

# Lime Management

When using intense turf management practices, and carefully applying the correct type and amount of fertilizer, it's easy to see and measure the positive effects of an application. This is not the case when applying lime. Plant responses to lime are slow, of long duration and not easily spotted. However, when soil pH drops below pH 5, in order to achieve maximum fertilizer efficiency, lime must be applied before the fertilizer dressing. On acid soils, lime applications will improve the growing vigor for most turf grasses. A lime application will continue to neutralize acidity anywhere from two to three years. In this article, we will discuss the reasons and benefits of making lime applications.

## Soil Acidity

Soil acidity, and its effect on nutrient availability, results from a lack of exchangeable metallic cations (Ca, Mg, K, Na) in the soil. The soil has an inherent capacity to absorb cations, called the cation exchange capacity (CEC), that varies with clay and organic matter content. The quantity of the adsorbed basic cations (Ca, Mg, K, Na) expressed as the percent of base saturation directly determines the hydrogen (H) concentration in the soil. (Example: Ca 60% – Mg 25% – K 3% – Na 2% of cation exchange capacity; this soil would be 90% base saturated, or contain 10% hydrogen.) As a result, adding suitable quantities of one or more of the above cations displaces H and attains an increase in soil pH. Calcium and magnesium are the two best suited; they are plentiful, widespread and relatively inexpensive. In addition, they have a desired effect on the soil's physical conditions.

Most grasses thrive best on slightly acidic soils (pH values of 5.8-6.5). At this range the best balance of available nutrients is achieved. Refer to [Figure 1](#).

## Changes to the Soil from Lime Applications

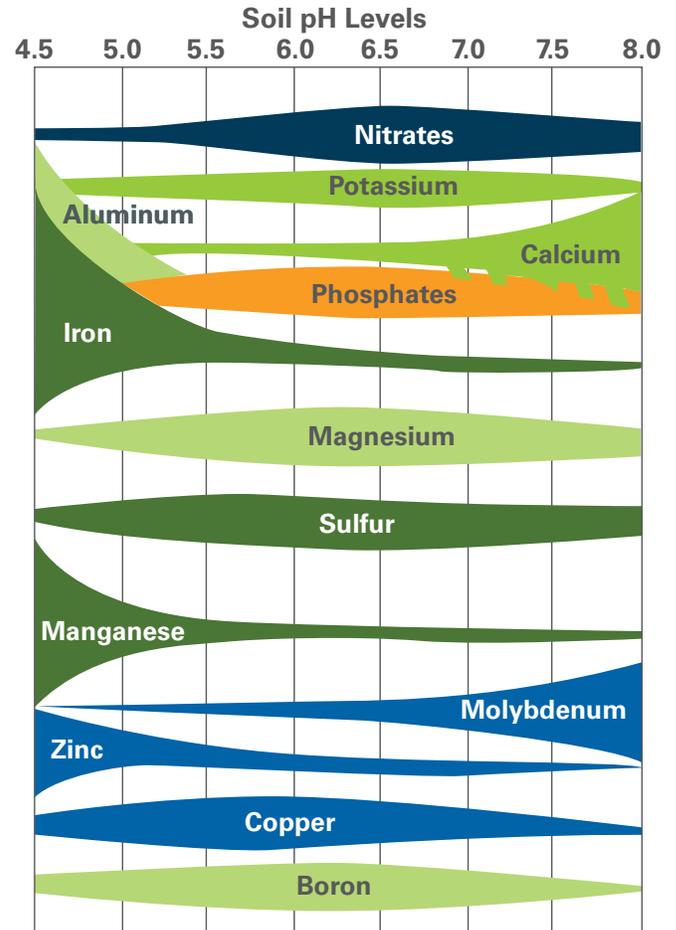
When applied to the soil, limestone undergoes several changes, the first of which is calcium and magnesium go into the soil solution with the help of carbon dioxide. Next, the acid dominated clay mineral adsorbs the calcium and magnesium ions from the soil solution. This can be diagrammed as follows:

## Reaction with CO<sub>2</sub>

When lime is applied to the soil it reacts with the carbon dioxide in the soil air and forms bicarbonates.



