Title
Adjusting Soil pH in California Gardens

ISBN
978-1-62711-189-8

Author
Blakey, Dustin

Publication Date
2021-04-01

Peer reviewed

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UC ANR Publication 8710 | April 2021
https://doi.org/10.3733/ucanr.8710
http://anrcatalog.ucanr.edu

UC PEER REVIEWED

Miniature rose growing in alkaline soil showing symptoms of a nutrient deficiency.

Adjusting Soil pH in California Gardens

DUSTIN BLAKEY, UC Cooperative Extension Farm Advisor in Inyo and Mono counties

Plant health can be affected by the acidity of soil. The conditions best for plant growth depend on the particular plant, but most plants prefer soil that is neither very acidic nor very alkaline. Many factors influence soil acidity—including climate, organic material in soil, soil texture, irrigation water, natural minerals that form the soil, and fertilizers.

Soil acidity can be adjusted to optimize plant growth, but adjusting acidity is not always the best course of action. Instead, it may be best to grow plants adapted to the native soil. For gardeners who decide to adjust the acidity of soil, it is important to understand when and how to do so.

QUANTIFYING ACIDITY

Acidity, measured on a logarithmic scale called pH, depends on the concentration of hydrogen in a solution. In the case of soils, acidity depends on how much hydrogen is dissolved in the liquid that soil particles hold.

Possible pH values range from 0 to 14. A soil with a pH of 7.0 is considered neutral—that is, it is neither acidic nor alkaline. A pH value below 7 is acidic while a value above 7 is alkaline. Distilled vinegar used in cooking is very acidic and has a pH of about 2.4. Household chlorine bleach is very alkaline, with a pH of about 11. Each whole-number change in pH value represents a 10-fold change in acidity. For example, a solution with a pH of 6 is 10 times more acidic than a solution with a pH of 7.

As noted, most crops perform best when the soil is neither too acidic nor too alkaline. For many crops, a soil pH somewhere between 5.5 and 7.5 works well. In this range, most plant nutrients are chemically available to plant roots (fig. 1), though some plants require a soil acidity outside this range. Soils in California generally range in pH from 5 to 8.5, but most are higher than pH 7.

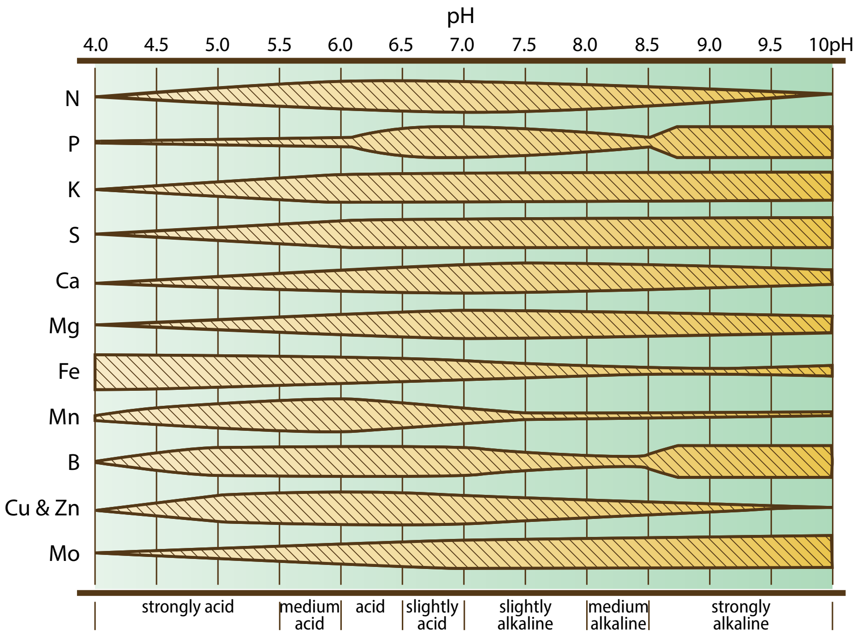

Figure 1. The relative availability of nutrients in soil changes with pH. *Source:* Pittenger 2015.

IDENTIFYING WHEN TO ADJUST SOIL PH

While it is possible to add amendments to soil to adjust the pH, doing so is not always the best course of action. It is generally best to work with the soil you have rather than try to attain the soil you wish for.

Ideally, gardeners should select plants that are adapted to the native soil. If a gardener wishes to grow a plant that is not tolerant of local soil conditions, the best long-term solution may be to grow it in a container or raised bed filled with a suitable soil mix.

All soils have a natural pH that depends on the minerals in the soil and conditions that arise over very long time periods, during soil development. In a garden, fighting a soil's natural pH can be challenging. When gardeners attempt to adjust soil acidity, the results are often temporary. Moreover, products that raise or lower pH are slow to react in the soil.

If gardeners decide to adjust the pH in a garden, they should do so based on careful evaluation of the condition of their plants. A soil may not need pH adjustment, even if it is technically outside the ideal range for a garden, unless plants show symptoms of nutrient deficiencies or toxicities.

