Extension FactSheet

ANR-9-02

The Ohio State University Extension

Agriculture and Natural Resources, 2120 Fyffe Rd., Columbus, OH 43210-1084

Understanding Value in Lime

Clif Little
OSU Extension Agent, Guernsey County

Dr. Maurice Watson
Extension Soil Fertility Specialist

For many years we have referred to correcting soil pH as "sweetening the soil." It seems to be universally agreed upon that maintaining proper pH for plant growth is very important. What is less clear is why pH drops, what the lime recommendation is based on, and what is the most economical source of lime.

Why soil pH drops is fairly easy to explain. There are many factors, both natural and managed, that contribute to increasing acidity. Any increase in the acidic cation Hydrogen (H) or a decrease in basic cations, Calcium (Ca), Magnesium (Mg), Potassium (K), and Sodium (Na), through leaching from the soil profile and through uptake by the plant may reduce the pH.[1] The parent materials, which make up the soil, may release basic cations, which tends to increase soil pH, or release Aluminum (Al) and Iron (Fe), which tends to decrease soil pH. The release of Al by weathering is the most common source of increased acidity.[1] Plant removal by animal or mechanical harvest also removes basic cations, reducing soil pH.

Additional reasons for pH decrease include acid rain, application of ammonium and potassium fertilizers, and organic matter decomposition. The type of vegetation grown may also influence soil pH. For example, deep-rooted species such as warm-season grasses may absorb basic cations from deeper soil and bring them to the surface.

Lime recommendations are based on many factors. Among the most important are soil pH, soil buffering capacity (buffer pH), crop to be grown, plow depth, and lime history.[2]

Soil pH identifies the active acidity, or alkalinity, of a soil solution. The pH measurement is expressed as a measurement of hydrogen ion activity or concentration in a solution. The pH scale is from 1 to 14. A neutral solution of soil has a value of 7.0. The ability of lime to neutralize pH is measured by the Effective Neutralizing Power (ENP). The effective neutralizing power of lime is expressed on the basis of pounds per ton as a percentage of the fineness index, multiplied by the total neutralizing power and percentage of dry matter.[3]

Comparing Lime Products

An example of comparing two liming products in regard to ENP and cost is as follows:

Product 1: has an ENP of 1,286 lbs/ton
Product 2: has an ENP of 1,702 lbs/ton

The cost of each product is $15/ton. If our soil test calls for an application of 2,000 lbs/A of calcium carbonate equivalent, what is the best choice and how much do we need?

Best choice: Take the cost divided by the ENP.

$$\text{Product 1} = \frac{\$15}{1{,}286 \text{ lbs.}} = 0.012 \text{ dollars/lb/ENP}$$

$$\text{Product 2} = \frac{\$15}{1{,}702 \text{ lbs.}} = 0.009 \text{ dollars/lb/ENP}$$

Similarly: 15 dollars x 100 cts/dollar/1,702 lbs = 0.9 cts/lb.

Product 2 has the lowest cost per pound of neutralizing value. This, however, does not reflect total cost. In order to calculate total cost, we must determine our application rate.

Buffer capacity (buffer pH) or cation exchange capacity of the soil best explains differences in lime requirements. The buffer capacity of a soil reflects the resistance to a change in pH. The amount of clay and organic matter influences buffer capacity. This simple notion explains why soils of the same pH may have a different lime requirement. For instance, much more lime may be required to raise the pH of a clay soil than will be required to raise the pH of a sandy soil.

Liming materials vary significantly in terms of purity, fineness, and moisture. These factors help us select the most economical source of lime and determine the application rate of lime. Fortunately, state law, sections 905.51 to 905.66 of the Ohio Revised Code, requires lime manufacturers to label lime products. The most important item on the lime product label for determining application rate and value is the Effective Neutralizing Power (ENP).

The lime application recommendation is usually provided on the soil test recommendation as a calcium carbonate equivalent basis and is specific for the crop, soil, lime history, and tillage depth indicated on the test submission form. This means that we must adjust the application of the liming material up or down based on its ENP.

