SL58

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# Lime and Liming -- A Florida Perspective [1]

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Some of the points explored in this publication are:

- Why liming of acidic soil is sometimes necessary
- How to determine if lime is needed
- How to determine how much lime to apply
- How to evaluate various liming materials

Correction of low soil pH with lime is a major concern to all who grow plants, from the commercial producer to the home gardener. That's because soil pH, the measurement most commonly used as an index of root-zone acidity or alkalinity, has an important influence on the chemical environment of plant roots and consequently on plant nutrition.

Much has been written about soil pH and liming -- and there is considerable misinformation in popular use. Just how acid is acid? How does one evaluate which factors are pertinent to specific plant and soil situations? When is liming wise and when isn't it? Answering these questions from the perspective of Florida soils and growing conditions is the objective of this publication.

## Why Lime Soil?

The reason for liming an acid soil is to improve the performance of the plants being cultivated. Soil acidity affects the plant root environment, which ultimately affects plant growth and performance. Most plants grow better in slightly acid soil than in strongly acid soil. When a soil is too acid for proper plant growth, lime may be applied to reduce the acidity.

## What is Meant by "Strongly Acid" Soil?

In order to answer this question properly we need to consider how soil acidity is evaluated and how it relates to plant growth. Soil acidity is commonly indexed by the pH measured in a mixture of soil and water. The index is used together with other soil characteristics such as texture, organic matter, and clay mineralogy to estimate the degree of soil acidity and the influence the acidity may have on plant performance. While pH is easily measured, it is far less easily interpreted. For example, fine-textured soils, such as clay loams, with pH values below 5.0 are usually considered quite acid because most crops grow poorly on them. Organic soils and soil-less mixes used for potted plants are usually not

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considered too acid until their pH values drop below 4.5. That's because plant growth is not adversely affected until the pH falls below that level in those soils and mixes.

## What Soil Properties are Influenced by pH?

The influence of pH on soil chemistry is complex, and the impact of pH differences on plant performance varies with plant species. Some of the widely accepted adverse effects of low soil pH are:

1. Aluminum (Al) and manganese (Mn) toxicity to plant roots. These two elements increase in solubility as pH decreases, especially below pH 5.5.

2. Decreased availability of phosphorus (P) due to formation of insoluble iron (Fe) and aluminum compounds. Phosphorus is an essential nutrient which frequently must be applied to soil as fertilizer.

3. Poor performance of nitrogen-fixing bacteria.

## Are All of These Adverse Effects Always Important?

Some of these factors are of little or no significance in many plant-growing situations in Florida. For example, the amount of native Mn in Florida soils is generally very low, so Mn toxicity is not likely to be a concern. Likewise, organic soils and potting mixes contain so little Al that its influence on plant performance is insignificant. The effect of soil pH on nitrogen-fixing bacteria is only important if legumes are being grown.

## How do I Know if my Soil Needs Liming?

Remember that it's really not the soil that needs the liming -- it's the plants that grow in the soil that may benefit from the liming effect. Liming is needed only when your soil pH is below the recommended range for the plant species you are growing. To be sure your plants will benefit from liming, consult a reliable growing guide for the species you are cultivating. Next, take a representative soil sample and have it tested for pH. Home test kits are not very reliable. Professional tests are well worth the time and minimal cost. A reputable soil testing lab will want to know the kind of plants you will be growing in that soil before giving you a recommendation concerning liming. Be careful of advisors who recommend alteration of soil pH without knowledge of the **plants to be grown**.

## How do I Know How Much Lime is Needed?

Most professionals now use soil testing labs that perform a separate chemical test to determine how much lime is needed in a particular soil and crop situation. Testing is necessary because soil characteristics influence how effective lime will be in changing soil pH. The property of resisting pH change is referred to as the soil's buffering capacity. See Figure 1. For example, a clay loam soil would need more lime to raise its pH from 5.1 to 6.0 than would a loamy sand soil because the clay loam has a higher buffering capacity than the loamy sand soil. The practice of estimating lime requirement without a soil test is risky, and can lead to overliming.

