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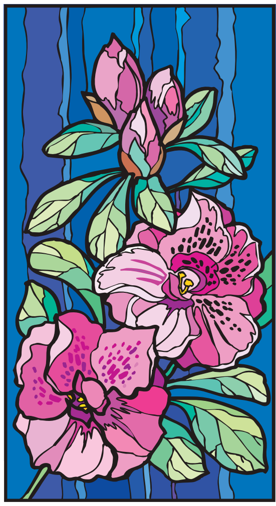

Acidifying Soil

in Landscapes and Gardens East of the Cascades

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The comfortable, sunny climate and numerous recreational activities east of the Cascade Mountain Range in Oregon and Washington attract many new residents each year. Unfortunately, these new residents often find that their previous gardening experience doesn't translate into success in their new environment. Long-time residents also are frustrated by poor growth of some ornamentals. The problem is compounded by garden catalogs full of picture-perfect produce and plants that aren't suited to environments east of the Cascades.

One problem for gardeners living east of the Cascades often is high soil pH. Some garden and landscape plants need an acidic soil (low pH) to remain healthy and flourish. For example, when soil is not acidic enough, azaleas, rhododendrons, and blueberries have small, yellow leaves with contrasting green veins. These plants will decline and may eventually die.

This publication explains the importance of soil pH to plant growth and discusses how to modify soil to help maples, rhododendrons, blueberries, fruit trees, and other "acid-loving" plants thrive in your garden and landscape.

Why is soil pH important?

Soil pH influences plant growth in many ways. Two of its primary functions are to control plant nutrient availability and the activity of soil microorganisms.

Plants use the dissolved nutrients in the soil for growth. Nutrients such as zinc, manganese, phosphorus, and iron are less soluble in water when soil pH is above 7.5. Thus, they are less available to plants in higher pH soil even if they are plentiful in the soil.

The small, yellow leaves in Figures 1–3 (page 2) are caused by a nutrient deficiency of iron and/or manganese. Iron deficiency results from soil pH too high for a plant. Even when soil pH is below 7.0, it still may be too high for some plants to obtain sufficient iron.

What is soil acidity?

The water and dissolved nutrients held between soil particles are known as the *soil solution*. Soil pH is a measure of hydrogen ion concentration in soil solution. As the hydrogen ion concentration (acidity) increases, soil pH decreases. Soil pH is expressed using a scale from 0 to 14. Soil pH values below 7.0 indicate an acidic soil; values above 7.0 indicate basic or alkaline soil.

Soil acidification occurs naturally west of the Cascade Mountain Range. Winter rainfall leaches calcium and magnesium (bases) from the soil, making it acidic. East of the Cascades, rainfall is low, especially at lower elevations, resulting in less leaching. Soils in these areas commonly have soil pH greater than 7.0 and are called basic or alkaline soils. Usually, mountainous soils covered by evergreens have higher precipitation and tend to be acidic (pH lower than 7.0).

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Plants differ in their ability to tolerate high or low soil pH. For example, vegetable gardens produce well when soil pH is 6.5 to 8.0. "Acid-loving" plants such as azaleas, blueberries, and rhododendrons require a soil pH below 6.0 and preferably below 5.5. Some varieties of the same plant (blueberries, for example) tolerate a slightly higher pH (6.0 vs. 5.0). Table 1 shows suggested soil pH for selected types of plants.

If you are planning to plant blueberries, azaleas, rhododendrons, or maples, check soil pH before planting and, if necessary, acidify the soil before planting. Soil acidification increases availability of iron, manganese, zinc, and other nutrients by lowering pH and increasing nutrient solubility.

Figure 1.—Maple leaves from a tree grown in soil with high soil pH show characteristic yellow leaves and green veins.

Determining the need for soil acidification

Plants are excellent indicators of the need for soil acidification. Several symptoms are exhibited when soil pH is too high for a plant.

A common iron deficiency symptom is smaller-than-normal leaves that are pale green or yellow (chlorotic) except for prominent, green veins (Figure 1). The plants also may have brown or "burnt" leaf edges (Figure 2). New or young leaves show iron deficiency first because iron can't be moved from old leaves to new ones. A mild iron deficiency can cause plants to be off-color (Figure 3), perform poorly, and, in chronic situations, eventually die.

