THE UNIVERSITY of TENNESSEE Extension

Soil pH Explained

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Originally compiled by Dr. Willard T. Witte[1]

This information will relate to plants being grown in a nursery field or landscape. Nutrient availability behaves slightly differently in container media (substrate). All nutrients including the minor elements must be supplied to container grown plants in soilless media. Tennessee soils naturally contain most of the minor elements required for most crops.

Introduction

Soil pH is a measure of the alkalinity or acidity of the soil. Soil pH is measured on a logarithmic scale from 0 (strongest acid) to 14 (strongest alkali or base). Neutral is 7. Slightly acid is considered to be 5.2 to 6.0, moderately acid 5.6 to 6.0, strongly acid 5.1 to 5.5, very strongly acid 4.5 to 5.0, and extremely acid below 4.5.

A change of one unit on this scale actually represents a tenfold change in pH. For example a soil pH reading of 5.5 is 10 times more acidic than a soil with a pH of 6.5. A soil with a pH of 4.5 is 100 times more acidic than a soil with a pH of 6.5. Most Tennessee nursery soils range between 4.5 and 6.5 with occasional higher values.

If a soil's pH becomes too acidic or too alkaline various key nutrients can become insoluble and unavailable to the plants. Too much lime can be applied.

Plants need a proper balance of macro and micronutrients in the soil and the soil pH has an important influence on the availability of nutrients and on the growth of different kinds of plants. For example, when the soil pH is low; nitrogen, phosphorus and potassium are tied up in the soil and not available to plants. Calcium and magnesium, which are essential plant nutrients, may be absent or deficient in low pH soils.

[1] UT Extension Nursery Specialist now retired.

Low pH increases the toxicity of aluminum, iron and manganese; however, in soils with proper pH, they are non-toxic and elements like sulfur, calcium, magnesium, and molybdate will be available for plant uptake.

The decomposition of organic matter improves soil structure. If soil pH is low, then the activity of soil organisms that break down organic matter is reduced. Proper soil pH increases microorganism activity which produces improved soil tilth, aeration and drainage. This is turn allows for better use of nutrients, increased root development, and drought tolerance.

Soils Tend to be Acid

Tennessee soils naturally tend to become acid in reaction with pH values from 4.5 to 6.5. Newly cleared land will generally test 4.3 in the Warren County area of Middle Tennessee. This is due to the removal of base forming ions (Ca, Mg, K) and subsequent replacement by acid forming ions (H, Al). The following conditions enhance or speed up this acidifying process.

1. Application of acid forming fertilizers which produce large amounts of H ions, such as urea, ammonium and sulfate fertilizers.
2. Removal of base forming ions by crops.
3. Removal of base forming ions by leaching and erosion.
4. Decomposition of organic matter which produces carbonic acids.
5. Tennessee soils gain approximately 16-18 pounds Sulfur per acre per year from auto emissions and coal smoke that settles here from various states. This gain is expected to diminish with more restrictions. While sulfur will lower the pH, it is one of the minor elements required for plant growth and is a benefit.
6. Rain and snow contribute 10 to 15 lbs per acre of Nitrogen (N) and probably 10 to 20 lbs per acre of Sulfur (S) annually. The S is highly variable depending on wind patterns from industrial emission sources. There is as much N in rain as there is in snow actually. Historically there has been enough S in rain and snow to cover our crop needs. That may be doubtful now with improved pollution control and very high yields like 200 bushel per acre corn, but I suspect it is still true for nursery stock.[2]

By adding base forming ions (that is, the Ca and Mg in lime and dolomite) the acid forming ions are displaced and the soil pH rises. Lime recommendations are made based on soil test results and the past experience that the University of Tennessee has with our soils.

[2] – Dr. Paul Denton, UT Extension Soil Scientist, 9-07

Soil Chemistry Affected

The chemical availability of nutrients may be affected by pH as follows:

1. Manganese availability increases as pH drops with toxic symptoms occurring on some plants at pH 5.0 or below. In some soils in Tennessee this is an important factor, as manganese is concentrated heavily enough to exist as "pellets". These look like shot gun pellets on the soil surface after a rain.
2. The availability of phosphorus, one of the major plant nutrients, decreases as pH rises or falls from about 6.3.
3. The availability of copper and zinc is greatest between 5.0 and 6.0.
4. Calcium, magnesium, and molybdenum become less and less available as pH drops from 7.0 to 4.0.
5. The activity of soil microorganisms affecting organic matter decomposition and nutrient availability (especially nitrogen) may be greatly reduced as soils become more and more acid.

In summary, these are all good reasons for keeping the soil pH between 5.5 and 6.5 for most plants, but there are some exceptions.