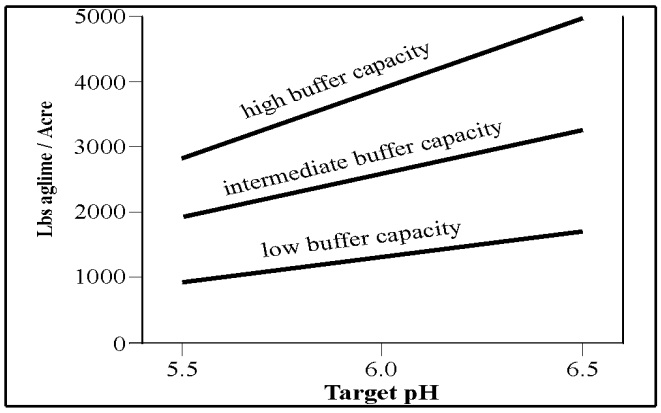



**Figure 1.** Example of amounts of aglime that might be needed to raise soil pH from 4.7 for three soils of differing buffering capacities. Sandy soils, so common in Florida, are mostly low in buffering capacity and need less lime to accomplish a given pH change than finer-textured soils of higher buffering capacity.

## What are the Consequences of Overliming?

Overliming causes the soil pH to increase beyond the range of optimum plant performance. Reduced plant growth is usually associated with deficiencies of micronutrients such as Mn, Fe, zinc (Zn), or copper (Cu), which become less available as soil pH increases. For example, raising soil pH above 6.4 causes Mn deficiency in many plant species in Florida. Overliming may be doubly costly -- it costs to buy and apply the lime, and it may cost in terms of reduced plant performance.

## What Factors Contribute to Overliming?

In Florida, the principal factors contributing to overliming are:

- application of lime to soil without first testing to determine if lime is needed
- liming to soil pH levels much higher than those necessary to achieve the desired plant response
- liming to supply calcium (Ca) and/or magnesium (Mg) as nutrient elements without sufficient regard to the effect of lime in raising soil pH
- assuming that the upper end of the "ideal pH range" for a plant is more desirable than the lower end of the range
- the belief that it is impossible to overlime with dolomite.

## Why is it Important to Distinguish Between Lime as a Modifier of Soil pH and Lime as a Calcium or Magnesium Nutrient Source?

The purpose for applying lime determines the **quantity** of material needed to accomplish that purpose. Liming soil to decrease acidity and provide a better root environment usually requires relatively large amounts of lime. One ton or more per acre may be needed for that purpose. The quantity of lime needed to supply Ca or Mg to soil as a nutrient element is measured in terms of **pounds** rather than tons per acre.

Lime that is applied to soil will simultaneously increase soil pH and supply Ca (and Mg, if the material is dolomitic). If there is a need for Ca or Mg as nutrients and an increase in soil pH is not desired, another source of Ca or Mg should be used. Gypsum and magnesium sulfate supply Ca and Mg, respectively, without affecting soil pH. Ignoring the pH effect of lime used as a Ca or Mg source can result in overliming and can result in poor plant performance.

## Is it Possible to Overlime With Dolomite?

Yes. Dolomite is a liming material, and any liming material has the potential to raise soil pH to a level where negative plant response is obtained. For example, liming blueberry plants or bahiagrass to pH 6.8 is considered overliming because those species grow better in soil of lower pH. Because the equilibrium pH of dolomite is lower than that of calcite and other aglime materials, there is an incorrect belief that it is impossible to overlime with dolomite. Remember that lime is applied to soil in order to benefit the plants that grow there, not to benefit the soil *per se*. Overliming refers to the effect on plants, not soil.

## What are the Characteristics of a Soil Liming Material?

Any material having the following characteristics may be used to lime soil:

1. Reduces soil acidity, with an accompanying increase in soil pH. This is the primary reason for applying lime to soil.
2. Does not add any elements to the soil which may adversely alter the soil's physical or chemical properties. (For example, sodium compounds would likely cause plant nutritional disorders in most soils and could lead to dispersion of clay soils.)

Since liming of soil requires relatively large amounts of material, it is desirable that the material used for liming be readily available and relatively inexpensive.

## What is the Most Common Agricultural Liming Material?

The most common material used for liming agricultural soils is finely ground limestone, a mineral composed of varying concentrations of calcium and magnesium carbonates. Limestone has all the desired characteristics of an agricultural liming material.

- The carbonates react in the soil to neutralize soil acidity and raise soil pH.
- No harmful elements are added to the soil. On the contrary, Ca and Mg are both plant essential elements whose addition in moderate amounts may be beneficial as plant nutrients.
- It's relatively inexpensive. Limestone is a fairly common mineral which only requires mining and grinding to prepare it for use in agriculture. Limestone processed for agricultural use is frequently referred to as "aglime."

## Why are There so Many Confusing Terms Used When Referring to Aglime?

**"Lime," "calcitic limestone," "calcite," "dolomite," "dolomitic limestone," "aragonite," "hi-cal"** -- all are names of aglime materials. As with any widely used material, there is considerable room for confusion.

