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LIME FOR MICHIGAN SOILS

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Applying lime to agricultural soils can provide farmers with a very good return on investment. Long-term experiments in Michigan and other Great Lakes states indicate that every dollar spent on agricultural lime applied according to soil test recommendations returns $5 to $10. Liming acid soils improves nutrient availability, microbial activity and overall soil productivity. Soil-applied lime neutralizes (or corrects) acidity, a soil chemical condition that affects the growth of crops. Lime also supplies soil with two essential plant nutrients: calcium and magnesium.

Recent soil test summaries indicate that about 10 percent of Michigan's 7.8 million acres of agricultural land need at least 2.5 tons/acre of lime, for a total of 1.95 million tons of lime needed statewide to neutralize soil acidity. Data on actual lime usage for Michigan is not available, but usage is estimated to be less than half of the amount needed. This is enough to neutralize only the acidity produced by annual applications of nitrogen fertilizer.

This bulletin covers the nature of soil acidity, the need and importance of liming the soil to neutralize acidity, comparisons of various liming materials and their neutralizing values, and guidelines for liming soils for crops grown in Michigan.

WHAT IS SOIL ACIDITY?

Although the use of synthetic fertilizers contributes to soil acidity, soil acidification results from the natural leaching of calcium (Ca) and magnesium (Mg) from the soil and the decomposition of plant residues. Positively charged hydrogen ions in the soil solution (water in the soil) and on the surface of clay and organic matter particles that make up the soil contribute to the **active acidity of the soil**. Soil pH is the measure of this active acidity. A pH value below 7.0 is acid, 7.0 is neutral, and above 7.0 is alkaline,

The amount or concentration of active acidity in the soil solution depends on the number of hydrogen ions held by the negatively charged soil particles of clay and organic matter. Hydrogen ions on these soil particle surfaces are known as exchangeable ions because they can be readily replaced by the positively charged ions of elements such as calcium, magnesium or potassium (K). These hydrogen ions are part of the **potential or reserve acidity** of the soil. The process of neutralization occurs because these ions are exchangeable.

Many acid Michigan soils contain considerable numbers of positively charged aluminum ions. Above pH 6.0, most of the aluminum is in inactive forms, but as the soil pH

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decreases below 6.0 toward 5.0, the aluminum becomes increasingly soluble and active. These ions react chemically in the soil to release hydrogen ions into the soil solution. Thus, aluminum is another source of potential acidity that accentuates the rate of soil acidification.

In a liming program, sufficient lime must be applied to neutralize both active and potential acidity. Actually, the *active* acidity in most Michigan soils could be neutralized by less than 1 pound of lime per acre. The remainder of the lime requirement is caused by *potential* acidity. At a given pH level, more lime is needed on fine-textured clayey soils than on coarse-textured sandy soils because the fine-textured soils have more exchangeable hydrogen and aluminum (potential acidity). Soils high in organic matter need more lime than those low in organic matter for the same reason.

WHAT IS LIME?

Chemically, lime is defined as calcium oxide (CaO). In this bulletin and agriculture in general, "lime" is used for a wide range of materials used to increase soil pH. Common lime materials available in Michigan include agricultural limestone (both calcitic and dolomitic), marl, and refuse or byproduct materials such as "sugar beet" lime, "water treatment" lime and other materials.

BENEFITS OF LIME

Liming acid soils has the general benefit of improving the productivity of soils and crop yields. Some additional benefits include:

1. Liming reduces aluminum and manganese availability in the soil to levels that are not harmful to crops.
2. Liming increases the availability of nitrogen (N), phosphorus (P), potassium, magnesium, calcium, sulfur (S), boron (B) and molybdenum (Mo).
3. All commonly used liming materials supply calcium, an essential plant nutrient. Calcium, however, is not commonly deficient in Michigan soils. Dolomitic materials supply both calcium and magnesium. Magnesium is frequently needed on sandy soils.
4. Liming promotes favorable microbial activity for decomposition of crop residues, which increases availability of soil nitrogen and sulfur.
5. Liming promotes better soil structure and tilth because of increased microbial action, increased crop residues from higher crop yields, and chemical effects of decreasing hydrogen ion concentration and increasing calcium and magnesium ion concentrations.
6. Liming promotes longevity of forage legume stands, particularly alfalfa, because it meets the high calcium requirements of these plants. It also increases nitrogen fixation by these legume plants — alfalfa, clover and soybean.