The pH of the soil can influence whether a nutrient is chemically available to plants. An essential plant nutrient such as iron may be present in the soil but unavailable to the plant due to the soil pH. Plants unable to obtain essential nutrients, either due to soil pH or scarcity in the soil, show deficiency symptoms.

When plants show symptoms associated with excessively alkaline or acidic soil conditions, such as yellowing between veins—known as interveinal chlorosis—gardeners should attempt to determine whether the pH of the soil is the cause. Basic information about most soils in California, including native pH values, can be found online—while information about local soils can be found by using the online tool SoilWeb, casoilresource.lawr.ucdavis.edu/gmap/.

MEASURING SOIL PH

Urban and suburban soils can be significantly modified during housing construction, so their acidity may differ significantly from values available online. Other activities that disturb the soil, such as gardening, can affect soil pH. Therefore, a measurement of acidity in a soil sample taken directly from a garden is more accurate than online soil survey data. Though the most accurate way to determine soil pH is through a soil test conducted by a laboratory, gardeners can purchase equipment such as a chemical test kit, paper pH test strips, or a digital pH meter to evaluate soil pH. All of these products should come with instructions for use.

With most soil chemical test kits, drops or tablets of specially selected chemicals are added to a solution extracted from soil, causing a color change or change of appearance. Charts or cards included with the kit translate the results into numerical values. Some kits rely on paper test strips to measure soil pH.

Paper test strips are easier to use than pH meters because they do not require setup or calibration, but they are less accurate. Furthermore, they must cover the correct range of pH values expected in the soil; most test strips only cover a narrow measurement range.

Digital meters can be purchased online or at tool supply stores for less than $20. Many devices are marketed as pH meters, but not all measure pH accurately. For the most reliable results, look for a device with a probe consisting of a glass orb and a small piece of metal at the end, similar to the item shown in figure 2.

Figure 2. Typical electrode probe of a digital pH meter.

A new meter may be calibrated incorrectly, so follow the unit's calibration instructions to improve accuracy before use. The calibration process may require gardeners to purchase an inexpensive buffer solution.

The recommended technique for home gardeners to prepare a soil sample for a pH test is to collect a dry soil sample and add to it an equal amount of distilled water. Stir the mixture until it resembles a slurry and then let it set for 1 hour. Stir the mixture again and take the pH measurement (Burt 2011).

INCREASING ACIDITY

In many areas of California, particularly the drier regions, it may be necessary to increase the acidity of the soil—to lower the pH—to grow some popular garden crops. This is usually accomplished in gardens by adding elemental sulfur to the soil. Bagged sulfur products for acidifying soil can be purchased at garden centers and nurseries.

Some plants, such as blueberries, are especially sensitive to high pH. A common symptom of plants grown in alkaline soil is yellowing of new growth, caused by a lack of available iron (fig. 3). This is called iron chlorosis. Correcting the soil pH usually solves the problem. In most cases, however, growing acid-loving plants in containers filled with a suitable soil mix is a better long-term solution than amending native, alkaline soil in a garden bed. See table 1 for suggested pH values for common plants.

Figure 3. Characteristic symptoms of iron deficiency in plants. Symptoms begin on younger leaves.

Table 1. Typical desirable soil pH ranges for select garden plants

Plant	pH range
Temperate fruit and nut trees	6.0–8.0
Citrus	6.0–7.5
Blueberries	4.5–5.5
Avocados	5.0–7.0
Azaleas	4.5–5.5
Herbaceous ornamentals	6.0–8.0
Most woody landscape species	5.5–8.0
Vegetables	6.0–8.0
Lawns	5.5–8.0

Sources: Locke et al. 2006; Pittenger 2015.

Table 2 shows how much elemental sulfur is needed to lower the soil pH to a desired level. Adding too much sulfur in one application can harm plants. Apply no more than 15 pounds per 1,000 square feet of soil in a single application. Wait 6 months, retest, and apply more sulfur if needed. Adjusting soil

Table 2. Pounds of elemental sulfur to add to soil to lower pH, per 1,000 square feet

Initial soil pH	Desired soil pH														
	5.0			5.5			6.0			6.5			7.0		
	sand	loam	clay	sand	loam	clay	sand	loam	clay	sand	loam	clay	sand	loam	clay
5.5	4	10	16	0	0	0	—	—	—	—	—	—	—	—	—
6.0	8	20	32	4	10	16	0	0	0	—	—	—	—	—	—
6.5	12	29	47	8	20	32	4	10	16	0	0	0	—	—	—
7.0	15	38	61	12	29	47	8	20	32	4	10	16	0	0	0
7.5	19	48	77	15	38	61	12	29	47	8	20	32	4	10	16
8.0	23	57	92	19	48	77	15	38	61	12	29	47	8	20	32

Source: Allen 2015.

Note: Do not apply more than 15 pounds per 1,000 square feet in one application. Retest in 6 months, then add more sulfur if appropriate.

Note: Dashes in table cells indicate that no data corresponds to the specified cells.

acidity for acid-loving plants is best performed prior to planting, when adjustments can be made quickly and plant damage is not as great a concern.

