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FACT SHEET

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SOIL ACIDITY AND LIMING

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Acid soils are found in East Texas and the Eastern Gulf Coast region as shown in figure 1. These soils become acid from the leaching effect of high rainfall along with parent materials low in basic elements.

Figure 1. Acid soil region of Texas (includes only parts of some counties).

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Causes of Soil Acidity

The degree of soil acidity or alkalinity depends on the kind of materials from which a soil is formed. For example, a soil that develops from basic rocks or alkaline parent materials generally has a higher pH than one formed from acidic rocks. The amount of rainfall also affects soil acidity development. Water passing through the soil slowly carries basic elements such as calcium, magnesium and sodium into the drainage water, leaving the acidic elements — hydrogen, aluminum and manganese.

Cropping also contributes to acidity because basic elements in crops are removed when the crops are harvested.

The loss of topsoil by erosion further reduces calcium and magnesium in the surface soil. Subsoils in most of the acid soil region are acid, so soil erosion gradually increases plowlayer acidity, unless this is offset through a regular liming program.

Ammonium nitrogen use also causes soil acidity. When ammonium in the soil is nitrified or converted to nitrate by soil micro-organisms, hydrogen ions (H+) are released, increasing acidity.

$$\underset{\text{Ammonium nitrogen}}{2NH_4^+} \xrightarrow[\text{Bacteria}]{3O_2} \underset{\text{Nitrate nitrogen}}{2NO_3^-} + \underset{\text{Hydrogen}}{4H^+}$$

This does not mean all the ammonium in fertilizers increases soil acidity. If the ammonium is absorbed by plants, hydrogen is not released in the soil. Ammonium nitrogen adds significantly to acidity development in the acid soil region of Texas because of the high rates used for forage production. Although use of an acid-forming fertilizer contributes to soil acidity, periodic liming, as indicated by a soil test is

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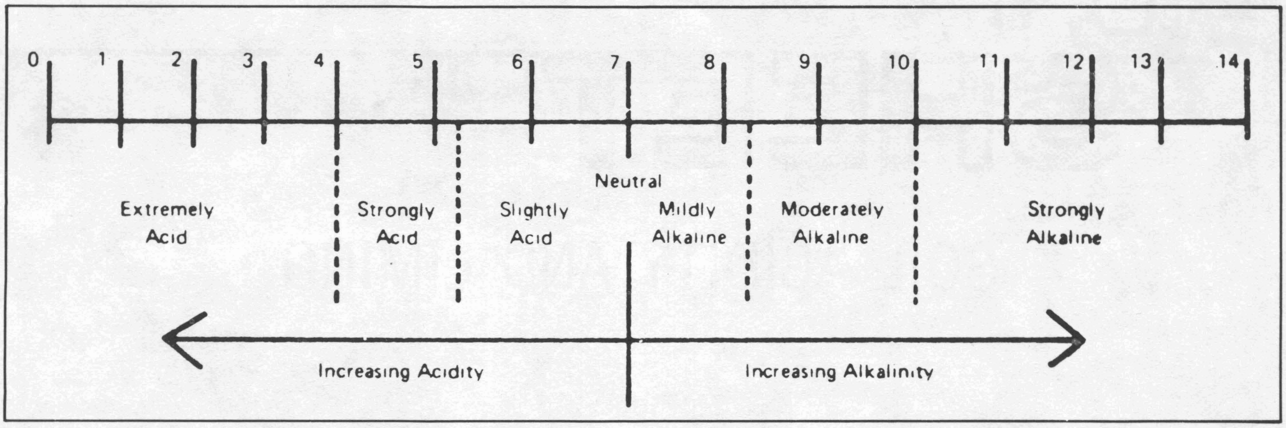


Figure 2. The degree of acidity or alkalinity is expressed as pH.

usually cheaper than using non-acidforming fertilizers.

