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When to Lime Soil and Liming Products Available in Florida[1]

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To cultivate robust and prolific plants, it is essential to maintain the desired pH of their soil. This axiom is true regardless of whether one is growing crops or plants in an agricultural or urban setting. Because it directly impacts the availability of essential plant nutrients, soil pH, also noted as the "soil reaction," is a crucial factor to consider. The internet is rife with misleading information describing the concept of soil acidity and alkalinity, as well as how the soil reaction affects plant growth. If you want to change the pH of Florida soil, it is not advisable to use information from just any internet source, as distinct types of soil require different lime quantities, types, and application techniques. In contrast, some soils may require elemental sulfur application to lower the soil pH. In Florida, recommendations to change soil pH should come from a local expert. This publication is intended for growers, Extension agents, and the general public to better understand better when to lime their soil and what things to look for in a liming product.

The pH Status of Florida Soils

The soil pH in Florida presents a diverse spectrum, ranging from highly acidic to extremely alkaline, influenced by both natural conditions and human activities. This variability in soil pH has significant implications for agriculture and crop production in the region.

In south Florida, alkaline soils are commonly encountered. The underlying geology plays a pivotal role in this phenomenon. The Florida peninsula is situated atop lime rock, which is relatively shallow in some areas, naturally imparting alkalinity to the surface soil. Moreover, human-induced factors exacerbate this condition. Activities such as earth-moving operations, like digging canals for drainage or constructing homes using subsurface fill material, often bring shallow rock or ancient seashells to the surface. These materials are rich in calcium carbonate, which increases soil pH, leading to alkalinity.

Additionally, the consistent and prolonged use of agricultural lime can also shift soil pH towards alkalinity. While lime is often applied to correct acidic soils, excessive use over time can push the pH beyond the neutral point, creating an alkaline environment.

Conversely, in north Florida, soils are naturally acidic. This acidity is advantageous for certain crops, such as potatoes. Northeast Florida's acidic soils have contributed to its renown in potato production. Acidic conditions are less conducive to potato scab, a common problem in soils with higher pH levels. However, crops requiring a soil pH closer to neutral necessitate liming to mitigate the natural or fertilizer-induced soil acidity. For row crops in north Florida, the desired soil pH typically ranges from mildly acidic to neutral. Farmers frequently apply lime to maintain

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this pH range, ensuring optimal growth conditions for their crops. This practice highlights the importance of regular soil testing and pH management in agriculture.

By closely monitoring and adjusting soil pH, farmers can create the most favorable environment for plant growth, enhancing both crop yield and quality while also preventing issues like disease and nutrient deficiencies. In summary, understanding and managing soil pH is crucial in Florida's agriculture, given the state's diverse soil types and the varying pH requirements of different crops. Effective soil pH management, guided by regular soil testing and tailored lime application, is key to successful crop production and sustainable agricultural practices in the region.

Description of Lime

Lime is an inorganic compound comprising of calcium oxides (CaO) and hydroxides (CaOH). Building materials like cement often include calcium-containing components such as marble and limestone. The type of rock that serves as the source of the calcium-containing substance is called limestone. Calcium carbonate ($CaCO_3$) is the dominant chemical component of limestone. In order to produce lime, limestone is heated to a high temperature that converts calcium carbonate to calcium oxide. Other names associated with lime include dolomitic lime, calcium oxide, quicklime, and dolomite. Dolomite is a liming material originating from parent material containing both magnesium carbonate and calcium carbonate. Dolomite is an excellent source of magnesium for agricultural plants.

The availability of nutrients in soil is affected by the soil reaction, which in turn affects the growth and performance of plants. Soils that are too acidic cannot provide the plant with optimal growing conditions throughout its entire life cycle. Since the vast majority of cultivated agronomic and horticultural plants are unable to thrive in soils with a high concentration of acid, soil pH is an essential factor that must be considered. If the soil is too acidic, lime application is required to maintain soil pH at a level suitable for plant growth, typically between 5.5 and 7.0.

Soil is considered acidic if the pH is less than 7.0 (Figure 1). Most Florida mineral soils are on the acidic side of pH 7.0 in their native state, and many are below pH 5.5. On the pH scale, organic soils and soilless medium are considered extremely acidic if their pH value is less than 4.5. However, the growth of most agricultural plants is negatively impacted when the pH of the soil is below 5.5. The simplest way to determine the soil reaction is to measure the soil pH using a mixture of soil and water.

Soil Properties That Are Impacted by Soil pH

Depending on the type of soil, pH has various impacts on soil quality. Once soil pH decreases below 6, nutrients in the soil become less available to plants (Figure 1). The following is a list of some of the most notable impacts of low soil pH:

1. If present, aluminum (Al) and manganese (Mn) may be found at toxic levels in soil with a low pH, particularly below 5.5.

2. The development of insoluble iron and aluminum compounds reduces phosphorus (P) availability, thus rendering P inaccessible to the plants and leading to poor P prediction models for phosphorus recommendations.

