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HO-241-W

Commercial Greenhouse and Nursery Production

Lowering Soil pH for Horticulture Crops

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The pH scale measures the acidity or alkalinity of a solution. The scale extends from 0 (a very strong acid) to 14 (a very strong base or highly alkaline). The middle of the scale, 7, is neutral, neither acidic nor basic. Soil pH is important because it affects the availability of nutrients in the rooting zone.

This publication explains when lowering soil pH is important for commercial producers and recommends practices to safely and effectively lower soil pH.

For more about soil pH, see Purdue Extension publication HO-240-W, *Commercial Greenhouse and Nursery Production: Soil pH* (available from the Purdue Extension Education Store, www.the-education-store.com).

When it comes to soil pH, an accurate diagnosis is essential. Before making any changes, test your soil pH. Purdue Extension provides a list of commercial soil testing labs at:

www.ag.purdue.edu/agry/extension/Pages/soil-testing-labs.aspx

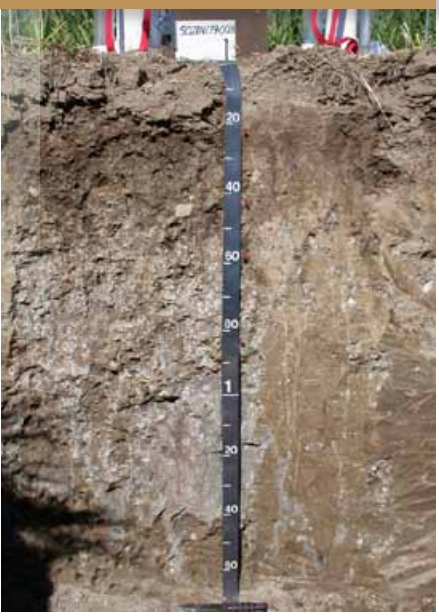

Photo by Phillip Owens, Purdue Agronomy

Why Lower Soil pH?

Some plants (such as blueberries or azaleas) are adapted to grow in acid soils — even as low as pH 4.5. If you are trying to grow them you may want a soil pH less than 6, but remember that even acid-loving plants have their limits.

Table 1. *Effects of soil amendments on pH.*

Amendment	Effect
Biological Reactions	
Organic matter	The reduction in pH is due to microbial degradation and production of organic acids. Large amounts are required.
Ammonium fertilizers	A comparatively minor effect on soil pH when used in appropriate amounts as a nitrogen fertilizer. Diammonium phosphate, monoammonium phosphate, and ammonium sulfate have more acidic potential than urea or ammonium nitrate. Calcium nitrate and potassium nitrate increase soil pH so should be avoided if pH is already too high.
Elemental sulfur (S)	Creates acidity as bacteria form sulfuric acid from elemental sulfur.
Nonbiological Reactions	
Aluminum sulfate ($Al_2(SO_4)_3$) and iron sulfate ($FeSO_4$)	Chemical reactions create acidity, therefore less temperature dependent than for biological reactions.

Table 2. Acidifying effect of some common fertilizers and soil amendments.

Material	Pounds of Pure $CaCO_3$ Needed to Neutralize Acidity in 100 Pounds of Soil[1]	Pounds of Material Equivalent in Acidifying Ability to 1 Pound of Sulfur
Elemental sulfur, S	312	1.0
Sulfur-coated urea (38-0-0)	118	2.6
Ammonium sulfate, $(NH_4)_2SO_4$ (21-0-0)	110	2.8
Urea, $(NH_2)_2CO$ (46-0-0)	81	3.9
Diammonium phosphate, $(NH_4)_2HPO_4$ (18-46-0)	70	4.5
Ammonium nitrate, NH_4NO_3 (34-0-0)	60	5.2
32% Liquid urea-ammonium nitrate (32-0-0)	55	5.7
Aluminum sulfate, $Al_2(SO_4)_3$	45	6.9
Ferric sulfate, $Fe(SO_4)_3 \cdot 9H_2O$	35	5.9
Peat[2]	30+	10.4 +
Pine bark mulch[2]	20+	15.6+
Compost[2]	0 to 10+	0 to 31.2+
Other animal manures[2]	0 to 10+	0 to 31.2+
Poultry litter[2]	0	0

[1] Values for pounds of $CaCO_3$ come from *Lowering Soil pH* (Alabama Cooperative Extension System publication S-04-08).
[2] Organic materials can be highly variable.

Many Indiana soils are alkaline because they are derived from limestone. In some cases, the surface soil may no longer be alkaline because the use of acid-forming nitrogen fertilizers and centuries of rainfall (since the time glaciers covered northern Indiana) have leached out the residual limestone that caused the high pH.