How Soil Acidity Is Expressed and Measured

The term used to express soil acidity is pH. The pH scale ranges from 0 to 14 as shown in figure 2. The two commonly accepted methods for measuring pH are chemical indicators and the glass electrode pH meter, illustrated in figure 3.

Figure 3. Soil acidity can be determined most accurately by use of the pH meter.

With either method, the first step is to collect a representative soil sample. A composite sample is needed and should be collected according to instructions provided by the soil testing service. Apply information gained from a pH determination only to the soil the sample represents.

For best results, pH meters are used. These meters are used by most soil testing laboratories and give the best measure of soil pH. Values for pH can be duplicated within 0.1 to 0.2 of a unit by using a pH meter.

Benefits from Liming

The major reason for liming acid soils is to prevent them from becoming acid enough to reduce crop yields. Liming has several beneficial effects:

- It reduces acidity and provides a more favorable environment for the growth of soil microorganisms. This is important especially for nitrogen fixation by legumes and for nitrification of ammonium to nitrate.
- Lime increases the availability of phosphorus, especially in soils containing large amounts of iron and aluminum. The solubility of iron and aluminum phosphates increases as acidity is reduced.
- Liming decreases potassium losses caused by leaching.
- Lime supplies calcium and magnesium, nutrients essential for plant growth.
- Adding calcium improves the structure of acid clay soils by causing clay particles to aggregate.
- Increasing the soil pH results in the precipitation of toxic aluminum, manganese and similar elements.

Selecting a Liming Material

A number of products listed in table 1 can be used for neutralizing soil acidity. When selecting a suitable

Table 1. Common liming materials available in Texas.

Material	Chemical composition	Average neutralizing value
Ground agricultural limestone	$CaCO_3$	90 to 98
Ground magnesium limestone	$CaCO_3$ plus 10 to 20% $MgCO_3$	90 to 98
Ground dolomitic limestone	$CaCO_3$ plus 35 to 40% $MgCO_3$	90 to 105
Hydrated lime*	$Ca(OH)_2$	145 to 150

*Construction lime is not used extensively for agricultural purposes.

material consider the need for magnesium, desired rate of pH change, materials available and relative neutralizing value.

Need for Magnesium. Where both calcium and magnesium are needed, use liming materials that contain both of these nutrients. Dolomitic limestone contains approximately equal amounts of calcium and magnesium carbonates, but experimental data show that 10 to 15 percent magnesium carbonate supplies adequate magnesium. The need for lime containing magnesium varies between regions but usually is greater where sandy soils predominate. This can be related to low soil magnesium levels, low lime usage, sandy soils' low capacity to retain magnesium and past use of calcitic lime in some areas.

Desired Rate of pH Change. When extremely acid soils are limed immediately before planting a crop, it is advisable to use finely ground limestone since it reacts more rapidly.

Materials Available. The most common agricultural liming material available in Texas is ground agricultural limestone. It ranges from nearly pure calcium carbonate or calcitic limestone to a mixture of calcium and magnesium carbonates or dolomitic limestone. Most liming materials, especially ground limestones, are slowly soluble in water and must be in contact with soil particles or acids to change the pH. Because of this, the same amount of a liming material composed of small particles causes a more rapid change in the pH than a coarse material composed of large particles. This is related to the total of exposed surfaces in an amount of material. Grinding coarse substances decreases the size of individual particles and increases the total surface exposed to soil acids. Desirable liming materials consist of particles with varied sizes.

Table 2 estimates the time required for limestone of different mesh sizes to react in soils. Most ground limestones used as liming materials are mixtures of different particle sizes, enabling them to neutralize soil acidity over a period of years with the fine particles acting immediately and the coarse ones extending the reaction period.