Figure 2.—The pale leaves of this apple tree, grown in soil with high soil pH, signal the need for soil acidification.

Table 1.—Suggested soil pH for common garden and landscape plants east of the Cascades.

Plant	Suggested soil pH range
Annual landscape plants	6.0 to 8.0
Azaleas	4.5 to 5.5
Blueberries	4.5 to 5.5
Fruit trees	6.0 to 8.0
Grapes	5.5 to 6.5
Herbaceous ornamentals	6.0 to 8.0
Lawns	5.5 to 8.0
Rhododendrons	4.5 to 5.5
Most shade trees (e.g., sweet gum, oak, sycamore)	5.5 to 8.0
pH-sensitive shade trees (maple, magnolia)	5.0 to 6.5
Vegetable gardens	6.0 to 8.0
Roses, forsythia, and clematis	5.5 to 8.0

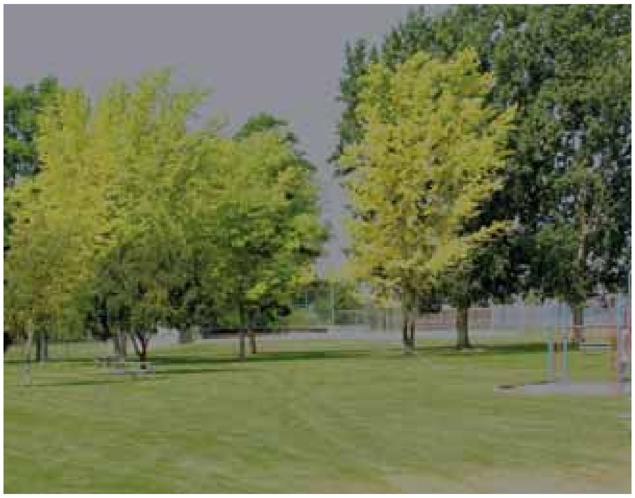

Figure 3.—The light green shade trees in this landscape are showing stress from high soil pH.

If your soil pH is above the values in Table 1, and plants are showing symptoms like those in Figures 1–3, you may choose to reduce the soil pH in your garden and/or landscape. If plants are green and growing normally, however, acidification is not necessary, even if soil pH is above the values shown in Table 1.

Because yellow leaves can be caused by several factors, do not start a program to acidify your soil based on plant symptoms alone. For example, nitrogen and sulfur deficiencies also cause leaves to turn yellow. However, these deficiencies do not cause contrasting dark green veins. If you apply nitrogen and sulfur fertilizer to yellow plants and they do not turn green, the problem might be iron deficiency caused by high soil pH.

Excessive sunlight, wind, and lack of water also can cause leaves to turn yellow. Generally, however, the dark green veins caused by iron deficiency are not present. When the yellow color is predominantly on the south or west side of perennial plants, excessive sunlight, wind, or lack of water may be the cause. This situation is especially true during the winter on the east side of the Cascades.

Begin by performing a soil test to estimate whether soil pH might be high enough to reduce plant growth. Any soil-testing laboratory will determine soil pH for a small fee, generally less than $10. A list of laboratories (*Laboratories Serving Oregon: Soil, Water, Plant Tissue, and Feed Analysis*, EM 8677) is available from your county office of the OSU Extension Service or on the OSU Extension website (http://extension.oregonstate.edu/catalog/html/em/em8677). Some local Master Gardener programs test soil pH for a small donation.

The first step in soil testing is to collect a soil sample that represents the area you want to test. Collect samples to a 12-inch depth from several locations within the area; mix them; and submit a single sandwich-bag-size container. For more information, see EC 628, *Soil Sampling for Home Gardens and Small Acreages* (http://extension.oregonstate.edu/catalog/html/ec/ec628).

Soil-test kits based on color solutions are available at many garden centers. While they can provide an estimate of soil pH, the results often are not accurate enough to serve as a guide for soil acidification. The solutions also degrade with time and heat, and matching the color of the soil-solution mixture with the kit's color chips can be a challenge. A laboratory analysis is the best way to determine soil pH.

