# Soil pH for Field Crops

The pH of a soil is among the most important soil characteristics for crop production. The pH of a soil is a measure of the activity of hydrogen ($H^+$) ions in the soil solution usually obtained by shaking soil with distilled water. Mathematically, the pH is the negative logarithm of the hydrogen ion activity of a soil which means that for each unit increase in pH there is a 10 times change in acidity (so a soil with a pH of 5 is 10 times more acid than a soil with a pH of 6 and 100 times more acid than a soil with a pH of 7). A soil with a pH value of 7 or greater is called an alkaline or basic soil. If the pH is less than 7, the soil is called acidic.

As soils become increasingly acidic (decreasing pH), important nutrients like phosphorus become less available to plants (Figure 1). Other elements, like aluminum, become more available and may actually become toxic to the plant, resulting in reduced crop yields. Liming to optimum pH not only increases the availability of essential nutrients, but also supplies additional calcium and magnesium, improves soil conditions for microorganisms, increases the effectiveness of triazine herbicides, and improves soil structure.

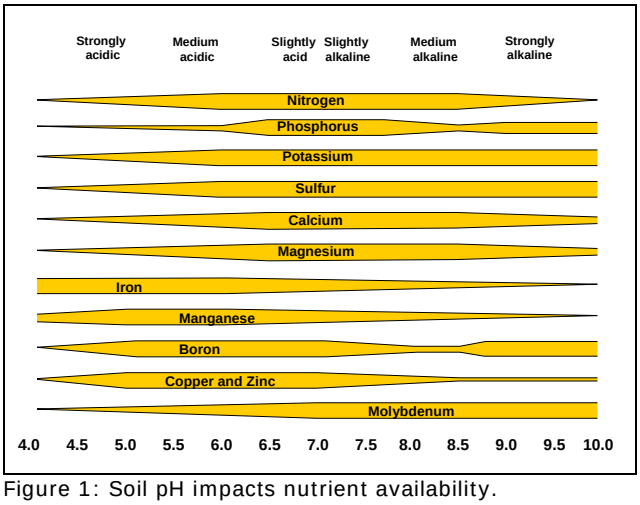


Figure 1: Soil pH impacts nutrient availability.

The pH of most calcareous soils (soils containing free calcium carbonates such as Honeoye, Lima, Ontario, and Kendaia soils) in the New York lime belt (soils commonly found along Interstate 90 from Buffalo to Albany) ranges from 7-8.5. Non-calcareous agricultural soils in New York vary from pH 4.5 to 7.

In humid climates such as we have in New York State, the leaching of calcium, magnesium, potassium and sodium ions naturally causes a decrease in pH over time because they leave the soil clays dominated by $H^+$ and aluminum ions ($Al^{3+}$). Human activity can change the pH of a soil too; the addition of most nitrogen fertilizers and organic nutrient sources (compost and manure) leads to formation of nitric acid ($HNO_3$) and/or sulfuric acid ($H_2SO_4$). Both are strong acids that cause an increase in soil acidity (i.e. a decrease the pH of the soil).

The soil pH ranges recommended for field crops are given in Table 1. It is important to test soil to determine if the pH is within the desired range. If a desirable pH is not maintained, increased yield expected from new varieties can not be realized. Extra fertilizer can not fix a problem caused by low pH either.

Table 1: Ranges and recommended soil pH for optimal growth of various field crops in New York.

| Crop Species | Normal growth pH range | Recommended pH range |
|---|---|---|
| Alfalfa | 6.5 to 7.5 | 6.6 to 7.0 |
| Barley | 6.3 to 7.0 | 6.3 to 6.5 |
| Birdsfoot trefoil | 6.0 to 7.0 | 6.3 to 6.5 |
| Clovers | 5.8 to 7.0 | 5.8 to 6.2 |
| Corn | 5.8 to 7.0 | 5.8 to 6.2 |
| Grasses | 5.8 to 7.0 | 5.8 to 6.2 |
| Oats | 5.8 to 7.0 | 5.8 to 6.2 |
| Soybeans | 6.5 to 7.5 | 6.6 to 7.0 |
| Wheat | 6.3 to 7.0 | 6.3 to 6.5 |

## Testing for soil pH

It is recommended to test each field for soil pH and fertility at least once in 3 years or twice per rotation. Take a minimum of 10-15 sub-samples from across a field (identified as a

unit differing from its neighbors in crop growth, soil type or past management usually not more than 10 acres in size). Grid-based sampling is recommended for larger fields where lime may be needed because for such fields, variable rate lime application of lime can have economic and environment benefits. Sampling should be done at least once in a rotation or every 5 to 8 years. A description of grid sampling can be found in the Cornell Guide for Integrated Field Crop Management (www.fieldcrops.org – 2.10.6).

Under minimum or no-tillage systems, the surface inch of the soil may become acid more rapidly than the original 0-8 inch plow layer. Thus, in no-tillage systems, the pH values of two soil layers (0-1 and 0-6 inches) should be determined. If soil pH of the surface 0-1 inch depth is low, but the pH of the 0-6 inch layer is adequate, lime addition is recommended to raise the pH of the soil surface. If both layers are strongly acidic, avoid no-tillage methods for the establishment of legumes until lime has been given 6 to 9 months to react with the soil. If the surface (0-1 inch depth) pH is adequate, but the 0-6 inch soil zone has a low pH, legumes could be no-till seeded into the soil without waiting as long for the lime to react as when both zones have a low soil pH.

For the most accurate pH determination, the soil sample should be submitted to an analytical laboratory such as the Cornell Nutrient Analysis Laboratory. A pH measurement is included if a general soil fertility assessment is requested. The pH of the soil can also be tested in the field using a Cornell pH test kit (Figure 2). For an experienced user, this field pH kit is accurate within 0.2 pH units.

When the soil pH is below 6, a complete soil test is recommended for the most accurate pH and lime recommendations. Soil pH kits, soil sample bags and instructions for the complete soil test can be obtained from your local Cornell Cooperative Extension office or directly from the laboratory:

Cornell Nutrient Analysis Laboratory
G01 Bradfield Hall, Cornell University
Ithaca, NY 14853
http://www.css.cornell.edu/soiltest

Order forms can be obtained from the website or by contacting the laboratory by phone: 607-255-4540, fax: 607-255-7656, or e-mail: soiltest@cornell.edu.

Figure 2: Cornel pH test kit allows for rapid assessment of soil pH.

A pH measurement tells us if lime is needed. The amount to be added depends on the capacity of the soil to buffer changes in pH with the addition of lime and the composition of the liming materials. This will be explained in more detail in fact sheets #6 (lime recommendations) and #7 (liming materials).

## Take-home message

Monitor soil pH on a regular basis (once every 3 years or twice during a rotation) for optimum crop management and yield.

## Additional resources

- Cornell Guide for Integrated Field Crop Management: www.fieldcrops.org.
- Cornell University Agronomy Fact Sheet #1 (Soil sampling for field crops); #6 (Lime recommendations); #7 (Liming materials). nmsp.css.cornell.edu/publications/factsheets.asp.
- Cornell Nutrient Guidelines for Field Crops: nmsp.css.cornell.edu/nutrient_guidelines.
- Cornell Nutrient Analysis Laboratory: www.css.cornell.edu/soiltest.

For more information

Cornell University
Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu

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