



ACIDIFYING SOIL

for Blueberries and Ornamental Plants in the Yard and Garden

West of the Cascade Mountain Range in Oregon and Washington

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Rhododendrons and blueberries are popular plants in home gardens in western Oregon and Washington. Both are easy to grow in most gardens, but problems with growth can occur if the soil is not sufficiently acidic. Even in the naturally acidic soil west of the Cascade Mountains, soil often is not acidic enough for these plants.

If your plants have small, yellow leaves, with contrasting green veins, or if the new growth is stunted, the problem may be soil conditions, not a disease or insect pest. These symptoms may appear a year or two after planting and likely will increase in severity if the soil conditions are not modified.

This publication explains the importance of soil acidity to plant growth and discusses how to modify it to ensure that rhododendrons, blueberries, and other “acid-loving” plants thrive in your garden.

Understanding soil acidity and pH

Acidity is a measure of the concentration of hydrogen ions in the soil solution. (The soil solution is the water held between soil particles.) Soil acidity is expressed as soil pH, using a scale from 0 to 14. Soil pH values below 7 indicate

acidic soil, and values above 7 indicate basic (alkaline) soil. As the hydrogen ion concentration and acidity increase, soil pH decreases. For western Oregon and western Washington, a soil pH below 5 is considered low and a soil pH above 7 is considered high.

Soil pH affects the overall conditions for root growth. It determines the availability of some elements required for plant growth as well as the availability of others that are toxic to plants.

Nutrients such as zinc and iron have limited availability when the soil pH is above 7.5. Soil is acidified (pH is lowered) to increase the amount of iron, zinc, and other nutrients available for plant growth.

To appreciate the importance of soil pH to plant growth, think of yourself in a swimming pool. If the water is too cold or too hot, or the chlorine content so high your eyes hurt, you might get out of the pool. Now, think of roots trying to grow in soil. If the soil pH is too high or too low, plant roots don't want to be there. Unfortunately, they can't get out. If they are not “comfortable” because the soil pH is too high or too low, they don't grow normally or don't carry enough nutrients to the plant.

Plants differ in their preferences for soil pH. For example, vegetable gardens produce well in a



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soil pH of 6.5, and lawns grow well in a pH of 6.0. “Acid-loving” plants such as azaleas, blueberries, and rhododendrons require a soil pH below 6 and preferably below 5.5. Refer to Table 1 for suggested soil pH for selected plants.

Soil acidification occurs naturally west of the Cascade Mountains. Winter rainfall leaches chemical compounds called bases (primarily calcium and magnesium) from the soil, making the soil acidic. The bases are leached into the groundwater, causing “hard” well water. The natural process of soil acidification is accelerated by the use of some nitrogen fertilizers, crop removal, and other gardening practices.

Rather than lowering soil pH, gardeners west of the Cascades usually need to increase it by adding lime. The only plants that normally require soil acidification in western Oregon and Washington are azalea, blueberry, rhododendron, and possibly camellia and dogwood. Some maples, sweet gum, a few oaks, and some conifers do not grow well in soil with pH above 6.5.

Determining the need for soil acidification

Plants are excellent indicators of the need for soil acidification. Several symptoms are exhibited when the soil pH is too high for a plant. A common 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 leaf edges. New growth is affected first.

These symptoms are caused by iron deficiency when soil pH is higher than optimum for the plant. The plant cannot obtain enough iron from the soil for normal growth. Iron deficiency can cause plants to perform poorly and eventually die.

Nitrogen and sulfur deficiencies also cause leaves to turn yellow. However, leaves affected by these deficiencies do not have contrasting green veins. Deficiencies of nitrogen and sulfur are uncommon in ornamental plants. As with iron deficiency, the new growth of sulfur-deficient plants is affected first. Nitrogen deficiency is seen first in older leaves. If an application of nitrogen or sulfur does not affect plant color, consider iron deficiency, and hence high soil pH, as a possible cause of yellow leaves.

