UMC
Science and Technology
GUIDE
Published by the University of Missouri - Columbia Extension Division
EXTENSION CONTINUING EDUCATION The State is the Campus

PLANT NUTRITION SERIES

Corrective Liming of Missouri Soils

R.G. Hanson
Department of Agronomy
College of Agriculture

Correcting soil acidity by liming should be the first step in proper fertility practices to increase profitable crop production. Liming your soil according to soil test recommendation will:

- Decrease soil acidity to desired level.
- Improve efficiency of other plant nutrients.
- Reduce availability of elements toxic to plants.
- Provide a proper cation balance of calcium and magnesium.
- Promote desirable bacterial activity.
- Help improve structure and tilth of some soils.

Lime needs are best determined by having a properly collected soil sample analyzed by a University of Missouri soil testing laboratory. Soil testing services are offered through University Extension Centers as well as through various agricultural industry dealers. Corrective lime recommendations based on soil test use the following analyses in calculating such recommendations:

- pH_s - acidity in salt solution
- N.A. - total neutralizable acidity
- Exchangeable calcium and magnesium
- C.E.C. - cation exchange capacity

Lime requirements are suggested in Missouri by crop and by soil region according to where the field sampled is located in the state, as shown in the soils regions map in Figure 1. In general terms, soils in regions 5, 6, 7 and 8 (south and southwest Missouri) have acid subsoils, and more lime is recommended there than in the other areas of the state.

Area No.	Soils
1	Knox, Marshall & associated soils
2	Grundy, Shelby
3	Putnam, Mexico, Lindley
4	Menfro, Winfield
5	Oswego, Parsons, Cherokee, Bates
6	Baxter, Craig
7	Clarksville, Lebanon
8	Union
9	Waverly
10	Dexter
11	Sharkey
12	Sarpy

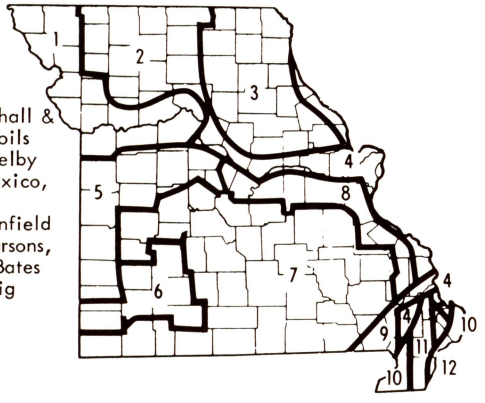

Figure 1. Associated Soil Areas of Missouri

pH_s Indicates When Lime Is Needed

The optimum pH_s (salt pH) desired for crop production, as indicated above, will vary by soil region and the crop to be grown. Three basic categories are used in selecting lime recommendations for your soil: (1) fields to be planted to alfalfa when soil pH_s is below 6.6 in soil regions 5, 6, 7 and 8; (2) row crops over the entire state for legume-grass and grass-forages in regions 5, 6, 7 and 8 when soil pH_s is below 6.1; and (3) legume and legume-grass mixtures in north and southeast Missouri.

These desired pH_s ranges are shown in Figures 2, 3 and 4, which illustrate the relationship between desired soil pH_s by crop and by soil regions within Missouri.

Determine Lime Requirements

The soil pH_s will determine when lime will be required. Another step is required to determine the quantity of liming material required to increase the soil pH_s into the desired range. A buffer method is used to determine the quantity of soil acidity, referred to as *neutralizable acidity* (N.A.). This is expressed in *milliequivalents* (me) of *neutralizable acidity* per 100 grams of soil.

The University of Missouri soil test reports provide corrective lime recommendations in pounds per acre of required effective neutralizing material (E.N.M.). This is determined by crop and soil region using pH_s and me of neutralizable acidity (N.A.). These are provided in Tables 1, 2 and 3.

For example when desiring to plant soybeans on soil that has a pH_s test of 5.2 and 7.0 me of N.A., using Table 2 it can be seen that 2,221 lbs/A of effective neutralizing material would be required to decrease soil acidity to a desired level.