The influence of soil pH on availability of plant nutrients is shown in Figure 1. Note that the width of the bar is related to the availability of the nutrient.

MEASURING LIME NEEDS

Soil testing and applying lime according to soil test results are the first two steps in an effective liming program. Retesting within every 3 to 4 years to monitor changes in the soil pH is also essential.

The lime requirement test used by the Michigan State University soil testing laboratory involves a buffer method called the SMP method. **This method measures both the reserve and active acidity. Some soil testing labs use the Mehlich 3 or the Sikora buffer methods. All are effective in determining the lime needs of mineral soils in the**

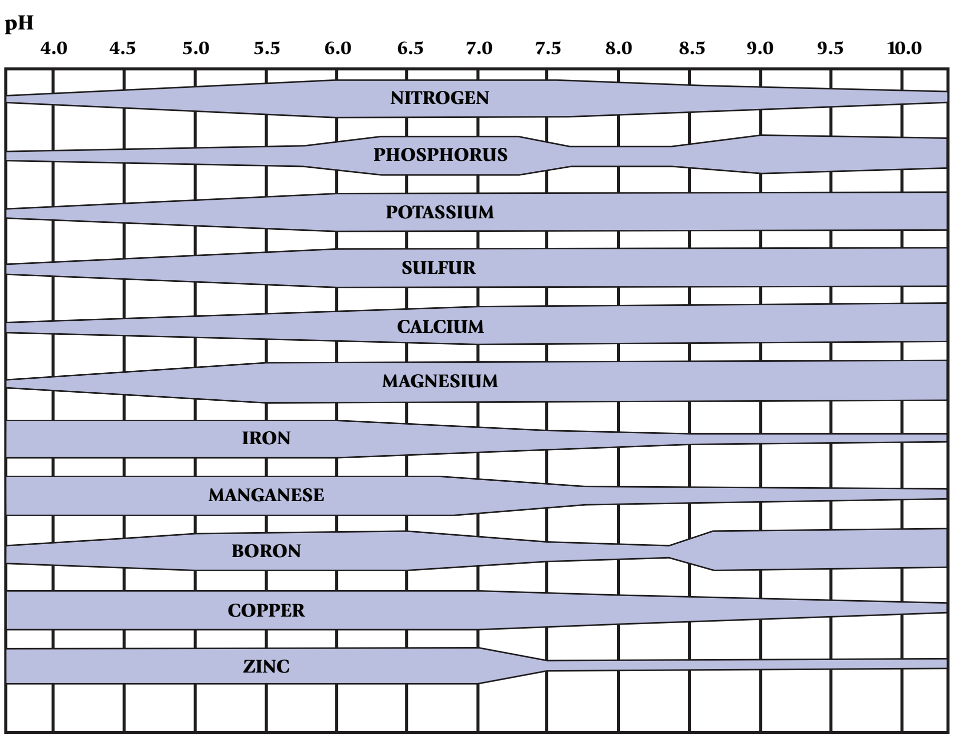

Fig. 1. The general relation of pH to the availability of plant nutrients in the soil: the wider the bar, the more available is the nutrient. (Adapted from Emil Truog, *USDA Yearbook of Agriculture*, 1943-47.)

Great Lakes region. A comparison of the SMP measurement (lime index) and lime requirement is given in Table 1.

In the absence of a lime requirement test based on a buffer method, lime needs can be estimated on the basis of soil pH and texture (Table 2). This method is not as satisfactory as the buffer-lime index system because lime need may be over- or under-recommended.

