LIME GUIDELINES FOR FIELD CROPS

TUTORIAL WORKBOOK-*TEACHING GUIDE*

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Nutrient Management Spear Program
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Contents

Teaching Goals

This section of the teaching module follows the Lime Guidelines for Field Crops Tutorial manual, Tutorial #1 and is designed to be compatible with a 1-hour computer laboratory exercise in which the whole class follows along together with an overhead projected version of the Lime Guidelines for Field Crops calculator.

The purposes of this segment of the curriculum are two-fold:

(1) To reinforce concept of pH management for field crops presented in lecture by reading through extension fact sheets and answering question independently or through group discussions.
(2) Become familiar with the "look and feel" of the tool/software by adding data, and the functionality of the software by actually interacting with it.

Completing this section of the curriculum after the lecture solidifies concepts presented in lecture by providing the same information in multiple learning formats. It also engages the use of professional reference tools (fact sheets and software), which provides experiences and skills that are immediately applicable for crop and farm advisors or managers.

Materials used for this section of the curriculum are:

(1) Software – Lime Guidelines for Field Crops.
(2) Tutorial Workbook– Lime Guidelines for Field Crops (pp. 1-10).

The tutorial for the Lime Guidelines for Field Crops calculator takes the users through a step by step set of reference fact sheets, questions, data entry, and evaluation exercises using the Lime Guidelines for Field Crops Calculator. This Teaching Guide offers guidance on discussion points for each section.

The tutorial begins with downloading and opening Lime Guidelines for Field Crops calculator on each student‟s desktop which requires an internet connection. If an internet connection is unavailable in the classroom, the calculator can be downloaded on a computer that does have internet access, and then transferred to class computers using a portable drive or disk.

It is recommended that no more than two people share a computer for optimal learning.

Introduction

Achieving optimum pH is essential for field crop production because soil pH affects many soil properties and processes including nutrient cycling, soil microbial activity, and soil structure. The native pH of a soil is determined by the type(s) of parent material the soil was developed from. Most agricultural soils in New York are acidic and have a natural pH below 7.0. Some New York soils are "calcareous", which means that they contain free calcium carbonate, or lime deposits, in the surface layer. Calcareous soils tend to have a pH in the range of 7.0-8.5 and the pH tends to be quite stable (i.e. difficult to change over time). Naturally acidic agricultural soils need to be monitored for pH over time as lime will need to be applied for optimum field crop production once the pH decreases below the minimum desired level.

The pH of a soil is a measure of hydrogen ion activity ($[H^+]$) in the soil solution. As the H^+ activity increases, soil pH decreases. As the soil pH decreases, most desirable crop nutrients become less available while others, often undesirable, become more available and can reach toxic levels (Figure 1).