- Natural materials can differ considerably in composition from one mine to the next.
- Technically correct definitions are frequently cumbersome, so everyday-use definitions develop which may be fine in local situations but which can cause confusion when used elsewhere.
- Legal definitions, as found in state aglime laws, are frequently different from one state to the next.

## How About Some Definitions of Aglime Terms?

Although brief definitions are also subject to the limitations stated above, here's an attempt at clarifying some common aglime terms used in Florida.

**Lime.** A material which, upon reaction with the soil, increases pH (decreases soil acidity) and does not add harmful elements to the soil. Usually, lime consists of finely ground carbonates of calcium and magnesium, although the term also includes oxides and hydroxides of calcium. In Florida, the term "lime" is often incorrectly used to imply calcitic limestone exclusively.

**Calcitic Limestone.** A term widely used by agronomists when referring to agricultural limestone with high calcium content. It contains mainly calcium carbonate but may also contain small amounts of magnesium carbonate. The term is not as restrictive in definition as calcite. It is often used to distinguish materials of low magnesium carbonate content from those of high content, the latter being referred to as dolomitic limestone. The Florida lime law (Chapter 5E - 1.001 of the Florida Administrative Code) contains the two following specifications: (a) "Standard calcitic liming material shall contain a minimum of 86% calcium carbonate expressed as $CaCO_3$," and (b) "Calcitic liming material shall contain a minimum of 70% calcium expressed as $CaCO_3$."

**Calcite.** A mineral which occurs in nature. Pure calcite is 100% calcium carbonate ( $CaCO_3$) which is crystallized in hexagonal form. Calcite is a common constituent in calcitic limestone, dolomite, marble, chalk, marl, seashells, and similar substances. Because the mineral calcite is pure $CaCO_3$, it is the standard by which the acid-neutralizing capability of all other liming materials is measured.

**Dolomite.** A mineral composed of calcium and magnesium carbonates. Pure dolomite contains 40 to 45% $MgCO_3$ and 54 to 58% $CaCO_3$.

**Dolomitic Limestone.** A material containing $MgCO_3$ in lesser concentrations than found in dolomite. In the aglime trade, a concentration of 15 to 20% $MgCO_3$ is common for material termed dolomitic limestone. Florida law requires that a material "contain a minimum of 36% magnesium carbonate expressed as $MgCO_3$" in order to be sold as "standard dolomitic liming material," and "a minimum of 30% magnesium expressed as $MgCO_3$" to be sold as "dolomitic liming material."

**Aragonite.** A mineral which in its pure form is 100% $CaCO_3$. It differs from calcite in its orthorhombic crystal form. Large deposits of aragonite found in the shallow waters of the Bahamas are mined for industrial uses, including use as aglime. The Bahamian aragonite is competitive in price with other forms of aglime in many areas because it is mined by dredges, does not need grinding, and is transported by barge directly to Florida's east-coast ports.

**"Hi-Cal" Lime.** A term used widely in Florida to identify an agricultural limestone having a high concentration of calcium. It is usually used to distinguish the material from dolomite or dolomitic limestone. Calcite, aragonite, and calcitic limestones would all be considered "hi-cal" aglimes.

## What Factors Influence Aglime Quality?

The two principal factors influencing aglime quality are:

- its acid-neutralizing capacity
- the fineness to which it is ground.

Acid-neutralizing capacity is usually measured as the calcium carbonate equivalence (CCE). The CCE is defined as the acid-neutralizing capacity of a liming material expressed as percent by weight of pure $CaCO_3$. Thus, pure calcite or pure aragonite have a CCE of 100%.

The fineness to which aglime is ground determines in large part the rate at which it will react in soil. As particle size decreases, aglime dissolves more rapidly and changes pH over a shorter period of time. Particle size is such an important aspect of aglime quality that particle size specifications are part of most aglime laws. It might be noted here that limestone crushed for road-building is far too coarse to be effective in lowering agricultural soil pH, even if applied at several times the recommended aglime rate per acre.

## What are Typical Calcium Carbonate Equivalents (CCE) of Some Liming Materials?

Table 1 presents typical CCE values of some common liming materials and the tons of each material needed to produce the same neutralizing power as one ton of pure $CaCO_3$.

## How is CCE Determined?

To determine CCE, a carefully weighed sample of the lime material is reacted with an acid under laboratory conditions prescribed by a standardized procedure.

## Is It Possible to Have a CCE Greater than 100?

Yes. When a material contains appreciable amounts of magnesium carbonate, calcium hydroxide, calcium oxide, or magnesium oxide, it will have greater neutralizing power than the same weight of calcium carbonate. This will result in a CCE greater than that of pure $CaCO_3$, which is 100.