The SMP buffer method of determining lime requirement tends to fail on soils with a low buffering capacity (low cation exchange capacity). This situation is easily recognized from soil test results. The conditions are as follows: a sand or loamy sand soil texture (soil management group 4 or 5); soil pH suggests that lime should be applied; and lime index indicates that less than 1 ton of lime is needed when soil pH is 0.3 to 0.5 pH unit below the target pH or lime index indicates less than 2 tons of lime are needed when soil pH is 0.6 unit or more below the target pH. If all three conditions exist, the SMP buffer method has likely underestimated lime need. Apply 1 ton of lime per acre if soil pH is 0.3 to 0.5 pH unit below the target pH when the lime index indicates that the lime need is less than 1 ton per acre. Apply 2 tons per acre if soil pH is 0.6 unit or more below target pH when the lime index indicates that the lime need is less than 2 tons per acre.

Adjust lime rate for tillage depth. Lime recommendations made by the MSU Soil and Plant Nutrient Lab assume a 9-inch tillage depth. Recommendations from other labs may be for an 8- inch tillage depth. Some tillage tools will effectively mix surface-applied lime to only one-half or two-thirds of the total tillage depth. To adjust the lime rate for the effective tillage depth, divide the recommended amount of lime (MSU recommendation) by 9 and multiply this number by the effective tillage depth. For example, if the MSU lime recommendation is 4.5 tons per acre and the effective tillage depth is 7 inches, then the lime recommendation will be (4.5/9) x 7 = 3.5 tons per acre.

Table 1. Tons of limestone needed on mineral soils to raise pH to 6.0, 6.5 or 6.8 as determined by the lime index (SMP buffer) method on the basis of 90% neutralizing value.

	Mineral soils			Organic soils	
	Desired soil pH			Initial	Raise pH
Lime index	**6.0**	**6.5**	**6.8**	**soil pH**	**to: 5.3**
	—tons lime per acre*—				tons lime/a
70………	—	—	0.0	5.3	0.0
69………	—	0.6	0.8	5.2	0.7
68………	1.2	1.6	1.8	5.1	1.4
67………	1.9	2.5	2.9	5.0	2.1
66………	2.7	3.5	3.9	4.9	2.8
65………	3.5	4.4	4.9	4.8	3.5
64………	4.3	5.3	5.9	4.7	4.2
63………	5.1	6.3	6.9	4.6	4.9
62………	5.8	7.2	8.0	4.5	5.6
61………	6.6	8.2	9.0	4.4	6.3
60………	7.4	9.1	10.0	4.3	7.0

*To convert lime recommendations to depth of incorporation other than 9 inches, divide rates by 9 and multiply by the depth of plowing. The maximum suggested lime recommendation for one season is 6 tons. The maximum suggested recommendation for one application is 4 tons. (See text.)

Table 2. Tons of limestone required, as estimated from soil pH and texture, to raise the pH of a 9-inch tillage zone to pH 6.5. Add ¾ ton per acre to raise soil pH to 6.8.

		Soil pH range			
Texture of plow layer	**Soil management group**	**4.5 to 4.9**	**5.0 to 5.4**	**5.5 to 5.9**	**6.0 to 6.4**
		—Tons of lime recommended*—			
Clay and silty clay	1	8	6¾	5½	3½
Clay loams or loams	2	6¾	5½	4	2¾
Sandy loams	3	5½	4	3½	2
Loamy sands	4	4	3½	2¾	1½**
Sands	5	3½	2¾	2	¾**

*Lime recommendations based on a liming material having 25% passing through a 100-mesh sieve and having a neutralizing value of 90.

** Applying 2 tons per acre will allow more uniform application and justify the expense of application. Overapplying lime to this degree on these soils will not generally cause any agronomic problems.