Compost is sometimes recommended as an acidifying product for garden soils. Compost can improve many aspects of soil health, including nutrient availability, but it probably will have little effect on soil pH when typical amounts are applied. Mature compost can range in pH from 6 to 8, so it is unlikely to lower soil pH into the range preferred by acid-loving plants.

For an extensive overview of techniques for acidifying alkaline soils, see Locke et al. (2006).

REDUCING ACIDITY

While naturally acidic soils are rare in California, some fertilizers and amendments can, over time, cause soils to become acidic. But when naturally acidic soils do occur, as in some areas of California, it may be necessary to raise the pH of the soil to make it more alkaline.

When soil pH needs to be increased in the home garden, the usual method is to amend the soil with pulverized limestone or dolomite. These materials react to neutralize the acid in the soil, much as an antacid works to relieve heartburn.

Limestone and dolomite move into and react with soil *very slowly*. If these amendments are used to raise soil pH, the process should be begun before planting to allow time for the reaction to occur.

The correct amount of limestone or dolomite to apply to a soil is difficult to determine without a laboratory soil test that characterizes the composition of the soil and identifies ions dissolved in the soil that can affect pH. The appropriate quantity of product to apply can be influenced by the amount of calcium in the soil, the soil texture (for example, the amount of sand, silt, and clay), and other factors that are not easy to test at home.

If a pH test indicates a need to raise the pH and a laboratory soil test cannot be obtained to determine the appropriate amount of limestone or dolomite, a good starting point is to attempt to raise the pH approximately 1 point by incorporating limestone or dolomite into soil as follows: for sand, incorporate 20 pounds per 1,000 square feet; for loam, 45 pounds per 1,000 square feet; for clay loam, 90 pounds per 1,000 square feet (Lorenz and Maynard 1988). Retest the pH value in 1 year to evaluate the results. As suggested above, these recommendations are less accurate than recommendations given by a laboratory because the amount of lime needed to decrease acidity depends on many factors beyond the pH value.

The choice between using dolomite or limestone depends on the soil's need for magnesium, an essential plant nutrient. California's soils vary greatly in their magnesium content. If the decision is made to raise the soil pH, a product should be selected that matches plants' nutrient needs. Dolomite should be used in soils low in magnesium. Limestone only provides calcium and is suitable for soils with ample magnesium. Without a laboratory soil test, the only way to know if soil is deficient in magnesium or other elements is to identify plants' nutrient deficiency symptoms.

Gardeners are often tempted to apply wood ashes, hydrated lime, or other products to soil to alter the pH. While these amendments can be effective, they are easy to apply incorrectly and therefore should be avoided. A careful application of limestone or dolomite is less likely to cause unwanted effects in the garden.

BE PATIENT

Adjusting soil pH is never a quick process. Exercise patience after applying any amendment meant to raise or lower pH. It's always possible to apply more material later, but material cannot readily be removed. Regular pH testing helps determine if application of additional product is needed.

Testing soil pH annually, at the same time of year and under similar conditions, helps improve the reliability of results and aids in interpretation of changes that occur over time.

REFERENCES

Allen, T. 2015. Adjusting soil pH. Amherst: UMass Extension Soil and Plant Nutrient Testing Laboratory. https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/spttl_3_adjusting_soil_ph_0.pdf

Burt, R. 2011. Soil Survey Laboratory Information Manual. Soil Survey Investigations Report No. 45, Version 2.0. R. Burt (ed.). Lincoln, NE: U.S. Department of Agriculture Natural Resources Conservation Service. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052226.pdf

Locke, K., D. Horneck, J. Hart, and R. Stevens. 2006. Acidifying soil in landscapes and gardens east of the Cascades. Corvallis: Oregon State University Extension Service Publication EC 1585-E. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1585.pdf

Lorenz, O. A., and D. N. Maynard. 1988. Knott's handbook for vegetable growers. 3rd ed. New York: John Wiley & Sons.

Pittenger, D., ed. 2015. California Master Gardener handbook. 2nd ed. Davis: UC Agriculture and Natural Resources Publication 3382.

FURTHER READING

Surls, R., V. Borel, and A. Biscaro. 2016. Soils in urban agriculture: Testing, remediation, and best management practices. Davis: UC Agriculture and Natural Resources Publication 8552. https://dtsc.ca.gov/wp-content/uploads/sites/31/2020/05/Exide_FS_Soil_ADA.pdf

Wildman, W. E. 1976. Diagnosing soil physical problems. Oakland: UC Division of Agricultural Sciences Publication 2664e. https://anrcatalog.ucanr.edu/pdf/2664e.pdf

To order or obtain UC ANR publications and other products, visit the UC ANR online catalog at https://anrcatalog.ucanr.edu/ or phone 1-800-994-8849. Direct inquiries to

UC Agriculture and Natural Resources Publishing
2801 Second Street
Davis, CA 95618
Telephone 1-800-994-8849
E-mail: anrcatalog@ucanr.edu

Publication 8710

ISBN-13: 978-1-62711-189-8

An electronic copy of this publication can be found at the UC ANR catalog website, http://anrcatalog.ucanr.edu/.

UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by UC ANR Associate Editor for environmental horticulture, arboriculture, and sustainable landscapes Janet S. Hartin.

web-4/21-LC/SO