LIMING MINNESOTA SOILS

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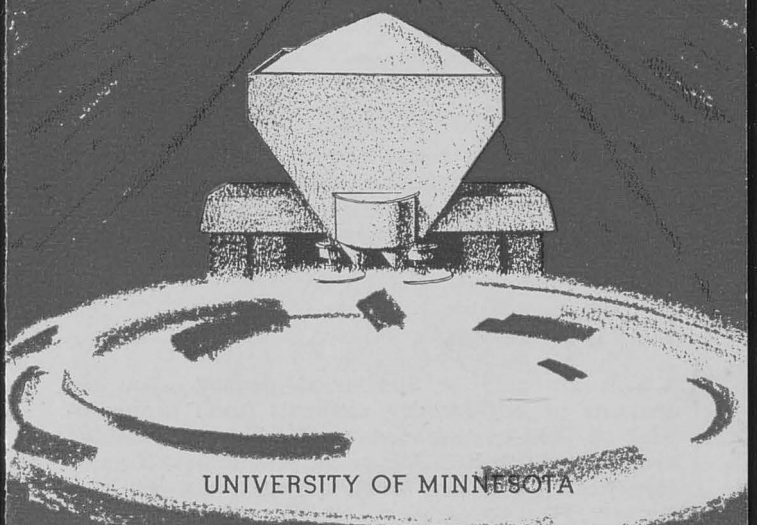

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Liming Minnesota Soils

As much as one-third of Minnesota's cropland could benefit from liming. Not all of our soils are lime deficient, but those that are differ greatly in the amounts of lime required. Why? Because the lime content varies in the many parent materials that form our soils and in the amount that has been leached out by rainfall. Other factors too, such as vegetation, time, slope, and cultivation, have worked to bring about these differences in liming needs.

What Are the Benefits of Liming?

- √ Lime furnishes calcium and magnesium for plant growth.
- √ Lime makes nitrogen and phosphorus more available to growing plants.
- √ Lime promotes the growth of favorable soil bacteria in acid soils.
- √ Lime prevents soil acids, aluminum, manganese, and iron from becoming toxic to plants.
- √ Lime improves the physical conditions of many soils by promoting a crumblike structure.
- √ Lime may help cut down on soil and water losses by improving soil tilth.
- √ Lime lessens the possibility of insect and disease damage by promoting vigorous plant growth.

What Is Lime?

Agricultural lime is any material containing calcium or calcium and magnesium that, when properly applied, will neutralize soil acidity. While gypsum contains calcium it is not a liming material because it does not correct soil acidity.

What Is Soil Acidity?

Soils are acid or alkaline depending upon the amounts of acid-forming elements (such as hydrogen), or base-forming elements (such as calcium and magnesium) present. When acid- and base-forming elements are balanced, a soil is neutral and will have

a pH of 7. As bases are removed by cropping and leaching, a soil becomes acid and may have a pH of 5 or lower. The addition of lime to a soil adds calcium or calcium and magnesium. This reduces the activity of the acid-forming elements and so soils become less acid.

Acid-forming elements are found in the soil water and attached to the clay and organic matter particles in soils. A liming program attempts to neutralize both of these acid formers. That is why liming recommendations call for greater amounts of lime on fine-textured soils and those high in organic matter than on coarse-textured, sandy soils.

How acid or alkaline a soil is can be determined with color indicators or more accurately, with a pH meter. A pH of 7 indicates a neutral reaction. Pure distilled water has a pH of 7. Sour milk and lemon juice are acid substances with pH values below 7. On the other hand, alkaline materials such as sea water and soap have pH values of 8 and 9, respectively. Hence, the lower the soil pH value falls below 7, the more acid it is; the higher the pH value above 7, the more alkaline the soil.

Do Crops Differ in Their pH Needs?

Yes. Alfalfa and sweet clover require the highest pH, so lime is usually recommended to meet these needs. Corn is quite tolerant to a wide range of soil pH. Some specialty crops, such as potatoes, strawberries, and blueberries, require a low pH because of

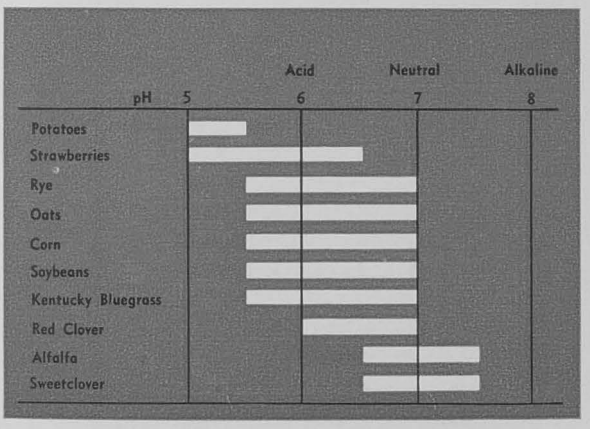

Fig. 1. Suitable pH ranges for various crops.