Liming Material Quality Determines Quantity Necessary

The standard used for determining the capacity of a liming material to neutralize excess soil acidity (Liming Material Quality) are (1) purity and (2) fineness of grind. Therefore, the effectiveness of liming materials can vary considerably.

As defined in the Missouri Agricultural Liming Materials Act of 1976, "Agricultural Liming Materials" are those materials containing calcium or calcium and magnesium in the carbonate, oxide or hydroxide form or a combination thereof, which are capable of neutralizing soil acidity and supplying plant nutrients, and shall have minimum specification of ninety (90) per cent of the material passing through a United

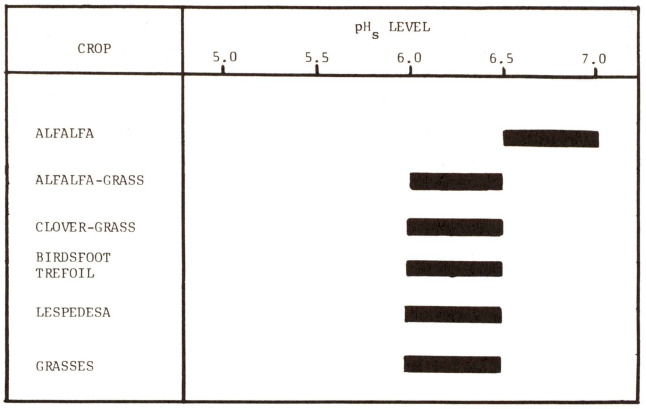

Figure 2. Recommended Soil pH$_s$ for Forage Crops in South and Southwest Missouri Soil Regions 5, 6, 7 and 8

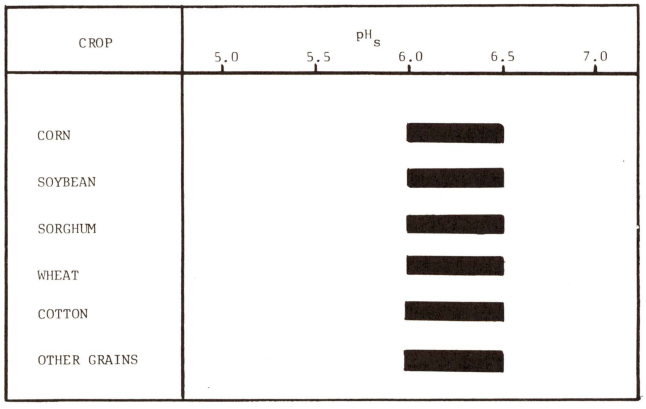

Figure 3. Recommended Soil pH$_s$ for the Common Row Crops in Missouri

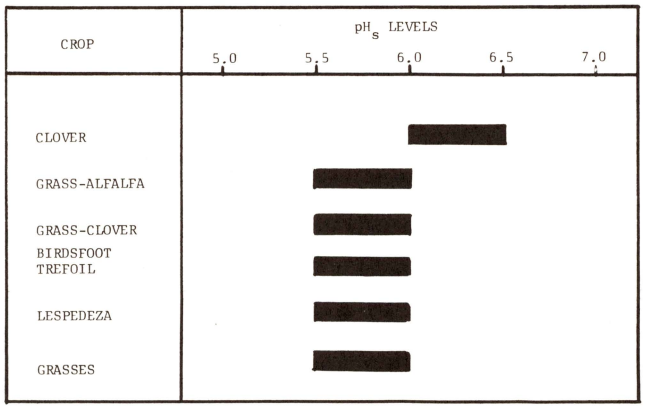

Figure 4. Recommended Soil pH$_s$ for Common Forage Crops in North and Southeast Missouri Soil Regions 1, 2, 3, 4, 9, 10, 11 and 12

TABLE 1

Desired pH$_s$ 6.6-7.0

Soil Regions 5-6-7-8

Crops: Alfalfa or more than 1/3 Alfalfa in alfalfa-grass stands.

Effective Neutralizing Material* suggested for different soil test amounts of Neutralizable Acidity (N.A.) when pH$_s$ is below 6.6.