Determining Application Rate and Cost

The application rate of each, based on 1 ton/acre:

Product 1 = $\frac{\text{1,286 lbs. ENP}}{\text{2,000 lbs. Recommended application of pure calcium carbonate}}$ = 0.643

Recommended rate $\frac{\text{2,000 lbs.}}{0.643}$ = 3,110 lbs. to apply/acre

Product 2 = $\frac{\text{1,702 lbs. ENP}}{\text{2,000 lbs. Recommended application of pure calcium carbonate}}$ = 0.851

Recommended rate $\frac{\text{2,000 lbs.}}{0.851}$ = 2,350 lbs. to apply/acre

The cost of each:

Product 1 = $\frac{\text{3,110 lbs.}}{\text{2,000 lb./ton}}$ = 1.55 ton/A x $15/ton = $23.25/acre

Plus spreading cost, we'll say $4/ton:

1.55 ton/A x $4/ton = $6.20/A

Total Cost is $6.20/A + $23.25/A = $29.45/acre

Product 2 = $\frac{\text{2,350 lbs.}}{\text{2,000 lb/ton}}$ = 1.175 ton/A x $15/ton = $17.63/acre

Plus spreading cost:

1.17 ton/A x $4/ton = $4.68/A

Total Cost is $4.68/A + $17.63/A = $22.31/acre

The difference in total cost of these two liming materials at a one ton/acre recommendation is more than $7/acre. What is your soil test calling for? Are you applying the correct amount of lime? Even with very few liming materials available to choose from, significant differences exist in value.

Utilizing Lime Labels

Let's compare some lime labels. Figure 1 is an example of a lime label. Below the label you'll find the calculations necessary to compare these liming products. These lime labels are used for educational purposes only and should not be utilized as a guide for your purchasing decisions. Those purchasing lime are provided examples of utilizing a lime label and calculations that should be utilized when comparing or applying lime.

Figure 1. Sample Lime Label

Dolometic Limestone Pellets Minimum Guaranteed Analysis No. 1	**$25/ton**	**Particle Size Before Pelletizing**	
Elemental Calcium (Ca)	21.0%	% Passing	Mesh
Elemental Magnesium (Mg)	12.0%	100	4
Calcium Carbonate Equivalent	105.9%	100	8
Carbonates:		100	10
Calcium Carbonate (CaCO3)	52.4%	100	20
Magnesium Carbonate (MgCO3)	41.6%	99	40
Total Carbonates	97.5%	99	50
Oxides:		98	60
Calcium Oxide (CaO)	29.4%	93	100
Magnesium Oxide (MgO)	19.9%	65	200
Total Oxides	51.1%		
Water Soluable Binder	min. approx. 2.0%		
Moisture	max. 1.0%		
ENP	2,060 lbs. per ton		

Cost/ENP

Calculations:

$25 x 100 cts/dollar / 2,060 ENP = 1.2 cts/lb. ENP

Amount of Lime Needed per Acre

2,060 ENP / 2,000 lbs/A recommended = 1.03

2,000 lbs/A recommended / 1.03 = 1,942 lbs/A of No. 1 lime needed, or 0.97 ton, as compared to pure calcium carbonate.

Total Cost

Calculations:

$25/ton x 0.97 = $24.25/A

Spreading cost is: $5.82/A for spreading (@ $6/ton, spreading cost is: $6.00 x 0.97 = $5.82)

Total cost is $24.50 + $5.82 = $30.32/A

Figure 2

Pulverized Dolometic Lime Minimum Guaranteed Analysis No. 2	$17/ton	Particle Size	
Elemental Calcium (Ca)	21.0%	% Passing	Mesh
Elemental Magnesium (Mg)	12.0%	100	4
Calcium Carbonate Equivalent	105.9%	100	8
Carbonates:		100	10
Calcium Carbonate (CaCO3)	52.4%	100	20
Magnesium Carbonate (MgCO3)	41.6%	99	40
Total Carbonates	97.5%	99	50
Oxides:		98	60
Calcium Oxide (CaO)	29.4%	93	100
Magnesium Oxide (MgO)	19.9%	65	200
Total Oxides	51.1%		
Water Soluable Binder Moisture	min. approx. 2.0% max. 0.4%		
ENP	1,885 lbs per ton		

Cost/ENP
Calculations:
$17 x 100 cts/dollar / 1,885 ENP = 0.9 cts/lb ENP

Amount of Lime Needed per Acre
Calculations:
1,885 lbs. ENP / 2,000 lbs./A recommended = 0.94
Then: 2,000 lbs/A recommended/0.94 = 2,128 lbs/A of No. 2 lime needed, or 1.06 tons, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $17/ton x 1.06 = $18.02/A
Spreading cost is: $6.36/A for spreading; (@$6/ton, spreading cost is $6.00 x 1.06 = $6.36)

