically correct, it is really inconvenient to use such small numbers; it is also very easy to make mistakes with the number of "0"s. Chemists have therefore developed the "pH" calculation that converts these numbers into a more convenient form. The calculation is

$$pH = -\log_{10} \text{concentration of } H^+ \text{ ions}$$

Using this calculation, we can now express acidity as follows:

pH of orange juice	3.6
pH of milk	6.4

pH is therefore not a real chemical substance, it is a calculation that gives us a simple way to express the concentration of H^+ ions.

A similar calculation can be done on the hydroxide (OH^-) ion concentration:
$pOH = -\log_{10}$ concentration of OH^- ions
There is a fixed relationship between pH and pOH: pH + pOH =14

A few points about pH.

A pH value of 7.0 is neutral (equal amounts of H^+ and OH^- ions.)
Values below 7.0 are considered to be acidic (more H^+ than OH^- ions.)
Values above 7.0 are alkaline or basic (fewer H^+ than OH^- ions.)

The pH scale "normally" runs from 0 to 14. Contrary to popular belief it is possible (but unusual) to have values below 0 or above 14.

The pH scale is not linear but is logarithmic which means it is in steps of 10. A pH value of 5.0 is ten times more acidic than 6.0. pH 4.0 is ten times more acidic than 5.0 or 100 times more acidic than 6.0.

Most plants can tolerate a wide range of pH values if they are grown in a soil-less medium. However plants are sensitive to pH changes in a mineral soil, not because of the hydrogen ion concentrations but because of secondary reactions.

When the pH of a typical soil is low, large amounts of minerals dissolve to the point where they are toxic. Crop failure in an acidic soil is usually due to toxic amounts of aluminum and to a lesser extent manganese, iron and nickel. On organic soils that do not contain minerals that can dissolve, it is possible to get high production at pH values as low as 4.5.

At high pH values the opposite happens. Many minerals come out of solution and are no longer available to plants. Plants therefore suffer from deficiencies of several nutrients including iron, manganese and zinc.

Phosphorus is removed from the soil solution by reactions with minerals at both high and low pH values. It is therefore available over a limited pH range.

The optimum soil pH for plant growth is usually between values of 5.8 and 6.8. In this range nutrients are available to plants and the levels of dissolved minerals are not high enough to be toxic.

Some plants have specific pH ranges that they prefer. Alfalfa grows best at pH values above 7.0 while pineapple prefers acidic soils with pH values below 5.8.

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