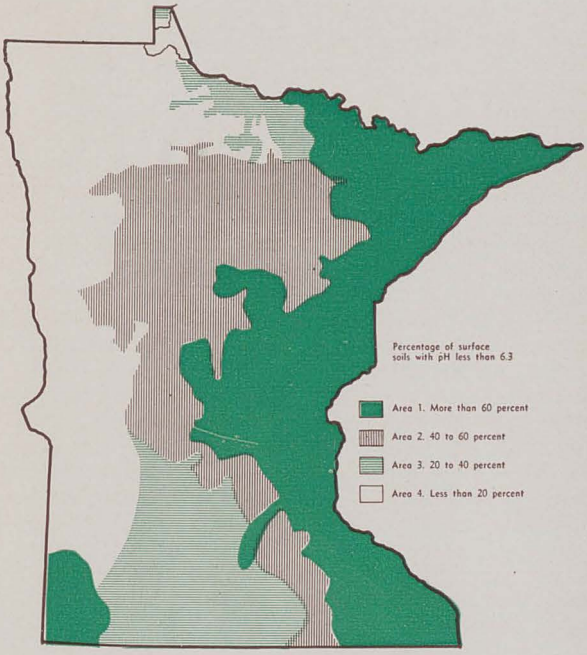

Fig. 2. Areas of lime need in Minnesota.

disease (potato scab) or nutritional problems at high pH levels. On very acid soils, potato growers sometimes apply as little as 200 or 300 pounds of lime per acre. Such applications are intended mainly to furnish calcium and magnesium to the crop and are not sufficient to greatly lower the soil acidity.

Figure 1 shows the pH ranges at which several field crops thrive best on mineral soils. On peat and muck soils a pH of around 6 is usually best.

Lime Needs of Minnesota Soils

The soils of Minnesota can be divided into four general classes according to their liming needs (see figure 2).

Area 1: Strongly acid surface soils. These are mainly eastern Minnesota soils formed on lime-poor parent materials and/or under conditions of higher rainfall. Certain southwestern Minnesota soils formed on lime-rich parent material are also included. Although the latter soils occur in an area of lower rainfall, their high permeability to water movement has left them

acid to varying depths. In places where high lime subsoils are near the surface, liming is more important for starting legume stands than it is for maintaining established stands.

Area 2: Moderately acid surface soils. Some of the subsoils in the northern part of this area may have high lime content at rather shallow depths, even though the surface soils are acid. Such soils may show little response to liming.

Area 3: Acid to neutral surface soils. The need for lime is greatest in the eastern part of the area. It drops off with decreasing rainfall toward the west where many subsoils are well supplied with lime.

Area 4: Neutral to alkaline soils. These occupy a large section of western Minnesota. Soils often contain free lime in the rooting zone which sometimes causes "chlorosis" or yellowing in field crops and ornamentals. Liming is not recommended on these soils.

Which Liming Materials Are Common in Minnesota?

The liming materials most commonly used in Minnesota are:

Ground agricultural limestone may be either calcitic (calcium carbonate) or dolomitic (a mixture of calcium and magnesium carbonates). Most of the limestone quarried in Minnesota is dolomitic. Sandy soils and many peat and muck soils are often poorly supplied with magnesium. In these cases, the magnesium in dolomitic limestone may be beneficial to plants.

Marl is a loose material composed mostly of calcium carbonate, and varying amounts of silt, clay, and organic matter. Minnesota's most extensive marl deposits are in the northern part of the state. The value of marl is determined by its quality and costs of digging, drying, and spreading. Marl contains little or no magnesium.

Blast furnace slag, a by-product of the iron refining industry, is sometimes used in northeastern Minnesota. Unlike limestone and marl, its calcium and magnesium are silicates instead of carbonates. Furnace slag is as effective a liming material as ground limestone of similar quality.

Other, less popular liming materials include **waste lime** (from water softening plants, sugar beet factories, and acetylene plants), **burned lime,** and **slacked lime.**

Table 1. Rates of ground limestone recommended according to soil pH and texture

Soil pH	Lime recommended	
	Loams, silt loams, clay loams, peats, and mucks	Sandy loams and sands
	tons per acre	
6.3	none	none
6.2	none	none
6.0 and 6.1	2.0	2.0
5.8 and 5.9	2.5	2.0
5.6 and 5.7	3.0	2.0
5.4 and 5.5	3.5	2.5
5.2 and 5.3	4.0	2.5
5.1	4.5	2.5
5.0	4.5	3.0
4.5-4.9	5.0	3.0
Less than 4.5	6.0	3.5

What Rates of Lime Are Recommended?