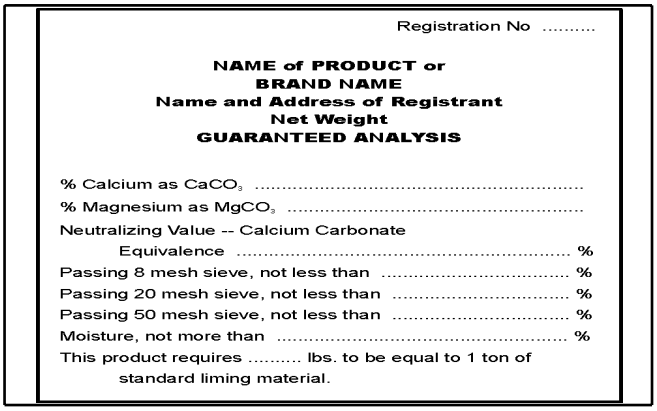
## How is Particle Size of Aglime Measured and Expressed?

The usual testing procedure is to pass a sample through a series of standard sieves and express the results as percentage passing through, or remaining on the variously sized sieves. Sieves are typically made of wire cloth and are designated by the number of openings per linear inch (mesh) in the cloth. For example, a 60-mesh sieve has 60 openings per linear inch (i.e., 3,600 per square inch). A particle passing through a standard 60-mesh sieve would have a diameter of less than 0.0098 inch (<0.25 mm). Such material would have the consistency of flour. An aglime will ordinarily be composed of particles of

many different sizes, ranging from very fine, dust-like particles to coarse, sand-like ones.

## What Does A Florida Lime Tag Look Like?

Figure 2 is an example of the tag which must accompany any lime sold in Florida. Some variation may occur, but the essential information is prescribed by law.



Registration No .....

**NAME of PRODUCT or**
**BRAND NAME**
**Name and Address of Registrant**
**Net Weight**
**GUARANTEED ANALYSIS**

% Calcium as $CaCO_3$ .....
% Magnesium as $MgCO_3$ .....
Neutralizing Value -- Calcium Carbonate Equivalence ..... %
Passing 8 mesh sieve, not less than ..... %
Passing 20 mesh sieve, not less than ..... %
Passing 50 mesh sieve, not less than ..... %
Moisture, not more than ..... %
This product requires ..... lbs. to be equal to 1 ton of standard liming material.

**Figure 2.** An example of a Florida Lime Tag.

## What is Meant by the Term "Ton of Standard Liming Material" Used on the Florida Lime Tag?

"Standard liming material" is defined in the Florida Commercial Fertilizer Law as aglime having a minimum neutralizing value of 90% CCE. Thus, one ton of standard liming material is 2000 pounds of material having a minimum CCE of 90%.

## Are There any Other Means by Which a Florida Consumer Can Compare the Neutralizing Value of Aglimes?

The Florida aglime tag bears the statement, "This product requires _____ lbs. to be equal to one ton of standard liming material." Thus, if a material has a higher CCE than 90%, less than 2,000 pounds would be required to have the neutralizing potential of 2,000 pounds of standard liming material. Conversely, if a material has a CCE less than 90%, more than 2,000 pounds will be required. For some consumers, the values given in this required statement are easier to understand and compare than are the CCE values.

## Why is Moisture Content of Aglime Guaranteed on the Florida Aglime Tag?

Aglime is quite dusty because of the fineness to which it is ground. It is usually sprayed with water to facilitate bulk handling and to prevent excessive drift loss during field spreading. For aglime sold in Florida, a maximum moisture content of 15% is allowed so that the consumer will pay for no more water than that needed for dust control.

## Summary

In this publication we've explored the subject of liming acid soils -- why liming is sometimes necessary, how to determine if and how much lime is needed, and how to evaluate liming materials commonly found on the market. Particular emphasis has been placed on examples pertinent to Florida. However, given the diversity of soils in the state, be careful of generalizations and consult with local professionals before making soil management decisions if you have doubts or questions about the subjects of lime and liming.

**Table 1.** Typical CCE values.

| **Liming Material** | **Typical CCE (%)** | **Tons Required to be Equivalent to 1.0 Ton of $CaCO_3$** |
|---|---|---|
| calcite (pure) | 100 | 1.0 |
| calcitic limestone | 75 to 100 | 1.3 to 1.0 |
| dolomitic limestone | 75 to 108 | 1.3 to 0.9 |
| aragonite | 95 to 100 | 1.1 to 1.0 |
| hydrated lime ($Ca(OH)_2$) | 120 to 136 | 0.8 to 0.7 |
| wood ash | 30 to 70 | 3.3 to 1.4 |