HOW AND WHEN TO LIME

The maximum lime recommendation in any season is 6 tons per acre on mineral soils. The soil should be retested for additional lime needs in 2 years if the lime index is less than 65 (see Table 1). The maximum suggested rate in one application is 4 tons per acre because it is difficult to mix larger amounts thoroughly with the soil. When larger amounts are needed, it is best to use split applications. One-half to two-thirds of the requirement should be applied and incorporated with a primary tillage implement. The remainder should be applied and worked into the soil a few months later.

The equipment used for spreading lime should spread the material evenly. If possible, the lime should be applied and worked into the soil 6 months to 1 year before planting crops with high lime requirements. It takes time for the lime to neutralize the soil acidity and raise the soil pH. Where alfalfa and other forage legumes are included in the crop sequence, it is important to apply needed lime at least 6 months before seeding. The best time for this application is late summer or early fall preceding primary tillage rather than in the spring because there is less hazard of excess soil compaction by spreading equipment in the fall.

CROP GUIDELINES

Crops vary in their tolerance of soil acidity. The soil pH ranges in which crops grow best are given in Table 3. A few plants require strongly acid soils, but most others require a higher pH. When crops are grown in rotation, apply lime for the most pH-sensitive crop. Below are some special considerations.

On established sod that is predominantly grass (pastures, hayfields) and is not to be reseeded for several years, topdress with lime only if the pH is less than 5.8, using not more than 2 tons per acre. For established legume hayfields, especially alfalfa, apply 2 tons of lime per acre as needed to prevent the soil pH from falling below 6.0. When these fields are to be taken out of pasture or hay, test the soil and apply the required amount of lime before primary tillage.

For potatoes, adjust pH to 6.0. If there is no history of scab, and if scab-tolerant varieties are grown, consider liming to pH 6.5. Do not apply more than 2 tons per acre at one time to reduce the possibility of scab. Apply lime well ahead of growing potatoes — for example, apply lime immediately after harvest of the previous crop to allow time for the lime to react before the next crop of potatoes is grown. If potatoes are not the primary crop in the rotation, it may be best to lime for optimum production of the primary crop or crops.

No-till corn and soybean production presents some unique pH adjustment challenges. Soils in no-till corn production may develop an acid layer in the 2 to 3 inches just below the surface, especially if the nitrogen is applied on the surface. This condition reduces the effectiveness of some herbicides. Annual or every-other-year application of 0.5 to 1 ton of lime per acre is often necessary to maintain a favorable surface soil pH. Check the pH of the top 3 inches annually. Even when nitrogen is placed down in the soil, application of 1 ton of lime per acre every 2 to 3 years may be necessary to maintain a favorable pH in the active root zone. It may not be economical to apply only 1 ton per acre, however, so the other option is to apply more (usually near 2 tons per acre) less frequently. Another approach is to apply half the amount of lime recommended on the basis of a 0- to 8-inch soil test. The effects of surface-applied lime will gradually move downward.

Crops grown on organic soils do not benefit from liming above a soil pH of 5.3 except for celery, which requires a soil pH near 5.8. Blueberries benefit from lime only when the pH falls below 4.0; then apply 4 tons per acre. Recommended lime rates given in Table 4 are intended to raise organic soil pH to near 5.3. Some organic soils have acid subsoils; others have alkaline subsoils. Because some of this material may be brought to the surface during plowing or primary tillage, take soil samples to the planned plow depth for determining lime needs.

For lawns, check the pH of the 0- to 3-inch soil depth.I If it is below 5.5, topdress at a rate of 25 to 50 pounds of finely ground lime per 1,000 square feet. When establishing a lawn, test the soil and apply lime at the recommended rate, mixing it into the soil before seeding.

TYPES OF LIMING MATERIALS

Calcitic Limestone

Calcitic limestone, sometimes called high-calcium limestone or calcic limestone, contains less than 5 percent magnesium. With the exception of limestone quarried in Monroe County, most of the agricultural limestone produced in the Lower Peninsula of Michigan is calcitic limestone.