Figure 1. This bar graph is interpreted as the thicker the graph the greater the availability of the particular element.



## Reaction with the Soil Clay

As the reaction of limestone proceeds, carbon dioxide is released, calcium and magnesium are adsorbed onto the clay mineral and the hydrogen reacts with oxygen to form water. The result is an increase in the soil pH.

## Effects of Lime on the Soil

Basically, lime affects the soil in three ways: physically, chemically and biologically.

## Physical

In heavy clay textured soils, the tendency is for the clay minerals to disassociate, breaking up into individual particles. When this happens, water infiltration rates and soil air levels are greatly reduced. Calcium and magnesium have the ability to prevent, or reverse, this breaking up of the soil structure; therefore, water infiltration can be enhanced with lime applications.

## Chemical

When lime is applied to a very acidic soil, a number of chemical changes occur, all of which improves soil productivity:

- Decreasing the concentration of hydrogen (H) ions
- Increasing the concentration of hydroxide (OH) ions
- Decreasing the solubility of iron, aluminum, manganese
- Increasing the availability of phosphates and molybdenum
- Increasing the exchangeable amounts of calcium and magnesium
- Increasing the percentage of base saturation
- Depending on conditions, availability of potassium may be either increased or decreased

The result of the above list of chemical changes is the enhancement of nutrient availability and plant uptake of molybdenum, phosphorus, calcium and magnesium. At the same time, the solubility of iron, aluminum, and manganese (which are toxic at very low soil pH levels) is drastically reduced.

## Biological

Soil organisms also have an optimum soil pH level, as do soil nutrients. Most of the favorable fungi, bacteria, and multi-celled organisms are stimulated with a lime application on acid soils. Bacteria controls processes such as aminization, ammonification, sulfur oxidation, mineralization of organic matter, and non-symbiotic nitrogen fixation. If soil pH is too acidic, all of these processes slow down and become erratic.

In addition, some biological processes (specifically nitrification) require calcium and magnesium in large quantities. If they are inadequate, this process becomes difficult to predict. In fact, the successful growth and development of most soil microorganisms depend on lime for continued supplies of calcium and magnesium so that satisfactory biological activities can continue.

## Turf Grass Responses to Limestone

Turf grasses, and other plant species, are not universal in their responses to pH. Some species are tolerant, or even require low pH values, where others require alkaline pH values. The reasons are varied, however it usually involves the degree of specific nutrient availability. In the case of azaleas, high solubility of iron is required so a low pH < 5.0 is required. Whereas Zoysia grass can tolerate a wide pH range 4.5-7.5. **Table 1** is a partial list of plant tolerance to soil pH levels.

**Table 1.**

Plant Species	pH Range
Bermuda Grass	5.0-7.0
Bluegrass	6.0-7.5
Creeping Red Fescue	5.5-7.3
Bentgrass	5.5-7.5
Tall Fescue	5.5-7.3
Fescue Grass	5.5-6.5
St Augustine Grass	6.2-8.1
Buffalograss	6.2-8.5
Zoysia Grass	4.5-7.5

## Origin of Soil Acidity

Soils become acidic because excess hydrogen replaces the basic cations (Ca, Mg, K, Na). The replaced basic cations are then leached below the root zone. Liming the soil reverses this reaction.