Unfortunately, deeper soil layers remain alkaline and construction and grading activities can return this high pH soil to the surface. In addition, many water sources have high pH and bicarbonate content and increase soil pH when used for irrigation.

Most plants do best in slightly acid soil, pH 6.0-6.5. Lowering soil pH must be done with care because soil pH levels below 6.0 begin to be detrimental for many plants. Some plants (such as blueberries or azaleas) require strongly acid soils to thrive, even as low as pH 4.5, but lower pH levels than this will be detrimental to them as well.

Ways to Lower Soil pH

Certain amendments and fertilizers can lower soil pH (Table 1). These products react with the soil to form acids, which lowers soil pH. Some of these reactions are purely chemical. However, microorganisms must metabolize other amendments before they can affect soil pH.

Biological reactions can be slower (and more seasonal) than chemical reactions since soil microbe activity drops if the soil is not warm, moist, and well aerated.

When selecting the best method of acidifying your soil, consider:

1. How much you want to lower the pH
2. Whether the soil amendment you select will also provide beneficial nutrients
3. Your time frame — how quickly do you need to change the soil pH?
4. Budget

Also consider the composition of the soil you want to change. It may be impractical to lower the pH of soils that contain free calcium carbonate, because calcium carbonate can neutralize any acids the amendment produces. That means one has to add even more acidifying amendments just to neutralize all the calcium carbonate. In such soils, it is best to grow plants that tolerate alkaline soils.

Types of Soil Amendments

Table 1 summarizes the three main types of soil amendments and their effects on soil. In-depth descriptions of each type of amendment appear below.

Table 3. Approximate amount of elemental sulfur needed to lower soil pH of a silt loam soil to a depth of 6 inches.[1]

Present Soil pH	Desired Soil pH				
	6.5	6.0	5.5	5.0	4.5
	Pounds Elemental Sulfur per 100 Square Feet				
8.0	3.0	4.0	5.5	7.0	8.0
7.5	2.0	3.5	4.5	6.0	7.0
7.0	1.0	2.0	3.5	5.0	6.0
6.5	—	1.0	2.5	4.0	4.5
6.0	—	—	1.0	2.5	3.5

[1]For sandy soils, reduce amount by 1/3; for clay soils, increase amount by 1/2; if aluminum sulfate is used, multiply by 6.

Organic Matter

Incorporating any organic matter will make soil more acidic, but sphagnum peat and pine bark mulch are particularly effective. However, enormous amounts of organic matter must be turned into the soil to have a significant effect on pH. Because of the cost and effort, this method is generally limited to small garden plots.

Ammonium Fertilizers

Ammonium fertilizers include urea, ammonium nitrate, and ammonium sulfate. Bacteria in the soil convert the ammonium into acidic compounds.

Ammonium fertilizers are convenient because they simultaneously fertilize your plants and acidify the soil. However, to avoid applying too much nitrogen, use these products only to make gradual changes to the soil pH. Still, there is less risk of lowering pH too much when using ammonium fertilizers than there is when using elemental sulfur. Ammonium fertilizers also can be used with acid-loving plants to maintain an already low soil pH.

Ammonium sulfate is an ammonium fertilizer that is two to three times more acid forming per pound of nitrogen than other commonly used ammonium fertilizers.

Sulfur Compounds

Elemental sulfur, iron sulfate, and aluminum sulfate are products that are often used to dramatically acidify the soil (by 1 or more pH units). Soil bacteria combine elemental sulfur with oxygen and water from the soil to form sulfuric acid. The bacteria require warm, moist, aerated soil. Acidification occurs faster when the application is incorporated into the soil than when the application is left on the soil surface. Sulfur compounds may take up to a year before they have their full effect on soil pH. Too much sulfur can reduce the soil pH below the optimum range for your plants, making conditions that are as bad, or worse, for the plants than the original alkaline soil.

Iron sulfate and aluminum sulfate lower soil pH faster than elemental sulfur since they require chemical rather than biological reactions. This speed carries the risk of applying excessive iron or aluminum if you add too much of these products (typically more than 5 pounds per 100 square feet).

Mix Amendments Properly

Soil amendments mainly lower just the pH of the soil they are incorporated into. Mixing amendments into the top 6 to 10 inches of topsoil is generally adequate to acidify soils. Most plants, including trees, absorb the majority of their nutrients from this area. However, deep roots may be subject to nutrient deficiencies since some of the nutrients that are only available in the upper acidified soil are difficult for plants to transport down to the roots.

Table 2 provides the rates of common fertilizers and amendments needed to acidify soils. Table 3 provides the approximate rates of elemental sulfur needed to acidify topsoil to a depth of 6 inches. If using an amendment other than elemental sulfur, multiply the rate given in Table 3 by the pounds of material equivalent to 1 pound of sulfur given in the right-hand column of Table 2.

References

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