Dolomitic Limestone

Dolomitic limestone contains appreciable amounts of magnesium carbonate. That being marketed in Michigan contains 15 to 45 percent magnesium carbonate; the remaining

Table 3. Desirable soil pH ranges for various crops grown on mineral soils.

Least acid-tolerant		**Medium acid-tolerant**		**More acid-tolerant**	
Alfalfa	6.3 to 7.8	Corn	5.5 to 7.5	Buckwheat	5.0 to 7.0
Asparagus	6.0 to 8.0	Grasses	5.5 to 7.5	Oats	5.0 to 7.0
Barley	6.5 to 7.8	Trefoil	5.5 to 7.0	Potatoes	5.2 to 6.5
Beans	6.0 to 7.5	Wheat	5.5 to 7.0	Raspberries	5.0 to 7.0
Peas	6.0 to 7.5			Rye	5.0 to 7.0
Red clover	6.0 to 7.5	**Strongly acid soils required**		Strawberries	5.0 to 6.5
Soybeans	6.0 to 7.0	Blueberries	4.0 to 5.1	Vetch	5.0 to 7.0
Sugar beets	6.0 to 7.5	Cranberries	4.2 to 5.0		
Sweet clover	6.5 to 7.8				

Table 4. Correction factor (CF) for neutralizing values other than 90. Multiply the CF times the recommended rate to determine the amount of material of a different neutralizing value to apply.

Neutralizing value or ECC	Correction factor*
140	0.64
130	0.69
120	0.75
110	0.80
100	0.90
90	1.00
80	1.12
70	1.29
60	1.50

*Ninety divided by the neutralizing value gives the correction factor.

85 to 55 percent is largely calcium carbonate. Practically all of the agricultural hydrated lime being used in Michigan is made from dolomitic limestone and is called dolomitic hydrate. There is no evidence to suggest that dolomitic limestone has any detrimental effect if used where magnesium is not limiting.

Magnesium (Mg) concentration is expressed as percent magnesium carbonate ($MgCO_3$) in the analysis report on limestone materials but is expressed as the element in fertilizer recommendations and soil test reports. To convert from $MgCO_3$ to Mg form, multiply the percent $MgCO_3$ by 0.29. For example, a dolomitic limestone having 30 percent $MgCO_3$ contains 8.7 percent Mg or 174 pounds elemental Mg per ton (0.30 x 0.29 x 2,000).

Magnesium deficiency may occur in acid soils that have a sandy loam, loamy sand or sand plow layer with a subsoil as coarse or coarser in texture than the plow layer. Application of calcitic limestone or marl to these soils may induce a magnesium deficiency. Responsive crops are cauliflower, muskmelon, celery, tomato, potato, pea, oat, wheat and rye.

Magnesium is recommended whenever one of the following three conditions exist: the exchangeable magnesium level is less than 35 ppm on coarse-textured soils and less than 50 ppm on fine-textured soils, or Mg is less than 3 percent of the total exchangeable bases (calcium plus magnesium plus potassium [K] expressed as milliequivalents per 100 grams of soil), or the percent K is greater than the percent Mg on an equivalence basis.

At least 1,000 pounds of dolomitic limestone should be applied on acid soils where magnesium is needed. (For further information on magnesium fertilization, see Extension bulletin E-2904, "Nutrient Recommendations for Field Crops in Michigan.")

Marl and Refuse Lime

Marl and refuse lime are satisfactory liming materials if applied in conformity with the lime contents and spread evenly. Marl consists of calcium carbonate, clay and organic matter. "Refuse lime" is a broad term that describes liming materials produced as byproducts of industry. In Michigan, commonly used refuse lime materials include ***sugar beet lime and water treatment lime***. Many of these materials have settled out of water charged with lime, are made up of very fine particles and may present some problems in spreading.