When soil pH is less than 7.0, acidification usually is needed only for acid-loving plants such as rhododendrons, azaleas, or blueberries. In this case, pH usually can be reduced relatively easily in small gardens and landscape beds.

Soil acidification basics

Soil acidification reduces soil pH so that plant nutrients are more available. Two types of acidifying materials—elemental sulfur (S) and acidifying fertilizers—are discussed in this section. A combination of the two provides a good, ongoing soil pH reduction program. See "How to acidify your soil," below, to determine how much acidifying material you'll need.

Regardless of whether you use elemental S or acidifying fertilizers, our recommendation is to acidify your soil gradually over several years. Two smaller applications of acidifying material a year apart are better than a single large application.

Soil acidification reactions may take a year or more to complete, so check soil pH annually to monitor change. Check pH at the same time each year, as soil pH varies seasonally and the acidification from elemental sulfur occurs during the warmer times of the year.

Lowering soil pH usually requires ongoing maintenance due to the volume of soil that needs to be changed and the continual use of irrigation water with a high pH. Where soils contain calcium carbonate, high-pH irrigation water is used, and/or subsoil drainage is poor, soil acidification may be an annual practice.

Elemental sulfur

Mixing elemental sulfur with the soil is one effective way to reduce soil pH. Aluminum sulfate also can be used, but it reacts faster and may be harsher to plants. Elemental sulfur, because it takes longer to react, is the best option for soil acidification. A reduction in soil pH occurs during the growing season following elemental sulfur addition.

When elemental sulfur is mixed with the soil, naturally occurring soil bacteria transform it to sulfuric acid. Sulfuric acid provides hydrogen ions to the soil solution, thus reducing soil pH.

The more finely the elemental sulfur is ground, the faster it will react in the soil and the more expensive it will be. Most elemental sulfur is finely ground and formed into pellets for ease of application.

Acidifying fertilizers

Continual use of soil-acidifying fertilizers and applications of soil organic matter will acidify soil over the long term. Fertilizers that contain the ammonium (NH_4^+) form of nitrogen—such as ammonium nitrate, urea, ammonium phosphate, and ammonium sulfate—will acidify soil. Soil bacteria change the ammonium form of nitrogen to nitrate (NO_3^-). A by-product of the process is hydrogen (H^+), which acidifies soil.

Ammonium sulfate acidifies soil more than other common nitrogen fertilizers. Ammonium nitrate and urea supply about half as much acidification as ammonium sulfate. Ammonium phosphate's ability to acidify soil is slightly less than that of urea or ammonium nitrate. Ammonium nitrate is no longer available or at best is difficult to obtain.

Use acidifying fertilizers as part of a slow, general approach to lowering soil pH. When plants show deficiency symptoms, a more direct approach is needed. In this case, apply elemental S, as described above.

Table 2.—Elemental sulfur application based on the vinegar or "fizz" test of calcareous soil.

Fizz test result	Amount of S to add (lb/1,000 sq ft)*	Number of years to apply before re-evaluating pH
No fizz	0	0
Fizz heard but not visible	50	0 to 1
Slight fizz	50	1 to 2
Moderate fizz	50	2 to 3
Vigorous fizz	50	3+

*1,000 sq ft = approximately 30 ft x 30 ft

How to acidify your soil

East of the Cascade Mountain Range, most soils with a pH above 7.5 contain calcium carbonate. These soils are termed calcareous, and they produce a fizzing reaction when a drop of weak acid is added to them. To test your soil, add a drop of household vinegar to the soil. If the soil fizzes, it is calcareous. If so, follow the instructions below for "Acidifying calcareous soils."

Not all soils with a pH above 7.5 are calcareous. If plant symptoms indicate an iron deficiency and your soil does not fizz, submit a soil sample to a laboratory to determine soil pH. Then follow the instructions under "Acidifying noncalcareous soils."

Acidifying calcareous soil

If the fizz test indicates that your soil is calcareous, use elemental S for acidification. See Table 2 to determine the amount of elemental S to add. Acidifying calcareous soils is difficult due to the buffering capacity of the soil. These soils resist pH change and may take many years of elemental S applications to permanently lower pH.