Since most farm crops grow best in the pH range of 6.5 to 7, lime is recommended at rates that will reduce soil acidity to this level. The amount and time of previous lime applications, soil pH, and texture are used to determine how much lime to apply. Table 1 shows the rates of lime recommended by the University of Minnesota Soil Testing Laboratory.

When and How Should Lime Be Applied?

Acid soils in rotations that include a legume crop should receive lime 6 to 18 months before the new legume seeding is established. In other rotations, lime should be applied in the fall. However, it is better to apply at the time of seeding than not at all. In any case, the reasons for "liming on time" (in the fall) are good ones:

(1) *Time* is necessary for lime to dissolve and establish areas of "sweet" soil favorable to the early growth of young plants.

(2) Delivery and spreading problems associated with soft fields and spring road restrictions are often avoided.

(3) Soil samples taken in the summer on fields scheduled for fall liming receive prompt attention by laboratory personnel and county agents.

Lime must be spread uniformly for best results. Make sure that each application strip is lapped sufficiently to avoid alternating good and poor strips in the following year's crop. While this may seem unimportant at first, on large fields it is not unusual for such strips to add up to several acres of poor alfalfa. It is also a good practice to keep trucks off soft fields, since the soil structure can be damaged by the wheels.

Work lime into the seedbed. Discing or harrowing followed by plowing will distribute lime throughout the surface 2 or 3 inches where it will be within easy reach of seedling roots. Be sure to follow this rule: Lime, disc or harrow, then plow. This is especially important on strongly acid soils that are being limed for the first time. Plowing, without first discing the lime into the soil will turn the lime down out of reach of the seedlings. Uneven distribution of lime throughout the plow layer is often the reason why soil pH tests don't show changes 1 or 2 years after lime has been applied.

How Are Liming Materials Valued?

Two things determine the value of agricultural liming materials—purity and fineness-of-grinding. Pure calcium carbonate is used as a standard for other liming materials. The purity or the neutralizing value of a liming material is expressed in terms of its calcium carbonate equivalent (C.C.E.). Pure calcium carbonate has a C.C.E. of 100 percent. Thus, a limestone made up of 95 percent calcium carbonate and 5 percent sand and clay impurities has a C.C.E. of 95 percent. The neutralizing values of other liming materials vary above or below 100 as shown in table 2. Limestones sold to Minnesota farmers generally vary from 80 to 98 percent C.C.E.

Table 2. The neutralizing values of commonly used liming materials

Materials	Neutralizing values
	percent
Calcium carbonate	100
Magnesium carbonate	119
Calcitic limestone	less than 100
Dolomitic limestone	less than 108
Burned lime	less than 179
Hydrated lime	less than 136
Blast furnace slag	less than 96

Table 3. Liming costs in selected Minnesota counties (includes delivery and spreading costs)

County	Area	Cost per ton of limestone: Without Federal cost-sharing	Cost per ton of limestone: With Federal cost-sharing
Dodge	SE	$2.90	$1.45
Watonwan	SC	4.80	2.40
Pipestone	SW	9.00	4.50
Stearns	C	6.40	2.00
Carlton	NE	5.80	2.90
Cass	NC	8.00	2.55

To be effective, limestone must first dissolve in the soil. Because calcium and magnesium carbonates do not readily dissolve, their effectiveness also depends greatly on particle size. Limestone should be ground finely enough so that at least 80 percent will pass through an 8-mesh sieve.

Liming materials sold under the Federal cost-sharing program are inspected and must meet A.S.C. specifications for purity and fineness.

How Expensive Is Liming?

Liming costs include the price of lime, transportation charges from quarry to field, and spreading costs. Since most limestone quarries are in southeastern Minnesota, liming costs vary with the distance from that area. Table 3 shows how these costs differ in the state.

What's Next?

Visit your county extension agent or county A.S.C. office. These folks will explain how, with the aid of Federal cost-sharing, you can get your liming job done this year. While you're there, ask them about local lime producers or vendors who can help you with your supply and spreading needs.

Remember to lime on time—spread lime in the fall on fields to be seeded down to legumes the next spring. Collect soil samples in the summer and send them to the University of Minnesota Soil Testing Laboratory for analysis. For a small fee you will be given information on both the lime and fertilizer needs of your soils and crops.

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