Under the Michigan Lime Law, marl and refuse lime materials are sold and guaranteed on the basis of the number of pounds of calcium carbonate equivalent per cubic yard. (This term is explained in the section on effectiveness of lime materials.) Michigan marl averages about 3.5 percent magnesium carbonate.

Marl and refuse liming materials are sometimes applied on the basis of 2 cubic yards being equivalent to 1 ton of limestone. but more than two-thirds of the marl now being applied tests between 1,200 and 1,800 pounds of calcium carbonate equivalent per yard. This suggests that using a general guide may result in overliming soils.

FORMS OF LIME

Lime Suspensions

"Lime suspensions," "liquid lime" and "fluid lime" are all names for a system of suspending lime in a fluid (water or liquid fertilizer) for delivery to the field. **There is nothing special about the liming effectiveness of lime suspensions**. The principles of neutralization of soil acidity are the same for lime suspensions as they are for dry liming materials.

The limestone used in suspensions is usually finer than 100-mesh. It is suspended in water or liquid fertilizers (water is most commonly used) with a dispersing agent and clay as the suspending agent. Typically, suspensions contain 50 to 75 percent liming material, 0.5 to 5 percent clay and a small amount of dispersing agent; the remainder is liquid fertilizer or water. Nitrogen fertilizer solutions are used as well as nitrogen-potassium and sulfur-containing solutions. Fertilizers containing phosphorus should not be used. Lime solutions containing appreciable amounts of calcium oxide (CaO) should not be used with nitrogen solutions containing urea as it enhances volatile nitrogen loss.

Lime suspensions have the following advantages.

1. They react faster than coarser materials.
2. They can be combined with N, K and S fertilizer solutions.

3. They pose no dust problem during application.
4. It is easy to apply them uniformly.
5. Renters favor them because of their fast reaction. (The effect is quick but short-term.)

Lime suspensions have the following disadvantages:

1. They may have to be applied annually.
2. They may cost more in the long term.
3. They cannot be used with phosphorus fertilizer.
4. Large pH changes are not possible when small quantities are applied.
5. Application in combination with herbicides is not recommended.

Pelletized Lime

Pelletized lime consists of very fine calcitic or dolomitic limestone formed into pellets with a soluble binding agent. Nearly all of the limestone particles pass a 100-mesh sieve and 25 to 40 percent can pass a 200-mesh sieve. There is nothing special about the effectiveness of pelletized lime. It is chemically the same as traditional agricultural lime and neutralizes soil acidity the same way.

Pelletized lime has the following advantages:

1. It is a source of high quality lime.
2. It can be blended with fertilizers for row or broadcast application.
3. It spreads uniformly.

Pelletized lime has the following disadvantages:

1. It is more expensive than traditional calcitic or dolomitic limestone.
2. When applied at the same rate, it does not change pH any more quickly than regular agricultural calcitic or dolomitic limestone.
3. The liming effect is localized in the area around the granule or pellet.

LIME MATERIALS COMPARED

A standard is needed when comparing the effectiveness of lime materials because a pound of one kind of lime does not necessarily equal a pound of a different kind of lime. There are differences among states in terminology and methods used to compare liming materials. In Michigan, the standard used to compare the effectiveness of lime materials is effective calcium carbonate (ECC), which is based on purity and fineness of material.

Purity

Because calcium carbonate ($CaCO3$) is the most common ingredient in limestone, it is used as a standard of comparison. Pure calcium carbonate is given a neutralizing value of 100 (chemically the formula weight is 100 g/mol, $MgCO_3$ = 84) (see Table 5). A calcitic limestone with 98 percent calcium carbonate, 1 percent clay and 1 percent sand has a neutralizing value of 98. The neutralizing value of liming materials varies above and below 100 as the capacity to neutralize acidity varies from that of calcium carbonate. The relative neutralizing value of pure $MgCO3$ is 119 (100/84) (see Table 5).