Total cost is: $18.02 + $6.36 = $24.38/A

Figure 3

N Hydrated Lime Dolomitic Minimum Guaranteed Analysis No. 3	$30/ton	Particle Size	
Elemental Calcium (Ca)	34.0%	% Passing	Mesh
Elemental Magnesium (Mg)	20.0%	100	4
Calcium Carbonate Equivalent	165.%	100	8
Oxides:		100	10
Calcium Oxide (CaO)	46.5%	100	20
Magnesium Oxide (MgO)	32.0%	100	50
Total Oxides	78.5%	99	60
Calcium Hydroxide (CaOH2)	63.2%	99	100
Moisture	max. 0.4%	97	200
ENP	3,265 lbs per ton		

Cost/ENP
Calculations:
$30 x 100 cts/dollar / 3,265 ENP = 0.92 cts/lb ENP

Amount of Lime Needed per Acre
Calculations:
3,265 lbs ENP / 2,000 lbs/A recommended = 1.63
Then: 2,000 lbs/A recommended/ 1.63 = 1,227 lbs/A of No. 3 lime needed, or 0.61 tons, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $30/ton x 0.61 = $18.30/A
Spreading cost is: $3.66/A for spreading; (@$6/ton, spreading cost is $6.00 x 0.61 = $3.66)

Total cost is: $18.30 + $3.66 = $21.96/A

Figure 4

Dolometic Lime Pulverized Bulk Agricultural Limestone Guaranteed Analysis			
No. 4		**$15/ton**	
Minimum Calcium	21.0%	% Passing	Mesh
Minimum Magnesium	12.0%	100	No. 8
Total Neutralizing Power	105.0	95	No. 20
		70	No. 60
		60	No.100

The lime label in Figure 4 is incomplete. To compare this lime product, we need more information, in particular the ENP. We can calculate the ENP with the information provided, or we may ask the dealer for the ENP. In addition, we may find a complete lime label in the Ohio Department of Agriculture's annual analysis results of liming materials. The process for calculating the ENP is completed below. The standards and formulas are described in Ohio Lime Law, ORC Section 905.51-905.65. We must also estimate the moisture content for this liming material. It is common to be provided incomplete lime labels when purchasing bulk materials.

Formulas Utilized in Calculations

We will assume a dry matter content of 99%.

Pounds of ENP per Ton = 2,000 x ENP x % Dry Matter/ 100

ENP = (Fineness Index/100) x % TNP/100

Fineness Index = 0.2 (% pass No. 8 - % pass No. 20) + 0.6 (% pass No. 20 - % pass No. 60) + 1 (% pass No. 60)

% Dry Matter = 100 - % Moisture

Calculations for Lime No. 4:
Fineness Index = 0.2 (100-95) + 0.6 (95-70) +1 (70) = 86
ENP = 86/100 x 105/100 = 0.90
% Dry Matter = 100 – 1.0 = 99
Pounds of ENP per ton = 2,000 x 0.90 x 99/100 = 1,782

Cost/ENP
Calculations:
$15 x 100 cts/dollar / 1,782 ENP = 0.84 cts/lb ENP

Amount of Lime Needed per Acre
1,782 lbs. ENP / 2,000 lbs/A recommended = 0.89

Then: 2,000 lbs/A recommended/ 0.89 = 2,247 lbs/A of No. 4 lime needed, or 1.12 ton, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $15/ton x 1.12 = $16.80/A

Spreading cost is: $6.72/A for spreading; (@$6/ton, spreading cost is $6.00 x 1.12 = $6.72)

Total cost is: $16.80 + $6.72 = $23.52/A

Figure 5

Calacitic Lime Halon Agricultural Ground Limestone			
No. 5	**Guaranteed Analysis**	**$15/ton**	
Calcium	min. 29%	% Passing	Mesh
Magnesium	min. 6%	95	No. 8
Total Neutralizing Power	98%	70	No. 20
		50	No. 60
		40	No. 100

We will utilize the same formulas as we did for product No. 4 and assume a dry matter content of 99%.

