UNIVERSITY OF MINNESOTA EXTENSION

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Liming Materials for Minnesota Soils

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WHAT IS A LIMING MATERIAL?

An agricultural liming material is defined as a material containing calcium (Ca) and/or magnesium (Mg) compounds capable of neutralizing soil acidity. These materials include: limestone (both calcitic and dolomitic), burned lime, slaked lime, marl, shells, and by-products such as sugar beet lime, and sludge from water treatment plants.

Fluid lime is a term that is generally used to describe the concept of suspending liming materials of various types in either water or fertilizer solutions. Frequently, the liming material in fluid lime is finely ground agricultural limestone with a high neutralizing value. Advantages include rapid availability and application with existing fluid fertilizer equipment. Drawbacks are low rates of application and relatively high cost for the lime applied.

LIME NEUTRALIZES SOIL ACIDITY

Everything that contains calcium or magnesium is not necessarily a liming material. Gypsum, for example, is calcium sulfate ($CaS0_4 \cdot H_2O$). When added to the soil, the calcium in the gypsum can displace the hydrogen on a clay particle. The hydrogen, however, would remain in the soil solution and the pH would not change because of the absence of carbonate.

When added to the soil, calcium and/or magnesium dissolved from the liming materials displace hydrogen (H^+) from the clay particles. It is the hydrogen ion (H^+) that makes soils acid. The displaced hydrogen then reacts with carbonate, reducing soil acidity. Carbonate dissolved from the limestone materials forms carbonic acid. Carbonic acid is not stable in soils and quickly forms carbon dioxide and water. With this chemical process, the hydrogen (H^+) has been converted from an ion on a clay particle to a neutral molecule of water, thereby reducing soil acidity. The chemical reaction for this process is shown at the top of the page.

$$H^+\text{-Clay} + CaCO_3 \rightarrow Ca^{++}\text{-Clay} + H_2CO_3$$

(Limestone) (Carbonic Acid)

Then:

$$H_2CO_3 \rightarrow H_2O + CO_2$$

(Water) (Carbon Dioxide)

LIMESTONE QUALITY

In Minnesota, liming materials are analyzed and sold on the basis of **E**ffective **N**eutralizing **P**ower (ENP). The analysis label lists pounds of ENP per ton of liming material. Similarly, lime suggestions are now provided in terms of lb of ENP per acre. The ENP is calculated from an analysis of carbonate content and a measure of particle sizes. In the past, recommendations were made in terms of tons per acre. Specific suggestions in terms of lb ENP per acre for major crops in Minnesota are listed in Fact Sheet AG-FS-5956.

The chemical purity of the limestone material is expressed in terms of **T**otal **N**eutralizing **P**ower (TNP). In the past, the purity of liming materials was expressed on the basis of Calcium Carbonate Equivalent (CCE). The TNP is the same as the old CCE. The **F**iness **I**ndex (FI) is determined in the laboratory by measuring the percentage of the liming material that passes through sieves of various sizes. Three sieve sizes (8 mesh, 20 mesh, 60 mesh) are used. The FI is determined from the following equation:

FI = (% passing 8 mesh but remaining on 20 mesh) x0.2
+ (% passing 20 mesh but remaining on 60 mesh) x 0.6
+ (% passing 60 mesh) x 1.0

The smaller particles (those that pass through the 60 mesh sieve) bring about a rapid change in soil pH. The larger particles (those that pass through the 8 mesh sieve but remain on the 20 mesh sieve) dissolve more slowly in soils and provide for an increase in pH over a longer period of time.

In general, Ag Lime is a mixture of particles of various sizes. This mixture provides for both a rapid increase in soil pH and maintenance of this increase for a period of time.

When purity, moisture content, and fineness index have been determined, the % ENP is calculated from the following equation:

% ENP = % TNP X FI X % Dry Matter

A VARIETY OF LIMING MATERIALS

For several years, ground agricultural limestone or Ag lime was the primary liming material used in Minnesota. There are, however, a number of by-product materials that can be used to increase soil pH. In some situations, these materials are given to the grower. In other cases, there is no or a small charge for the material, but the grower pays the cost of hauling. The moisture content and TNP of these materials varies over a wide range. The grower who uses these products should have them analyzed. With this analysis, it's possible to determine the pounds of ENP per acre to apply to bring the soil pH to a desired level.

There is one other factor to consider when choosing a liming material. The liming material selected should spread easily so that it's possible to achieve a uniform application over the entire field. Ag lime spreads easily. On the other hand, liming material that contain relatively large amount of water (sugar beet lime (PCC); water softening lime) are more difficult to spread uniformly over the field. This lack of uniform spreading could cause production problems for several years after application.

If applied to supply equivalent amounts of ENP per acre, all liming materials should have an equal effect on crop yield. So, the decision on source to use should be based primarily on cost.

DOLOMITIC VERSUS CALCITIC LIMESTONE

Most of the Ag lime quarried in Minnesota contains both calcium and magnesium. Both of these nutrients are essential for crop production. Calcium requirements of crops are low and Minnesota soils contain ample amounts of this nutrient. There are some who believe that, when lime is needed, only calcitic lime should be used.

This belief originates from a concept which suggests that there is an ideal ratio of calcium to magnesium in soils and any deviation from this ratio will cause problems with crop production. Several field trials have been conducted to test the validity of this concept. The results are clear: the ratio of calcium to magnesium in soils has not had any effect on crop yield in the northern Com Belt. Wisconsin researchers, for example, varied the ratio of calcium to magnesium from 2 to 8 and found no effect on the yield of alfalfa grown on a sandy soil and a silt loam soil.

The calcium to magnesium ratio is not important in Minnesota soils. However, the supply of magnesium can affect production. Magnesium will be needed in a fertilizer program if the soil test for magnesium is low. The use of dolomitic lime is one of the easiest and most cost effective ways to add magnesium to soils.

ECONOMIC CONSIDERATIONS

The determination of the ENP of various liming materials has economic implications for the grower. With this measurement, it's now possible to compare various liming materials on a cost basis. The following equation can be used to calculate this cost:

$$\textit{Cost/lb ENP} = \frac{\textit{Price/ton of Material (\$)}}{\textit{lb of ENP per ton}}$$

THE LIME LAW AND THE LIME USER

The implementation of the Minnesota Lime Law in 1990 was a major step forward. Although new terminology was introduced in making liming suggestions, it should not be confusing. This law does provide a standardized system for calculating costs. Growers have a basis for computing costs of a wide variety of liming materials. This ability to calculate costs and choose liming materials based on costs improves the profitability of Minnesota growers who need lime for crop production.

Additional Publications

FS-05956-Liming Needs in Minnesota

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