The lime recommendations given in Tables 1 and 2 are for a lime material with a neutralizing value of 90. If the material used has a neutralizing value greatly different from 90, the amount should be adjusted. Table 4 can be used for this purpose. For example, if the recommended rate was 4 tons and the neutralizing value of the available liming material was 80, the amount of that material to apply would be 4.5 tons (90/80 times 4 tons). Ground limestone materials sold in Michigan usually range in neutralizing value from 80 to 103 percent. High grade limestone (hydrated) materials may run as high as 130. Table 5 gives neutralizing values for some lime materials.

The expression "calcium carbonate equivalent" has a similar meaning to "neutralizing value". Neutralizing value (NV) refers to the ability of a lime material to neutralize soil acidity relative to pure calcium carbonate and is expressed as a percentage. Calcium carbonate equivalent (CCE) refers to the equivalent amount (in pounds) of pure calcium carbonate in a ton or cubic yard of lime material. If a lime material has a NV of 85, it will have a CCE of 1,700 pounds per ton. Marl is commonly sold on a volume basis. Therefore, if a cubic yard of marl has a calcium carbonate equivalent of 1,240 pounds, this means that a cubic yard of marl will neutralize the same amount of acidity as 1,240 pounds of pure calcium carbonate. For materials sold on a volume basis, the bulk density of the material is taken into consideration by the analytical lab when determining the CCE.

Table 5. Neutralizing value (percent) of various liming materials compared with pure calcium carbonate.

Material	Neutralizing value
Calcium carbonate (pure)	100
Magnesium carbonate (pure)	119
Calcium hydrate (pure)	135
Magnesium hydrate (pure)	172
Calcitic limestone (agricultural grade)	70-95
Dolomitic limestone (agricultural grade)	95-108
Calcitic hydrated lime	up to 135
Dolomitic hydrated lime	up to 172
Sugar beet or water treatment lime	80-90

Fineness

Liming materials react at different rates because of their chemical composition, their hardness and the fineness to which the materials are ground. The finer the material, the more surface area it has and the more quickly it will react when thoroughly mixed with the soil. Fineness of grind can be controlled more easily than chemical composition or hardness, so this property usually affects the rate of reaction more than the other two. Figure 2 shows the availability of limestone as affected by mesh size (8-mesh is approximately 1/8 inch). For agricultural use, limestone should be ground so that practically all the material passes through an 8-mesh sieve, with all the fine material retained in the product.

A fineness factor allows comparison of the effectiveness of materials that are different in fineness of grind and neutralizing value. To calculate the fineness factor, multiply the percent material coarser than 8-mesh times 0 (0 percent effective), the percent material between 8- and 60-mesh times 0.50 (50 percent effective) and the percent material finer than 60-mesh times 1 (100 percent effective). Add these values to obtain the fineness factor.

A new number, called "effective calcium carbonate" (ECC), takes into account both the neutralizing value (NV) and the fineness factor (FF). It is calculated by multiplying the neutralizing value by the fineness factor.

In the example in Table 6, the two samples have the same ECC but different neutralizing values and sieve analyses. The calculated ECC value can be substituted for neutralizing value (NV) in Table 4 to adjust lime rates.

Adjust rate for tillage depth:

Price Comparison

Price is an important consideration in choosing liming material because ***the same amount of ECC is required to neutralize a given amount of soil acidity regardless of the lime source***. To compare the cost of liming materials, divide the percent ECC by 100, then multiply by 2,000. This gives pounds of ECC per ton of material. The price of the material (per ton) divided by ECC (pounds per ton) gives dollars/pound/ECC. An example of this is shown in Table 7.