Calculations for Lime No. 5:
Fineness Index = 0.2 (95-70) + 0.6 (70-50) + 1 (50) = 67
ENP = 67/100 x 98/100 = 0.66
% Dry Matter = 100 – 1.0 = 99
Pounds of ENP per ton = 2,000 x 0.66 x 99/100 = 1,307

Cost/ENP
Calculations:
$15 x 100 cts/dollar / 1,307 ENP = 1.15 cts/lb ENP

Amount of Lime Needed per Acre
Calculations:
1,307 lbs ENP / 2,000 lbs./A recommended = 0.65

Then: 2000 lbs/A recommended/ 0.65 = 3,077 lbs/A of No. 5 lime needed, or 1.54 tons, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $15/ton x 1.54 = $23.10/A

Spreading cost is: $9.24/A for spreading; (@$6/ton, spreading cost is $6.00 x 1.54 = $9.24)

Total cost is: $23.10 + $9.24 = $32.34/A

Figure 6

Pulverized Industrial By-Product No. 6	$4/ton		% Passing	Mesh
Minimum % Calcium	27%		% Passing	Mesh
Minimum % Magnesium	6%		99	No. 20
Total Neutralizing Power as Percent Calcium Carbonate	90%		90	No. 60
Effective Neutralizing Power per Ton	1,380 lbs.		75	No.100
Maximum Moisture and other heavy metals not listed	20%			

Cost/ENP
Calculations:
$4 x 100 cts/dollar / 1,380 ENP = 0.29 cts/lb ENP

Amount of Lime Needed per Acre
Calculations:
1,380 lbs ENP / 2,000 lbs/A recommended = 0.69
Then: 2,000 lbs/A recommended/ 0.69 = 2,899 lbs/A of No. 6 lime needed, or 1.45 tons, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $4/ton x 1.45 = $5.80/A
Spreading cost is: $8.70/A for spreading; (@$6/ton, spreading cost is $6.00 x 1.45 = $8.70)

Total cost is: $5.80 + $8.70 = $14.50/A

Figure 7

Pulverized Dolomitic Limestone Minimum Guaranteed Analysis #7	Unburnt			$18/ton
Elemental Calcium	21%		% Passing	Mesh
Calcium Oxide	30%		100	8
Calcium Carbonate	54%		100	10
Elemental Mag	11%		95	20
Mg Oxide	20%		90	50
Mg Carbonate	43%		80	60
Calcium Carbonate Equiv	104%		75	100
Moisture	<1%		50	200
ENP	1,731# per T			

Cost/ENP
Calculations:
$18 x 100 cts/dollar / 1,731 ENP = 1.04 cts/lb ENP

Amount of Lime Needed per Acre
Calculations:
1,731 lbs ENP / 2,000 lbs/A recommended = 0.87
Then: 2,000 lbs/A recommended/ 0.87 = 2,299 lbs/A of #7 lime needed, or 1.15 ton, as compared to pure calcium carbonate.

Total Cost
Calculations:
Lime cost is: $18/ton x 1.15 = $20.70/A
Spreading cost is: $6.90/A for spreading; (@$6/ton, spreading cost is $6.00 x 1.15 = $6.90)

Total cost is: $20.70 + $6.90 = $27.60/A

Summary of Labels Compared:

Item No.	Cost/ENP(Cts/lb)	Cost for application of 1 ton per acre and $6 per ton spreading cost
No. 7	1.04	$27.60
No. 6	0.29	$14.50
No. 5	1.15	$32.34
No. 4	0.84	$23.52
No. 3	0.92	$21.96
No. 2	0.90	$24.38
No. 1	1.21	$30.32

Cheapest cost per lb ENP: No. 6
This is not always the case, since this cost does not include spreading cost.

Range in application rate at 1 ton CCE seen in all labels
No. 5, 3,077 to No. 3, 1,227

Spreading cost range, at an application rate of 1 ton per acre:
No. 5, $9.24/A to No. 3, $3.66/A

Many new liming materials have been made available in recent years. As indicated in the examples provided, significant differences exist in terms of total cost of applying liming materials. In these examples, we do not account for other differences, such as ease of handling, uniformity of spreading, heavy metals, and other factors.

We would like to thank Bill Goodman, Specialist in Charge, ODA, Feed and Fertilizer Section, for reviewing this fact sheet.

For additional information, contact your local office of Ohio State University Extension.

References

1. Tisdale, S. L., W. L. Nelson, and J. D. Beaton, *Soil Fertility and Fertilizers*. 4th Ed. New York: Macmillan, 1985.
2. Vistosh, M. L., J. W. Johnson, and D. Mengel, Eds. 1995. *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa*. Extension Bulletin E-2567. Michigan State University. East Lansing, Mich.
3. Ohio Lime Law: Revised Code 905.51.
4. Knudsen, D., *Estimating Ag Lime Quality*. Nebraska Guide G84-714-A. University of Nebraska-Lincoln.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Keith L. Smith, Director, Ohio State University Extension.

TDD # 1 (800) 589-8292 (Ohio only) or (614) 292-1868

8/02-ebb