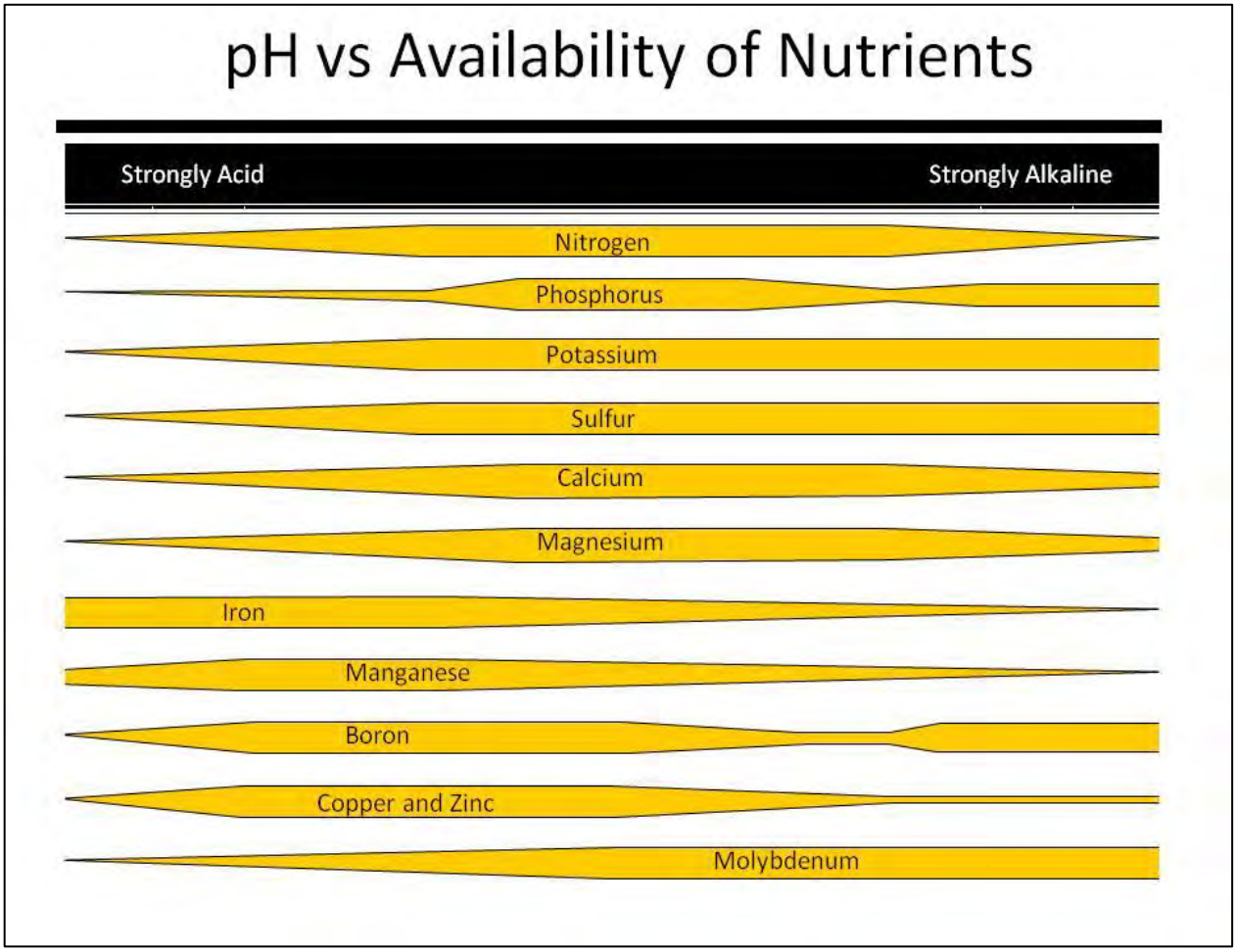


Figure 1: Availability of plant nutrients as soil pH changes.

Addition of lime can counterbalance the acidity of a soil. This is a two-step process that involved replacement of H^+ and Al^{3+} ions on the clay surfaces with Ca from the liming material followed by neutralization of the acidity by reaction of the H^+ and Al^{3+} ions with CO_3 to form aluminum hydroxide, water and carbon dioxide (Figure 2).