Soil Test Me. N.A.	Lbs /A ENM*
1.0	400
2.0	800
3.0	1200
4.0	1600
5.0	2000
6.0	2400
7.0	2800
8.0	3200
10.0	4000

Calculation

ENM = N.A. x 400

TABLE 2

Desired pH$_s$ 6.1-6.5

Crops	Soil Regions
All grains, cotton, tobacco -----	All
Alfalfa or more than 1/3 alfalfa in mixtures----------	All but 5-6-7-8
Clovers or more than 1/3 clover in mixtures----------	All
Birdsfoot trefoil, lespedeza, grasses----------	5-6-7-8

Effective Neutralizing Material suggested for different soil test values of neutralizable acidity and pH$_s$ when pH$_s$ is below 6.1.

	Lbs /A Effective Neutralizing Material (ENM)* pH$_s$					
Soil Test Me. N.A.	4.0	4.4	4.8	5.2	5.6	6.0
1.0	361	352	338	317	283	220
2.0	722	703	676	635	567	441
3.0	1083	1055	1014	952	850	661
4.0	1444	1406	1352	1269	1134	882
5.0	1805	1758	1690	1587	1417	1102
6.0	2166	2109	2028	1904	1701	1322
7.0	2527	2461	2365	2221	1984	1543
8.0	2888	2812	2703	2538	2267	1763
9.0	3249	3164	3041	2856	2551	1983
10.0	3610	3515	3379	3173	2834	2204

Calculation:

$$ENM = 400 \times \left(N.A. - \frac{Me.\ N.A.}{41.425 - 10.307 \times pH_s + 0.629 \times pH_s^2}\right)$$

*Use 100 in case calculation is > 0 but < 100.

TABLE 3

Desired pH_S 5.6-6.0
All Soil Regions except 5-6-7-8

Crops

Grasses
Grass-alfalfa or clover-grass with less than 1/3 legume.
Birdsfoot trefoil-grass
Lespedeza-grass

Effective Neutralizing Material suggested for different soil test values for Neutralizable Acidity and pH_S when pH_S is below 5.6.

N.A.	Lbs /A Effective Neutralizing Material (ENM)* pH_S				
	4.0	4.4	4.8	5.2	5.5
1.0	314	298	262	216	162
2.0	628	586	524	431	324
3.0	942	878	787	647	487
4.0	1256	1171	1049	863	649
5.0	1570	1464	1311	1078	811
6.0	1884	1757	1573	1294	973
7.0	2198	2049	1835	1509	1136
8.0	2512	2343	2097	1725	1298
9.0	2826	2635	2360	1941	1460
10.0	3140	2928	2622	2156	1622

Calculation:

$$ENM = 400 \times \left(N.A. - \frac{Me.\ N.A.}{19.109 - 4.802 \times pH_S + 0.297 \times pH_S^2}\right)$$

*Use 100 in case ENM is > 0 but < 100.

TABLE 4

Pounds Effect Neutralizing Material (E. N. M.) Index Per Ton of Liming Materials

Per cent Calcium Carbonate Equivalent (% C. C. E.)	% Passing U. S. No. 40 Sieve						
	65	60	55	50	45	40	35
100	500	467	433	400	367	333	300
95	475	444	412	380	348	317	285
90	450	420	390	360	330	300	270
85	425	397	368	340	312	283	255
80	400	373	347	320	293	267	240
75	375	350	325	300	275	250	225
70	350	328	305	281	257	235	211

Equation:

$$\text{E. N. M. Index (lbs/Ton)} = \frac{\%\ \text{C. C. E.}}{100}\left[66.67 + 6.67\ (\%\ \text{passing U. S. no. 40 sieve})\right]$$

Determine per cent of calcium carbonate equivalent (C. C. E.) in the limestone being considered and the per cent that will pass a U. S. No. 40 sieve. Divide the indicated E. N. M. Index in this table into the E. N. M. required from your soil test report. Obtain the tons of liming material required per acre. In this example, divide 390 into the required E. N. M. indicated on your soil test report for corrective lime needed in tons/acre.