Table 1.—Suggested soil pH for common home garden and landscape plants in western Oregon and Washington.

Plant	Suggested soil pH range
Annual landscape plants	6.0 to 7.0
Azalea	4.5 to 5.5
Blueberry and cranberry	4.5 to 5.5
Blue hydrangea	4.5 to 6.0
Camellia	5.0 to 6.5
Dogwood	5.2 to 6.0
Fruit trees	6.0 to 7.0
Grapes	5.5 to 6.5
Herbaceous ornamentals	6.0 to 7.0
Lawns	5.5 to 8.0
Muskmelons, garlic, and cauliflower	6.5 to 7.5
Rhododendron	4.5 to 5.5
Shade trees	5.0 to 6.5
Vegetable gardens	6.0 to 7.0
Woody shrubs and vines such as roses, forsythia, and clematis	5.5 to 7.0



Figure 1.—Normal blueberry leaf (left) and iron-deficient leaf (right). Note the pale green leaf area and contrasting green veins on the iron-deficient leaf.

Excessive sunlight and a lack of water also can cause leaves to turn yellow (Figure 2). If the yellow color is predominantly on the south or west side of a plant, excessive sunlight or stress from lack of water may be the cause. Solving these problems may involve moving the plant or adjusting your watering schedule.

Because yellow leaves can be caused by several factors, do not start a program to acidify your soil based on plant symptoms alone. If you suspect a pH problem, have your soil tested by a commercial laboratory. Any soil-testing laboratory will determine soil pH for a small fee, generally less than \$10. A list of laboratories is available from your county office of the OSU Extension Service and on the Web (see “For more information,” page 6).

The first step in soil testing is to collect a soil sample. Collect soil from several locations, combining the soil in a single container. For more information, see EC 628, *Soil Sampling for Home Gardens and Small Acreages*.

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 usually 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 a better way to determine soil pH.

Acidifying materials

Two types of material can be used for soil acidification: elemental sulfur, which yields relatively rapid results, and nitrogen fertilizer, which acts more slowly. If soil acidification is needed, most homeowners want quick results, so elemental sulfur is the best option. If a decrease in soil pH of only 0.2 or 0.3 unit is desired, nitrogen fertilizer can be used.

Aluminum sulfate also lowers soil pH, but we do not recommend its use because of potential harmful side effects (aluminum toxicity to plant roots), which can significantly reduce plant growth.



Figure 2.—Yellowed leaves do not always indicate that the soil pH is too high. This rhododendron is growing in soil with a pH of 5.4. Always check the soil pH before deciding to acidify your soil.

Elemental sulfur

The most rapid reduction in soil pH is achieved by using elemental sulfur. When elemental sulfur (S) is mixed with the soil, naturally occurring bacteria, thiobacillus, oxidize it. The oxidation creates sulfuric acid in the soil solution, thus reducing soil pH. For the process to work properly, you must mix the elemental sulfur with the soil.

If your soil pH is below 6.5, further acidification can be accomplished fairly easily with elemental S. For example, in research conducted near Wilsonville, Oregon, a single application of 45 pounds of S per 1,000 square feet was made to a loam soil with a pH of 5.7 and 3.5 percent organic matter. After 2 years, the soil pH was reduced to and stabilized at pH 5.1.

Acidifying fertilizers

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 the nitrate (NO_3^-) form. A by-product of the process is hydrogen (H^+) ions, which acidify soil.

Ammonium nitrate and urea are about equal in their ability to acidify soil. Ammonium sulfate is the most acidifying of the group. It supplies twice as much acidity as ammonium nitrate or urea. Ammonium phosphate's ability to acidify soil is slightly less than that of urea or ammonium nitrate.