Calculating the Appropriate Amount of Lime to Incorporate into the Soil

Soil testing laboratories employ both standard (water-based) soil pH tests and buffer pH tests to accurately determine the precise amount of lime needed to adjust the soil's pH to an optimal level. The buffer soil test is particularly crucial as it takes into account various soil characteristics that resist pH change. These characteristics include soil texture, organic matter content, and the presence of certain minerals.

Soil texture plays a pivotal role in lime application. Finer soils, with higher clay content, typically require more lime to achieve the same pH change as coarser, sandier soils. This is because finer soils have a greater surface area and more negatively charged sites that can hold onto hydrogen ions, which contributes to soil acidity. The buffer pH test helps in gauging this resistance and guides the application of lime accordingly.

Applying the correct amount of lime is essential for multiple reasons. Over-liming can lead to an excessively alkaline soil condition, which can be just as detrimental as acidic soil. In alkaline conditions, certain micronutrients, such as iron, zinc, copper, and manganese, become less available to plants. This micronutrient unavailability can significantly impede plant growth and development. For instance, in Florida, soil pH levels exceeding 6.5 can lead to notable manganese deficiencies in some plants, impacting their health and productivity.

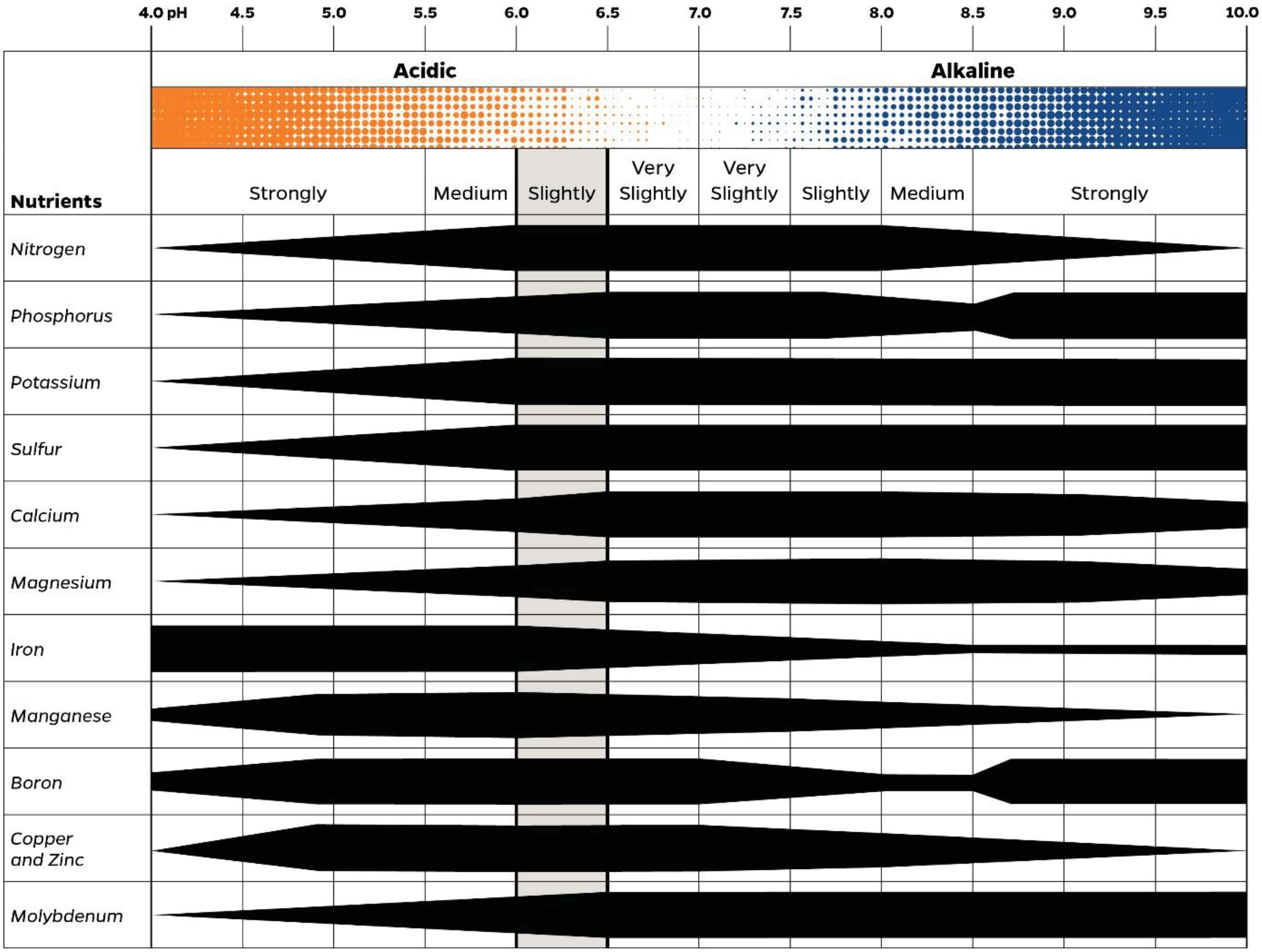

Figure 1. Soil pH affects nutrient availability in the soil. In this chart, nutrient availability at each pH level is indicated by the shape of the bubbles. At each particular pH range, nutrient availability in soil is high where the bubble portion is thicker and low where the bubble portion is thinner. The chart draws special attention to the slightly acidic (6.0 to 6.5) column, where nutrient availability is high for nitrogen, potassium, sulfur, boron, copper, and zinc.
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Furthermore, excessive lime application is not economically prudent. Using lime is a cost and using too much lime results in unnecessary expenditure. Also, correcting over-limed soil can be challenging and may involve additional costs and time.