On soils used in turf grass management, there are at least seven reasons for them becoming more acidic:

- Acidic parent materials (mineral or organic soil sources)
- Plant roots exude hydrogen compounds that form carbonic acid with the CO<sub>2</sub> excreted by the roots
- Basic cations are removed with clippings
- Leaching of the basic cations from the root zone
- Erosion of the humus and clay from surface soils
- Acid rain
- Addition of acid forming fertilizers (all nitrogen compounds)

**Table 2. The acid forming impact of various fertilizers, indicated as a negative amount of calcium carbonate that is neutralized from a lime application.**

	Fertilizer Type	Nutrient %	Amount Needed to Supply 20 lbs.	Calcium Carbonate Equivalent/20 lbs.
Nitrogen	Anhydrous Ammonium	82	24	-36
	Urea	46	43	-36
	Nitrogen Solutions	28-32	71-63	-36
	Ammonium Nitrate	34	59	-36
	Ammonium Sulfate	20	100	107
Phosphorus	Monoammonium Phosphate	52	38	21
	Diammonium Phosphate	46	43	-28
	Superphosphate	42	48	Neutral
Potassium	Potassium Chloride	62	32	Neutral
	Potassium Sulfate	50	40	Neutral

**Table 3. Comparison of soil texture and CEC on the lime rate required to achieve a relatively similar soil pH change.**

Soil Texture	CEC	Soil pH	Buffer pH	Lime Rate
Sand	6.0	5.6	6.8	45 lbs./1,000 sq. ft.
Silt Loam	14.0	5.5	6.6	90 lbs./1,000 sq. ft.
Silty Clay Loam	24.0	5.6	6.2	185 lbs./1,000 sq. ft.

Of these seven factors, acid forming fertilizers result in the greatest degree of acidification in turf grass. This is especially true in artificially constructed sand-based greens. **Table 2** diagrams the equivalent acidity of common fertilizer products.

The following chemical reactions (ammonification and nitrification) are combined processes in the soil and result in the production of hydrogen (acid). These processes occur with the use of all the acid forming nitrogen compounds identified in **Table 2**.



## Limestone Applications

In determining the need and the quantity of limestone to apply, the following factors are utilized by most soil laboratories: turf grass type, soil pH, Buffer pH and CEC.

Soil pH is the measurement made to determine how acidic the soil is and if the turf grass type has a need for limestone. The quantity of limestone to apply is determined by the Buffer pH (also called the Buffer Index) and CEC. The Buffer pH result is the laboratory test used to determine HOW the soil responds to a limestone application. Therefore, it determines how much limestone is needed. As noted earlier, CEC is determined by clay and organic matter content, and the higher the clay content, the more calcium is required to fill the exchange capacity. Therefore, the higher the CEC measurement, the greater the quantity of limestone that is needed to achieve the desired soil pH. **Table 3** illustrates how the different soil textures and CEC's impact the amount of lime needed to achieve the same pH change.

It is important to remember that limestone does not leach into the soil. Its movement is dependent upon physical movement. In turf grass production (in established turf) soil aeration is the "tillage" implement for incorporation, but the reality of this is that very little soil is disturbed during this process. As a result, 100 pounds/1,000 sq. ft. of lime might be required, but the MAXIMUM application on established turf should be no

more than 50 pounds/1,000 sq. ft. in any one application. Further, because of the lack of incorporation, limestone breakdown and acid neutralization will be slow. It will be difficult to evaluate the effect from any one application. Therefore, pH tracking should be done on a continuous basis, preferably every year.

**Table 4** is assuming the limestone used is 100 percent calcium carbonate equivalent. To compute the actual application rate, divide the recommendation by the percentage of the actual carbonate equivalent of the purchased limestone.

**Table 4. AgSource Laboratories uses the following table to approximate limestone applications.**

SMP Buffer pH	Desired Soil pH	
	Values are in lbs/1,000 sq. ft	
	6.5	6.0
7.2	0 lbs.	0 lbs.
7.1	15 lbs.	10 lbs.
7.0	20 lbs.	15 lbs.
6.9	25 lbs.	20 lbs.
6.8	40 lbs.	35 lbs.
6.7	75 lbs.	60 lbs.
6.6	90 lbs.	80 lbs.
6.5	120 lbs.	95 lbs.
6.4	155 lbs.	130 lbs.
6.3	185 lbs.	150 lbs.
6.2	185 lbs.	170 lbs.

On established turf grass do not apply more than 50 lbs. in one application. Above guideline is 100 percent calcium carbonate equivalent.