The use of acidifying fertilizer is not recommended for iron-deficient blueberries or ornamental plants when a decrease of more than 0.4 pH unit is needed. Acidifying fertilizers decrease soil pH more gradually than elemental sulfur. More than 2 years could be needed to decrease soil pH by 0.4 pH unit using a nitrogen fertilizer. For example, annual application to Willamette Valley lawns of approximately 3.5 pounds nitrogen per 1,000 square feet in the ammonium sulfate form will lower the soil pH 0.1 to 0.2 units each year.

Mixing ammonium fertilizers with soil is advisable but difficult around established shrubs. A surface application will acidify the top inch or two of soil. Decreasing soil pH in the surface inch or two of soil may provide relief from iron deficiency. When the soil pH is acidic only at the surface, only some branches may exhibit yellowing and stunted growth from iron deficiency.

Unlike elemental S, fertilizer should not be applied to blueberries or ornamental plants in the fall or to unplanted ground, as winter rains will carry nitrate down through the soil, where it can contaminate groundwater. See EC 1503, *Fertilizing Your Garden: Vegetables, Fruits, and Ornamentals*, for recommended rates and timing for various types of plants. Do not exceed recommended nitrogen rates in an attempt to achieve greater acidification.

How to acidify your soil

Our recommendation is to acidify your soil gradually over several years. Two small 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.

This section describes two procedures for acidifying soil: (1) soil acidification before planting, and (2) soil treatment for existing plants.

Acidifying soil before planting

The most effective approach is to add elemental S over a period of years, monitor soil pH, and wait until the desired pH is reached before planting (see Table 1).

Add elemental sulfur according to the clay content of soil as shown in Table 2 (page 5). Mix the sulfur into the soil.

For example, if your soil is sandy, add 10 to 20 pounds of elemental S per 1,000 square feet, as sulfur produces a greater reduction in soil pH in a sandy soil than in a loam or clayey soil. Add 40 to 50 pounds of elemental S per 1,000 square feet for clayey soils. Soil with a high organic matter content also requires more elemental S than sandy soil to achieve the same decrease in soil pH. Soil high in organic matter is dark, almost black in color, and usually breaks apart easily when moist. If your soil is high in organic matter and has medium or high clay content (produces a "ribbon" more than 1 inch long), add 40 to 50 pounds of elemental S per 1,000 square feet.

If you have questions about estimating soil clay content or organic matter content, contact your local Extension Service office.

After adding and mixing elemental S, allow several months for the reaction to proceed. A logical approach is to apply S in the fall and test the soil pH in the spring. If the desired soil pH has not been attained, repeat the process.

Estimating the amount of clay in your soil

Moisten approximately $\frac{1}{4}$ cup of soil so that the moist soil forms a coherent ball. Add water gradually until the soil has a consistency similar to pie dough, wood filler, or play-dough. The soil should not be runny or stick to your hand. Make a ball with the soil. The length of a soil “ribbon” will express the clay content of the soil. The soil “ribbon” should be about $\frac{1}{16}$ inch thick. To make a soil “ribbon,” press the soil down and forward with your thumb, rolling it across your index finger. Repeat the pushing/rolling action until the ribbon breaks. Consult Table 2 to estimate the amount of clay from the length of the ribbon.

Table 2.—Soil acidification with sulfur based on clay content of soil.

Length of soil “ribbon”	Percent clay in soil	Amount of elemental S to add (lb/1,000 sq ft)	Comments
Approximately 3 inches	More than 40	40 to 50	Very plastic and sticky when moistened to cake frosting consistency
Between 1 and 3 inches	Between 20 and 40	20 to 40	Slightly sticky when moistened to cake frosting consistency
Approximately 1 inch	Less than 20	10 to 20	May feel gritty from sand or smooth from high silt content

Many homeowners cannot wait more than a year for soil to be acidified before planting. In this case, the best option is to apply elemental S in the fall and plant in the spring. If you decide to plant before the pH has been lowered sufficiently, however, you may need to treat the root zone of individual plants after they are established (see below).