LIME LOSSES FROM THE SOIL

The effectiveness of lime is gradually expended over time because of reaction with soil acidity at the time of application and acidity that develops from application of nitrogen fertilizers, decomposition of organic residues and rainfall. Removal of calcium and magnesium by leaching and crop removal also contributes to reducing the longevity of the applied lime. After lime is applied, the soil pH will typically increase during the first 1 to 2 years and then plateau. The length of time that the pH stays relative stable will vary with the nature of the lime material applied, soil type, pH of the subsoil, crop rotation, nitrogen application, rainfall and perhaps other factors. When intensive fertilization is practiced, soil pH levels may drop more rapidly. Limed fields should be retested for soil pH within 3 to 4 years after application.

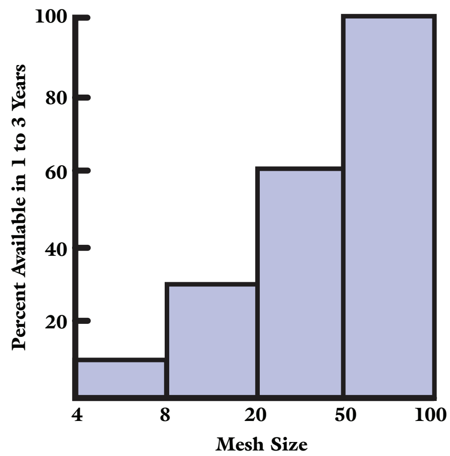

Fig. 2. The relative availability of ground limestone as influenced by mesh size.

EFFECT OF FERTILIZERS

Present fertilizer practices increase crop yields and thereby increase the removal of calcium and magnesium. In addition, many fertilizers leave an acidic residue in the soil. Table 8 gives the amount of lime (as pounds of calcium carbonate) required to neutralize the acidity formed from 1

Table 6. Example calculation of the effective calcium carbonate (ECC) for two lime sources with different analyses.*

Component or factor	Sample A	Sample B
Neutralizing value	90	100
Sieve analysis		
Coarser than 8-mesh (%)	2	10
8- to 60-mesh (%)	18	20
Finer than 60-mesh (%)	80	70
Calculated fineness factor		
% coarser than 8-mesh X 0 (0% effectiveness)	0	0
% 8- to 60-mesh X 0.5 (50% effectiveness)	9	10
% finer than 60-mesh X 1 (100% effectiveness)	80	70
Fineness factor	89	80
% ECC = fineness factor X (neutralizing value/100)	80	80

*The ECC can be substituted for neutralizing value in Table 4.

Table 7. Example calculation of the price comparison of two lime sources with different prices and ECCs.

Component or factor	Sample A	Sample B
Price of material in dollars per ton	$25	$30
% ECC	75	85
Pounds of ECC per ton = (ECC/100) X 2,000	1500	1700
Dollars/100 lb ECC = price per ton/ 100 lb ECC per ton	1.67	1.76

Table 8. Amount of lime ($CaCO_3$) required to neutralize the acidity produced by 1 pound of nitrogen from various sources.

Nitrogen source	Amount of lime
	lb lime/1 lb N
Ammonium nitrate	1.8
Anhydrous ammonia	1.8
Urea	1.9
Nitrogen solutions	1.8
Diammonium phosphate	4.3
Ammonium sulfate	5.2

pound of nitrogen for each of the various nitrogen fertilizers. The differences between these sources of nitrogen are not great enough to justify selection of any particular nitrogen source because the cost of lime is less than the differences in the cost of various nitrogen sources. These effects should be recognized, however, so that lime can be applied when needed.

MICHIGAN LIME LAW

The Michigan Lime Law is a labeling act designed to protect both the users and the producers of lime. It requires that all agricultural materials offered for sale in Michigan be licensed with the Michigan Department of Agriculture each year.

With each sale of lime, the purchaser is provided a written statement with the name and address of the person responsible for placing the commodity on the market, the name of the material, the net weight of the lime, the neutralizing value and the percentage of lime passing 8-, 60- and 100-mesh screens.

For marl and refuse limes, the volume (cubic yards) and test value expressed as pounds of calcium carbon equivalent per cubic yard are to be stated in place of the neutralizing value and screen size information.

A delivery of lime is ready for application.