Table 2. The availability of lime increases as the proportion of fine material increases. (H. B. Cheney and J. W. Fitts, "Good Limestone is Pure and Fine." *Iowa Farm Science*)

Particle size	Percentage available within 3 years
Held on 4-mesh	0
4- to 8-mesh	10
8- to 50-mesh	40
Passing 50-mesh	100

Relative Neutralizing Value. Relative neutralizing value of calcium carbonate equivalent is a standard value used to compare liming materials. The greater this value, the greater the materials' capacity to neutralize soil acidity. For example, dolomitic limestone with a value of 105 would have a neutralizing value 15 points above ground limestone, which has a value of 90. The rate per acre can be reduced 10 to 15 percent if this type limestone is substituted for ground limestone.

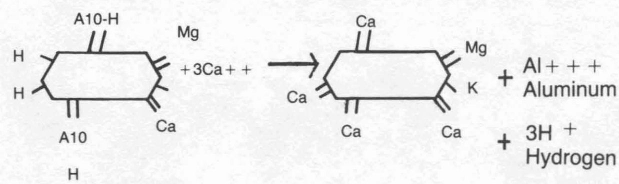
The relative neutralizing value assigned to a liming material indicates its maximum acidity reduction, not how fast the material will react.

How Lime Reduces Acidity

Removing or inactivating hydrogen and aluminum within a soil system reduces acidity by increasing the pH. The pH of a soil expresses only the amount of active hydrogen in the system, but aluminum in a soil can activate hydrogen. After liming the replaced hydrogen is leached out of the limed zone by drainage water. Aluminum is converted to insoluble forms which have no immediate effect on the soil or plants.

Most liming materials are slowly soluble in pure water. When the calcium carbonate in the liming material dissolves, some hydroxyl ions are generated which neutralize the hydrogen or acidity in the soil as illustrated by these reactions.

$$\underset{\text{Calcium carbonate}}{3\,CaCO_3} + \underset{\text{Water}}{3H_2O} \longrightarrow \underset{\text{Calcium}}{3\,Ca^{++}} + \underset{\text{Bicarbonate}}{03\,(HCO_3^-)} + \underset{\text{Hydroxyl}}{30H^-}$$



$$\underset{\text{Hydrogen}}{3\,H^+} + \underset{\text{Hydroxyl}}{30H^-} \longrightarrow \underset{\text{Water}}{3H_20}$$

Low pH High pH

Calcium movement in the bicarbonate form is relatively slow. Consequently, mix the lime with the soil to efficiently replace hydrogen and aluminum held by clay particles.

Lime Requirement

Lime requirement is the amount of limestone necessary to raise and maintain the soil pH in a desired range for 2 to 5 years. Lime requirement is affected by these important factors:

- The type of crops to be planted determine the desirable pH range to maintain. Many crops are tolerant of moderate acidity, if adequate plant nutrients are supplied.
- As the pH of soil decreases, the lime requirement increases.
- Lime requirement increases as the clay and organic matter content increases.
- The neutralizing value or calcium carbonate equivalent of a liming material affects the amount needed to produce the desired pH change. For example, the lime requirement could be reduced approximately one-third if hydrated lime with a neutralizing value of 150 were substituted for ground limestone that had a value of 100.

Application

Evenly spread the liming materials and mix with the soil. To accomplish this, apply lime during land preparation. The spreading method is not as important as the uniformity of application.

Where high rates (3 tons or more per acre) are needed, more complete mixing throughout the plowlayer is accomplished by applying from a third to half before plowing and the remainder later. The full effects from an application of lime may not be realized until the field has been plowed at least twice.

Where permanent pastures and hay mixtures are being seeded, mix sufficient lime into the plowlayer to bring the pH into the desired range. If this is done, the pH can be maintained by topdressing liming materials.

Applying lime in suspension is suitable if enough material is applied to meet lime requirements. The fine materials generally used react more rapidly requiring less lime to raise the pH but would require more frequent use.

Summary

- Apply lime only where needed. Not all soils are acid.
- Soil testing is a reliable method of determining lime requirements.
- Soil samples tested at 2- to 4-year intervals should determine liming frequency.
- Use acceptable quality limestone.

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