Therefore, conducting a soil test to determine the lime requirement is not just a recommended practice but an essential step in sustainable soil management. It ensures the appropriate soil pH for optimal plant growth, avoids the potential negative impacts of over-liming, and promotes efficient use of resources. This approach aligns with principles of precision agriculture, aiming to apply the right treatment, in the right amount, at the right time, to achieve the best outcomes in crop production.

Determining Aglime Quality

The ability of agricultural limestone to be reduced to a fine powder and its ability to neutralize acid are two of the most important factors determining product quality. The neutralizing capacity of agricultural limestone (“aglime”) is evaluated by its calcium carbonate equivalent (CCE). The CCE measures the acid-neutralizing strength of aglime relative to pure $CaCO_3$. It is frequently expressed as a percentage. Both pure calcite and pure aragonite are assigned a CCE value of 100% (Table 1). It has been demonstrated that the particle size of aglime significantly affects the time it takes to neutralize acid. Finer particle size in aglime allows it to dissolve more quickly, resulting in a faster effect on soil pH compared to aglime that is not ground as finely. Limestone used for road construction has a significantly coarser texture than the aglime used on agricultural soil. Road construction limestone would have little short-term effect on soil pH if used in agriculture. It is crucial to recognize this distinction.

Since the effectiveness of aglime is highly dependent on the particle size of its constituent particles, it is crucial to understand the methods used to measure aglime and how it is displayed on product labels. In general, aglime can be purchased in a variety of particle sizes ranging from dust-size to sand-size. Standard operating procedure in the limestone industry requires that aglime materials are passed through a series of sieves prior to being tested to ensure that they meet the state's minimum requirements.

Limestone and liming materials sold within Florida are governed by the Florida Commercial Fertilizer Law and must meet specifications for the fineness of grind, CCE, and magnesium content (in the case of dolomite). The state of Florida provides a guarantee that calcite and dolomitic limestones will be ground to meet the following conditions:

- At least 90% passes through the sieve with an 8 mm opening.
- A minimum of 80% may pass through a sieve with 20 mm openings.
- A minimum of 50% must pass through a sieve with 50 mm openings.

Calcite and dolomitic limestones shall also contain a maximum of 15% moisture with a minimum of 90% CCE. The consumers can verify the guaranteed parameters from the product label (e.g., Figure 2).

Take Home Message

- You will need to carry out a soil test to determine the pH of the soil on each individual parcel that makes up your farm.
- Consult with a seasoned agricultural professional if you are interested in determining the exact quantity of lime that is required for your farm.
- Make certain that the quality of the liming material has been evaluated before you commit to making a purchase.

Analysis

- **Calcium (Ca): 38.50%**
- **Calcium Carbonate ($CaCO_3$): 94.00%**
- **Calcium Carbonate Equivalent (CCE): 90.50%**
- **Effective Neutralizing Value (ENV): 87.00%**
- **Minimum ECCE: 80.00%**
- **Lime Score: 89**

Fineness

- **100% passing .... 6 Mesh Sieve**
- **100% passing .... 12 Mesh Sieve**
- **100% passing .... 16 Mesh Sieve**
- **100% passing .... 30 Mesh Sieve**
- **100% passing .... 50 Mesh Sieve**
- **100% passing .... 60 Mesh Sieve**
- **95% passing .... 80 Mesh Sieve**
- **95% passing .... 100 Mesh Sieve**
- **90% passing .... 200 Mesh Sieve**

- **Weight: 2,000 lb = 1 ton standard lime**
- **Moisture content: Max 1.5%**
- **Classification: Meets XYZ fineness classification for pulverized.**

Figure 2. An example of a lime tag for Calcitic liming material.
Credits: Lakesh K. Sharma, UF/IFAS

Resources

FDACS. 2021. "Appendix A: Labeling Guidelines." *How to Comply Fertilizer Manual*. https://www.fdacs.gov/content/download/3502/file/Fertilizer%20Registration%20and%20Labeling%20Guidelines.pdf

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Table 1. Typical CCE values of some common liming materials relative to pure $CaCO_3$. The asterisk (*) indicates the materials with an anti-liming effect (acidification).

Liming Materials	Typical CCE (%)
Calcite (pure)	100
Limestone (calcitic)	75–100
Limestone (dolomitic)	75–108
Aragonite	95–100
Hydrated lime, $Ca(OH_2)$	120–136
Marl	50–90
Burned Lime, CaO	178
Flue ash or dust	60–80
Wood ash	30–70
Basic slag	50–70
Gypsum	0
Urea	–83*
Ammonium sulfate	–110*
Diammonium phosphate	–70*
Source: IFAS blog by Cheryl Mackowiak, "Liming Material Options for Crop and Forage Production"	