Preferred pH Ranges

Every kind of plant is believed to have a preferred pH range for its best and fastest growth. A few kinds of plants grow best in a rather narrow pH range, while most plants fortunately tolerate a wide pH range. Rarely does any one kind of plant grow equally well in both distinctly acid and distinctly alkaline soils. We are all familiar with the gardener's rough classification of plants into 'acid loving' and 'lime loving' and there is quite a bit of truth in this grouping provided we don't carry it too far.

Acid loving generally refers to plants that do well between pH 4.0 and 6.0 with a preferred range of perhaps 5.0 to 5.5. This group contains all the ericaceous plants: heath, heather, azalea, rhododendron, mountain laurel (Kalmia), leucothoe, huckleberry, bearberry, pernettya, andromeda, blueberry, etc. The acid loving group also contains some of our choice small native flowering trees such as fringetree, silver bell, sourwood, yellowwood, franklinia, and stewartia which are adapted to the acid organic conditions of the forest floor.

Acid loving plants, especially the ericaceous ones, are often said to be lime-intolerant. This is thought to be due to the inability of their roots to take up iron under neutral or alkaline conditions, even though iron may be present in the soil. Most of us have seen the visual symptoms of iron chlorosis of azaleas grown in alkaline soil – the new leaves yellow except for the veins, or in severe cases all the new growth on one or more branches may turn completely yellow. Another feature of ericaceous plants is thought to be a tolerance of the large amount of aluminum ions present in strongly acid soils.

On the other side of the pH scale are the lime lovers, typified by plants that thrive or at least tolerate alkaline conditions and just won't do as well in strongly acid soil. Some examples are lilac and mockorange. Some would put elm, quince, linden and some junipers in this group. Many desert plants grow in alkaline soils but it is hard to pin down a pH range for this group, but somewhere around 7.0 to 7.5 or higher would seem about right. The main point to be made is that most of these plants grow perfectly well in slightly acid 6.5 soils but can also tolerate more alkalinity than most other plants.

A third group could be broken out for those plants which do best in moderately acid soils of 5.5 to 6.5. This includes the majority of nursery crops.

What to Do?

So what does all this mean to the nursery producer, landscaper, or gardener? Most obvious is that one should not attempt to grow acid loving and lime loving plants side by side – one or the other is going to suffer. It would seem to make sense to group the plantings into two or three groups according to preferred pH range of the plants, such as strongly acid - 4.5 or 5.0 to 5.5; moderately acid - 5.5 to 6.5; and slightly acid to alkaline - 6.5 to 7.5. Then the soil could be managed to bring the pH near the desired range.

Soil pH is usually easy to adjust either up or down. The addition of lime will raise the pH closer to neutral (pH 7) and perhaps higher. Lime applications to adjust pH to proper levels are one of the cheapest and most effective ways to aid the growth of nursery crops. There are four types of lime generally available; ground agricultural, dolomitic, hydrated and pelletized. All contain calcium which is the ingredient that actually raises the pH. Hydrated lime has been processed to release its effect more rapidly than other limes, is caustic and generally should not be used around the house. It can burn skin as well as plants. Because ground agricultural lime is difficult to spread with conventional lawn spreaders, many prefer the pelletized form which can be broadcast more easily. Pelletized lime has been crushed and reformulated into small pellets for convenient spreading. The pellets dissolve rapidly and begin changing the soil pH fairly soon. It is more expensive, but the handling makes up for the added cost.

Certain soil conditioners can alter the soil pH. Peat moss has an acidifying effect on pH. Lime washed composted sewage sludge often used in landscape beds during preparation or renovation, has a liming effect on the soil. Its high pH comes from the lime used during the composting process.

Occasionally it is necessary to lower the pH. Sulfur or products containing sulfur are traditionally used. Soil acidifying fertilizers can have aluminum sulfate or iron sulfate as the active ingredient.

To keep track of pH changes in the nursery or landscape, soil tests should definitely be taken and pH adjusted to the preferred range for the plants before they are planted. Thereafter, it is a good idea to sample a portion of the blocks prior to replanting 5 year crops.

Relative Salt Tolerance

Nearly all fertilizer materials are salts of various compounds. These dissolve in the soil water and become available to plants. Too much salt in the soil will burn the roots by drawing water out of the fine root tissue. Some plants are quite sensitive to this 'fertilizer burn' and are classed as having low salt tolerance. They need light fertilizer applications and care must be exercised when using the readily soluble or 'hot' fertilizers such as ammonium nitrate or concentrated liquid fertilizers.

Other plants can tolerate high levels of soluble salts in the soil, so they can withstand heavy fertilizer applications. The majority of the plants in the list have been classified by nursery researchers as having either low, medium, or high salt tolerance.

(This information was compiled by Dr. Witte from many different sources to help explain the effect of soil pH on plants. The list should be used as a guide rather than an exact measurement of preferred pH range for a plant. Hopefully, it will aid in managing the pH of nursery soils.)

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