Do not try to speed the process by applying more than the recommended amount of sulfur. Applying too much sulfur can cause soil pH to decrease so much that some elements in the soil become toxic to plants.

Acidifying the soil for existing plants

If existing shrubs or trees are suffering from pH-induced chlorosis, you can acidify a small part of the root zone. The plant then can obtain nutrients from this area. This procedure can be performed any time of the year, but fall is best.

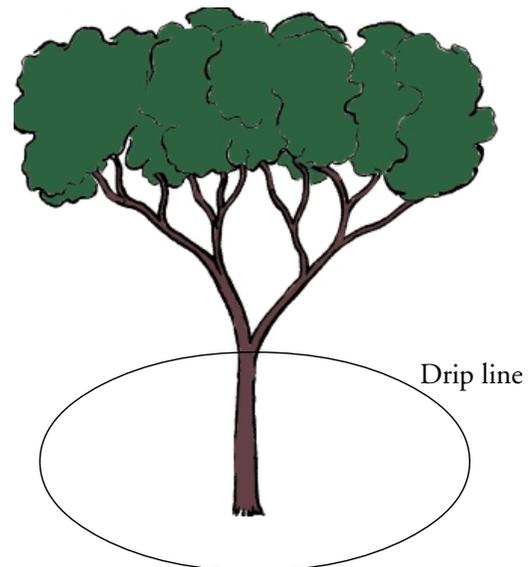


Figure 3.—When acidifying soil for an existing plant, dig holes around the drip line of the plant.

Dig a minimum of 4 holes per tree (preferably 8 to 12), at least 1 foot deep and 4 to 8 inches in diameter near the “drip line” (Figure 3, page 5). Mix ¼ cup elemental S with the soil removed from each hole. A small amount of iron (2 to 3 tablespoons) can be added as well. Refill the hole with the soil. Water is necessary for the reaction to proceed, but too much water is detrimental to the reaction of elemental S and soil. Keep the soil around the plant moist but not wet (not sticky or saturated).

Foliar iron application

Foliar iron sprays are recommended to alleviate iron deficiency in some situations. Use foliar application when plants show extreme symptoms and soil acidification is expected to require more than 2 years. Foliar sprays can help maintain plant health while soil pH is corrected. A combination of foliar iron sprays and a soil acidification program may be the only way established plants are able to survive a severe iron deficiency. Foliar sprays usually have a short-term effect, however, and need to be applied every other week during the growing season.

To prepare 3 gallons of iron spray, dissolve 2 ounces of ferrous sulfate in 3 gallons of water and add 2 tablespoons of mild household detergent. The detergent helps the spray stick to the foliage. Thoroughly wet foliage with the spray.

For more information

OSU Extension Service

Fertilizing Your Garden—Vegetables, Fruits, and Ornamentals, EC 1503 (1998).

Growing Blueberries in Your Home Garden, EC 1304 (1989).

A List of Analytical Laboratories Serving Oregon, EM 8677 (revised 2002).

Soil Sampling for Home Gardens and Small Acreages, EC 628 (revised 2002).

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

Copies of many of our publications and videos also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog (<http://eesc.oregonstate.edu>) or contact us by fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

WSU Cooperative Extension

Fertilizing Landscape Trees and Shrubs, EB 1034 (1991).

How to Identify Rhododendron and Azalea Problems, EB 1229 (1999).

Visit the WSU Cooperative Extension publications Web site at <http://pubs.wsu.edu>

Other publications

Agricultural Research Service. *Iron Deficiency in Plants: How to Control It in Yards and Gardens*, Home and Garden Bulletin Number 102 (1976).

Summary

Soil acidification sometimes is necessary for optimum plant growth. Plants with yellowing of leaves may be suffering from iron deficiency. Iron deficiency occurs when the soil pH is higher than the plant can tolerate. 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.
- Monitor the change through annual soil testing.
- Keep complete records of the amount of acidifying material added, the amount of mixing, and time of year the material was added.