Colorado State University
Extension
Colorado Master Gardener℠ Program

CMG GardenNotes #222

Soil pH

Outline:

Soil pH

Soil pH is a measurement of the acidity or alkalinity of a soil. On the pH scale, 7.0 is neutral. Below 7.0 is acidic, and above 7.0 is basic or alkaline. A pH range of 6.8 to 7.2 is termed ***near neutral***. A soil's pH is a product of the factors which formed it. Primarily, it is a result of the parent material of the soil and climate. The quality of irrigation water used can also have an effect on soil pH. Areas of the world with limited rainfall typically have alkaline soils while areas with higher rainfall typically have acid soils.

Soil pH is important to gardeners because it can affect the availability of plant nutrients as well as the soil ecology. In very acid or alkaline soils some plant nutrients convert to forms that are more difficult for plants to absorb. This can result in nutrient deficiencies. Plants which have evolved under such soil conditions often have developed mechanisms to deal with this issue.

In Colorado, many of our soils are alkaline with a pH of 7.0 to 8.3. Soils with a pH of 7.5 to 8.3 generally have a high calcium carbonate content (known as ***free lime***). This is important because it is impractical to lower a soil's pH if it contains free lime. Free lime buffers the soil against pH change by neutralizing acids which are added to the soil. Soils with a pH of 8.3 or higher normally have a very high sodium content (such soils are referred to as sodic). In some mountain soils and older gardens that have been irrigated and cultivated for many years the pH may be in the neutral range (6.8 to 7.2). When possible, select plants which are adapted to your soil pH.

Many gardening books list the preferred pH for common plants (generally 6.0 to 7.2). **Most common landscape plants can tolerate a wider range.** The exception is acid-loving plants, like blueberries, azaleas, and rhododendrons that need acid soil. Blue hydrangeas also require a pH lower than 5.0 to induce the blue flower color. [Figure 1]

Figure 1. Soil pH and Plant Growth

Soil Reaction	pH	Plant Growth
	>8.3	Too alkaline and sodic for most plants
	7.5	Iron availability becomes a problem on alkaline soils.
Alkaline soil	**7.2**	6.8 to 7.2 – "near neutral" 6.0 to 7.5 – acceptable for most plants
Neutral soil	**7.0**	
Acid soil	**6.8**	
	6.0	
	5.5	Reduced soil microbial activity esp. bacteria
	<4.6	Too acid for most plants

Managing Alkaline Soils

Manage Colorado soils with moderate to high alkalinity (pH above 7.5) by increasing soil organic matter content and managing soil moisture through organic mulches and proper irrigation. Overly wet or dry soils may amplify the issues created by high soil alkalinity.

In Colorado, a major problem with high pH is iron chlorosis. For details, refer to *CMG GardenNotes* #223, **Iron Chlorosis**.

Soils with a pH above 7.3 and/or with *free lime* cannot be adequately amended for acid-loving plants like blueberries, azaleas, and rhododendrons.

Gardeners may find a slight decrease in soil pH over many decades. This occurs as irrigation leaches out elements (calcium and magnesium) which contribute to the higher pH. Many fertilizers also add acidity to soil and plant roots secrete weak acids into the soil which may also contribute to a gradual pH change. The presence of free lime in a soil slows this gradual acidification.

Lowering the pH

Applications of elemental sulfur are often recommended to lower a soil's pH. This is effective in many parts of the country**. However it is not effective in many Colorado soils due to high levels of free lime.** In alkaline soils which contain free lime, drastically modifying the pH of the soil is impractical.

To test for ***free lime***, place a heaping tablespoon of crumbled dry soil in a cup. Moisten it with vinegar. If the soil-vinegar mix bubbles, the soil has free lime. **On soils with *free lime*, a gardener will not effectively lower the pH.**

On soils without free lime, the following products may help lower the pH.