For best results, apply elemental S in the fall preceding spring planting. This allows time for microbes to act on the sulfur before spring planting. For annual vegetable and flower gardens, work material evenly into the soil. Incorporation is difficult with established perennials. You can leave elemental S on the soil surface, but it will react slowly.

Acidifying noncalcareous soil

If the fizz test does not indicate that your soil contains calcium carbonate, it should be relatively easy to acidify your soil using either elemental S or acidifying fertilizers. Small gardens and individual plants can be treated rather easily. In fact, take care not to lower the soil pH too much. Excess application can lead to soil salinity or salt buildup, which causes leaf margin burn if adequate leaching does not occur.

Table 3.—Approximate amount of elemental sulfur needed to increase acidity and lower soil pH in three types of noncalcareous soils (lb S per 1,000 sq ft).*

Desired change in pH	Sand	Loam	Clay
8.5 to 6.5	45	55	70
8.0 to 6.5	25	35	45
7.5 to 6.5	10	15	25
7.0 to 6.5	2	3	5

*1,000 sq ft = approximately 30 ft x 30 ft

Using elemental sulfur

Use Table 3 to determine how much elemental S to add. For best results, apply elemental S in the fall preceding spring planting for best results. This allows time for microbes to act on the sulfur before spring planting. For annual vegetable and flower gardens, work material evenly into the soil. Incorporation is difficult with established perennials. You can leave elemental S on the soil surface, but it will react slowly.

Using acidifying fertilizers

Use acidifying fertilizers (ammonium nitrate, urea, ammonium phosphate, or ammonium sulfate) as part of your normal fertilization practices. See EC 1503, *Fertilizing Your Garden: Vegetables, Fruits, and Ornamentals*, for recommended fertilization rates and timing. Do not exceed recommended nitrogen rates in an attempt to achieve greater acidification, as nitrate can contaminate groundwater.

Mixing ammonium fertilizers with the soil is advisable, but be careful when working materials into the soil around established plant roots. An alternative is to irrigate after applying the fertilizer to wash it into the soil. Repeated surface applications will acidify the top 1 to 2 inches of soil.

Foliar applications of iron

When iron or manganese deficiency is severe, immediate action is needed. A foliar application of the nutrient directly to the plant is the quickest way to relieve the deficiency.

Chelated or sulfates of manganese and iron are examples of materials that can be applied to foliage. Look for the percentage of chelated ingredient in the product's active ingredient list. Products with a higher percentage of chelate ingredient are better. Follow recommended rates to avoid leaf burn, and do not apply in hot weather.

Although foliar applications can provide fast, temporary relief from nutrient deficiencies, they treat only the symptoms and don't correct the underlying problem (high soil pH). Also, they may need to be repeated a couple of times a week.

For more information

California Fertilizer Association, Soil Improvement Committee. 1995. *Western Fertilizer Handbook*, pp. 224–226.

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Robotham, M. and J. Hart. 2003. *Soil Sampling for Home Gardens and Small Acreages*, EC 628.

Many OSU Extension Service publications, as well as additional gardening information, may be viewed or downloaded from the Web (http://extension.oregonstate.edu/catalog/).

Copies of many of our publications, as well as videos and DVDs, also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog (Web address above) or contact us by phone (toll free 1-800-561-6719), e-mail (puborders@oregonstate.edu), or fax (541-737-0817).

Summary

Sometimes, soil acidification is necessary for optimum plant growth. Plants with yellowing leaves that do not respond to normal fertilization with nitrogen, phosphorus, and potassium may be suffering from other nutrient deficiencies. The most common solution is to acidify the soil.

If you attempt to acidify your soil, keep the following guidelines in mind.

- Proceed cautiously, as soil pH can be lowered beyond the desired level, especially in sandy soils and small areas.
- Monitor the change through annual soil testing.
- Develop a strategy of long-term and short-term use of acidifying materials.
- Keep complete records of the amount of acidifying materials added, the amount of mixing, and the time of year the material was applied.

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