States standard number eight sieve, thirty-five (35) per cent passing a United States standard sieve size number forty (40), and shall have a minimum calcium carbonate equivalent of seventy (70) per cent.

The laboratory analyses for purity of liming materials are expressed as calcium carbonate equivalent (C.C.E.). This, coupled with fineness of grind, is used to determine the effective neutralizing value, which is an index measurement referred to as Effective Neutralizing Material (E.N.M.). The E.N.M. index of the liming material is used to calculate the tons per acre to apply.

Table 4 can be used to calculate the quantity of liming material, according to quality, required to increase the soil pH_s into the desired range. For example, the soil requiring 2,221 lbs/A of E.N.M. would need an application of about 5.7 tons per acre of a liming material with 90 per cent C.C.E. and 55 per cent passing a 40 mesh sieve, because the E.N.M. index of this liming material is 390 (2221 ÷ 390 = 5.7 T/A).

Because of "no-till" and many other new soil conservation tillage methods now used in Missouri, no correction for plow depth will be calculated. Recommendations for required E.N.M. will be based on a 7-inch depth.

Corrective Magnesium Requirements and Effective Magnesium

Corrective magnesium is suggested when soil analyses report a per cent magnesium saturation of less than 5.1 per cent of the cation exchange capacity. The quantity of magnesium necessary to correct for low exchangeable magnesium will be reported as effective magnesium (E.Mg.). A soil magnesium saturation of 5.1-9.9 per cent is less than desired, and recommendations will be made to increase the per cent saturation to the level of 10 per cent.

Visual magnesium deficiencies are not likely to occur when the magnesium saturation exceeds 5 per cent, but mineral imbalances with some forages may occur on soils with less than 10 per cent magnesium saturation.

Application of liming materials containing magnesium will be the most economical way to correct for low soil magnesium. The per cent of magnesium and fineness of grind are used to calculate the pounds of effective magnesium (E.Mg.) per ton of liming material, which is also an index number. The quantity of any particular magnesium liming material necessary to correct soils low in exchangeable magnesium is then determined using this E.Mg. index.

Table 5 illustrates the variation in E.Mg. index of liming materials in relationship to per cent magnesium and fineness of grind. This table also serves to calculate the tons of a magnesium liming material required to supply a deficiency in exchangeable magnesium.

For example, suppose the effective magnesium requirement (E.M.) based on soil test is for 162 lbs/A, and a liming material contains 7.2 per cent Mg. and had 55 per cent enough to pass a U.S. No. 40 sieve. The quantity of this liming material required would be 2 tons per acre, because the E.Mg. index for this material is 81 (162 ÷ 81 = 2 T/A).

TABLE 5

Pounds of Effective Magnesium (E. Mg.) Per Ton Liming Material

Per cent Magnesium (Mg) in Material	% Passing U. S. No. 40 Sieve						
	65	60	55	50	45	40	35
13.2	172	161	149	138	126	115	103
11.5	150	140	130	120	110	100	90
10.1	132	123	114	105	97	88	79
8.6	112	105	97	90	82	75	67
7.2	94	88	81	75	69	63	56
5.7	74	69	64	59	55	50	45
4.3	56	52	49	45	41	37	34
2.8	37	34	32	29	27	24	22
1.4	18	17	16	15	13	12	11

Equation:

$$\text{E. Mg. Index (lbs/T)} = \frac{\%\ \text{Mg.}}{11.5}\ [20 + 2\ (\%\ \text{passing U. S. 40 sieve})]$$

Determine per cent magnesium and the per cent that will pass a U. S. Number 40 sieve. Your liming materials distributor should provide this information. In this example, divide the E. Mg. Index shown here (81) into the required effective magnesium (E. M.) under corrective lime needs of your soil test report to calculate tons/acre of material needed.