Elemental sulfur **is one chemical that can be used to lower soil pH. The soil type, existing pH, and the desired pH are used to determine the amount of elemental sulfur needed (see Table 1). Incorporate sulfur to a depth of six inches. It may take several months to over a year to react with the soil, lowering the pH. Test soil pH again 3 to 4 months after initial application. If the soil pH is not in the desired range, reapply.**

Table 1. Pounds of Sulfur Needed to Lower Soil pH[1]

Material	pH Change	Pounds per 100 Square Feet[2]
Sulfur	7.5 to 6.5	1.5
	8.0 to 6.5	3.5
	8.3 to 6.5	4.0

1 Effective only on soils without free lime, do the vinegar test.
2 Higher rates will be required on fine-textured, clayey soils and soils with a pH 7.3 and above.

Aluminum sulfate will also lower pH, but it is not recommended as a soil acidifying amendment because of the potential of aluminum toxicity to plant roots.

Acid sphagnum peat incorporated into the soil prior to planting will help provide a favorable rooting environment for the establishment of acid-loving plants in near neutral soils. Incorporate peat at the rate of one to two cubic feet per plant. The positive effects of acid peat will last a few years, but unless other measures are used, the pH of the soil will eventually increase. The pH will be driven up with the high calcium in our irrigation water. Soil with a pH above 7.3 and/or with *free lime* cannot be adequately amended for acid-loving plants.

Fertilizers – Use of **ammonium sulfate, ammonium nitrate** or **urea** as nitrogen fertilizer sources will also have a small effect on lowering soil pH in soils without free lime. However, do not use these fertilizers at rates greater than those required to meet the nitrogen needs of the plants. For example, ammonium sulfate fertilizer, 21-0-0, at ten pounds per 1000 square feet (maximum rate for crop application) may lower the pH from 7.3 to 7.2.

Raising the pH in Acid Soil

On acid soils, the pH can be raised by adding lime (calcium carbonate). The amount to add depends on the cation exchange capacity (nutrient-holding capacity) of the soil, which is based on the soil's clay content. Soil higher in clay will have a higher cation exchange capacity and will require more materials to raise the pH.

A laboratory test called **buffer index** measures the responsiveness of the soil to lime applications. The soil test will give recommendations on application rates based on the buffer index rather than just the pH. Table 3 gives an estimated amount of lime to apply to raise a soil's pH.

3. Limestone Application Rates to Raise Soil pH to Approximately 7.0 for Turf

	Lime Application Rate (pound per 1,000 square feet)		
Existing Soil pH	Sandy	Loamy	Clayey
5.5–6.0	20	25	35
5.0–5.5	30	40	50
3.4–5.0	40	55	80
3.5–4.5	50	70	80

- Lime application rates shown in this table are for dolomite, ground, and pelletized limestone and assume a soil organic matter level of approximately 2% or less. In soils with 4 to 5% organic matter, increase limestone application rates by 20%.
- Individual applications to turf should not exceed 50 pounds of limestone per 1,000 square feet.
- Avoid the use of hydrated or burned lime because it is hazardous to both humans and turf (can seriously burn skin and leaves). If hydrated lime is used, crease application rates in the above table by 50% and apply no more than 10 pounds of hydrated or burned line per 1000 square feet of turf.

Lime is commonly sold as ground agricultural limestone. It varies in how finely it has been ground. The finer the grind, the more rapidly it becomes effective in raising pH. **Calcitic lime** mostly contains calcium carbonate ($CaC0_3$). **Dolomitic lime** contains both calcium carbonate and dolomite [$MgCa(CO_3)_2$]. On most soils, both are generally satisfactory. However, on sandy soils low in organic matter, dolomitic lime may supplement low magnesium levels. Low soil magnesium levels should be verified with a soil test prior to applying dolomitic lime as excess levels of magnesium can lead to calcium deficiencies in some vegetables.

Home pH test kits

In alkaline soils, home pH kits have questionable value. Inexpensive kits do not calibrate closely enough on alkaline soils to be meaningful and small changes in techniques, such as how much water and the pH of the water used in the sample, can change results. Most home soil test kits are designed for acid soils.

Authors: David Whiting (CSU Extension, retired), Adrian Card (CSU Extension), Carl Wilson (CSU Extension, retired), and Jean Reeder, Ph.D., (USDA-ARS, retired) Revised by Eric Hammond (CSU Extension)

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