MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

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 (otherwise known as 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 of the climate. In Colorado, many of our soils are alkaline with a pH of 7.0 to 8.3. This is largely due to the high calcium carbonate content, known as **free lime**, that has accumulated in our soils through rock weathering and limited rainfall. In contrast, areas of the world with higher rainfall typically have acidic soils because the water leaches ions that contribute to alkalinity out of the soil profile. When soils contain an abundance of free lime, it is often impractical to lower the soil's pH by adding neutralizing acids because the excess free lime will buffer the effects of the acids. Soils with a pH of 8.3 or higher are typically also sodic soils, meaning that they have a very high sodium content.

The quality of irrigation water used can also influence soil pH. In some cases, irrigation water contains high levels of calcium carbonate which will further increase the soil pH. In other cases, irrigation water can promote a near neutral soil pH by leaching out ions that contribute to soil alkalinity. For example, some mountain soils and older gardens that have been irrigated and cultivated for many years have attained near neutral pH.

Soil pH is important to gardeners because it can affect the availability of plant nutrients and the soil ecology. In very acid or alkaline soils, some plant nutrients convert to forms that are more difficult for plants to absorb, which can result in nutrient deficiencies. Plants that have evolved under such soil conditions often develop mechanisms to deal with this issue. As a result, it's important to select plants that are adapted to your soil pH when possible.

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

Table 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 in alkaline soils
Alkaline Soil	**7.2**	**6.8 to 7.2 is near neutral**
Neutral Soil	**7.0**	**6.0 to 7.5 is acceptable for most plants**
Acid Soil	6.8	
	6.0	
	5.5	Reduced soil microbial activity, especially bacteria
	<4.6	Too acid for most plants

Managing Alkaline Soils

To manage Colorado soils with moderate to high alkalinity (pH above 7.5), increase soil organic matter content by using organic amendments and mulches. Additionally, use proper irrigation to manage soil moisture. 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. Our soils typically have an adequate supply of iron but, under alkaline conditions, the iron is present in a form that some plants are not able to access, leading to iron deficiencies.

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 ions (calcium and magnesium) which contribute to higher pH. Many fertilizers also add acidity to soil and plant roots secrete weak acids into the soil which may 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 their 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. **In soils with free lime, a gardener will not be able to effectively lower the pH.**

In 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. [**Table 2**] Incorporate sulfur to a depth of six inches. It may take several months to over a year for the sulfur to react with the soil, lowering the pH. Test soil pH again three to four months after initial application. If the soil pH is not in the desired range, reapply.

Table 2. 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 in fine-textured, clayey soils and soils with a pH 7.3 and above.

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

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. For example, ammonium sulfate fertilizer, 21-0-0, at ten pounds per one thousand square feet (maximum rate for crop application) may lower the pH from 7.3 to 7.2. However, do not use these fertilizers at rates greater than those required to meet the nitrogen needs of the plants.

Raising the pH

In acidic 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 lime to raise the pH.

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 will raise the pH. **Calcitic lime** mostly contains calcium carbonate (CaC03). **Dolomitic lime** contains both calcium carbonate and magnesium carbonate [MgCa(CO3)2]. On most soils, both are 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.

A laboratory test called a **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.

Table 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 to 6.0	20	25	35
5.0 to 5.5	30	40	50
3.4 to 5.0	40	55	80
3.5 to 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, decrease application rates in the above table by 50% and apply no more than 10 pounds of hydrated or burned lime per 1000 square feet of turf.

Home pH Test Kits

In alkaline soils, home pH kits have questionable value. Inexpensive kits cannot be calibrated accurately enough to be meaningful when used on alkaline soils. Small changes in techniques, such as how much water is used and the pH of the water used in the sample, can change results. Most home soil test kits are designed for acid soils.

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