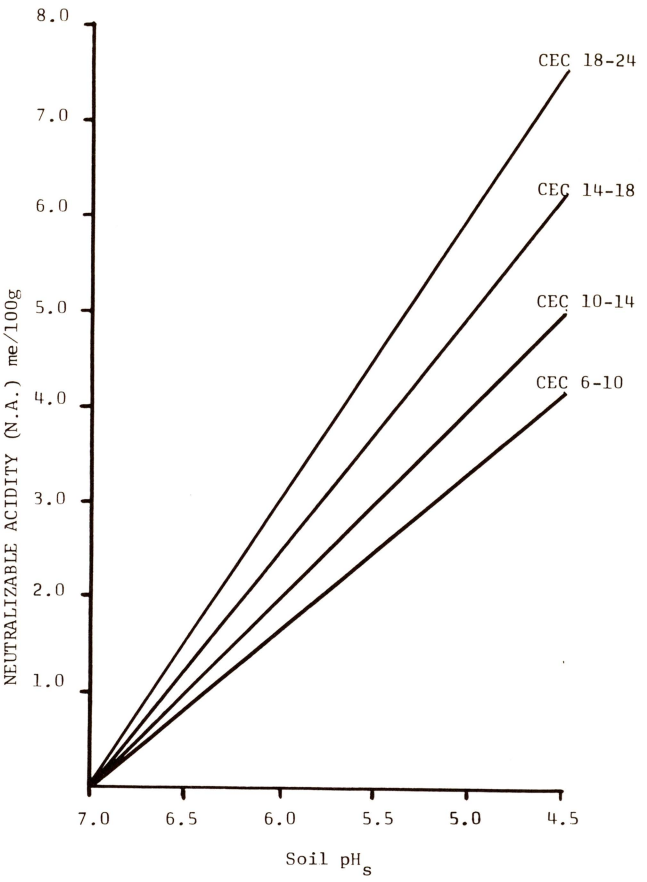

Figure 5. Relationship Between the Neutralizable Acidity, Soil pH_s and Cation Exchange Capacity of Missouri Soils

Cation Exchange, pH_s and Neutralizable Acidity

Soils will differ in their capacity to retain exchangeable calcium, magnesium and potassium. The capacity to retain such cations or the quantity of exchangeable cations held is referred to as the cation exchange capacity (C.E.C.). The C.E.C. is related to quantity and type of clay in the soil and the quantity of organic matter. The Missouri soil testing program determines C.E.C. by a summation of exchangeable calcium, magnesium, potassium and neutralizable acidity (N.A.), expressed as milliequivalent (me) per 100 grams of soil.

The relationship between soil pH_s and neutralizable acidity for soils at various cation exchange capacities is shown in Figure 5. This shows that our clay and clay loam soils have higher C.E.C. values and, therefore, more neutralizable acidity at the same pH_s than soils having lower cation exchange capacities, such as sands.

This means that soils with a high cation exchange capacity require more lime to increase the pH_s to a given level than those with low C.E.C. when both are originally at the same pH_s.

The University of Missouri computerized soil test interpretation program takes these factors into account when calculating lime recommendations.

General Considerations

There are some general or practical considerations when planning your corrective liming program. It may be impractical to apply limestone at a rate of less than two tons per acre. For recommended quantities of less than two, either apply two tons or wait 2-3 years.

High requirements for limestone may be applied in a single application or divided between two separate cropping seasons. This alternative is largely a financial consideration. Application and incorporation in a single application will facilitate obtaining the desired pH_s at an earlier date.

Benefit from liming will occur more rapidly when incorporated into the soil. For very acid soil conditions it is recommended to apply and incorporate lime from six months to a year before a crop sensitive to acid soil is to be planted.

Liming is considered a long-term investment in soil correction. Collecting representative soil samples from fields is essential in obtaining good results for both liming and fertilizing your crop.

Appreciation is expressed to Dr. T.R. Fisher, formerly associate professor of agronomy at UMC, upon whose research these recommendations are based. Contributions have also been supplied at one time or another to the general information by Dr. J.R. Brown and Dr. G.W. Colliver, associate professors of agronomy, and C.M. Christy and A.L. Preston, former state extension agronomy specialists.

Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice President for Extension, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65201.