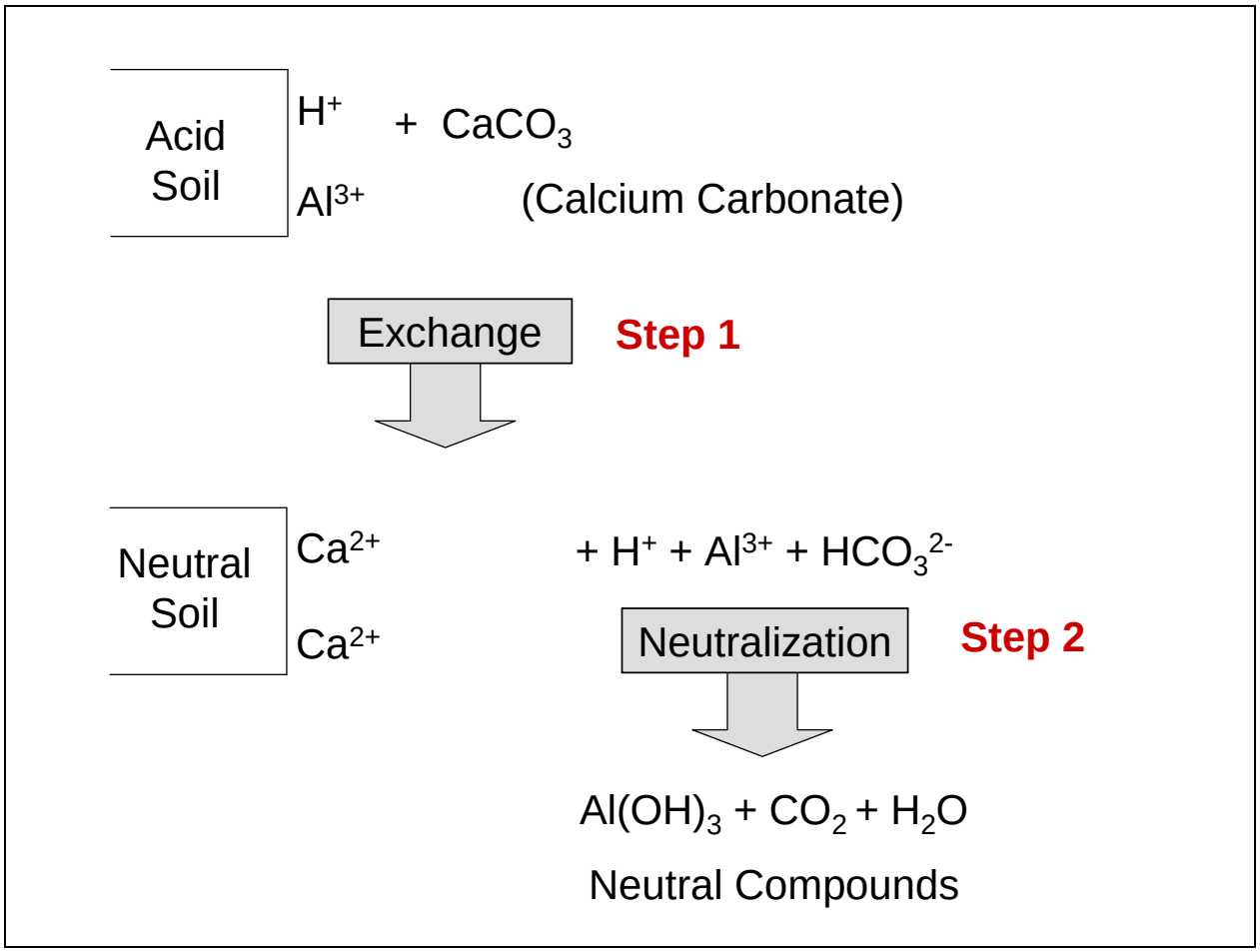


Figure 2: Two-step reaction of agricultural lime (in this case $CaCO_3$) with the soil.

The quality of a liming product is determined by its effective neutralizing value (ENV) which is a multiplication of its calcium carbonate equivalence (CCE) and its fineness, reflecting that a finer material reacts faster than a coarse material.

The lime calculator was designed to derive lime requirements, based on a soil pH, a particular rotation, a modified Mehlich buffer pH analysis, and tillage depth.

Warning: Useable output requires realistic values as input variables. Thus the quality of the output is dependent on the quality of the data used; accuracy of the input data is the responsibility of the person using the calculator.

Soil pH Basics

Teaching Guide: *Discussion on how soil pH can limit crop production through nutrient deficiency, toxicities, weed control, etc. Students should understand that pH management is the number one priority for field crop fertility management.*

Before getting started with the calculator, take some time to refresh the details of soil pH for field crops by reading Agronomy Fact Sheet 5 which can be found in the Appendix:

- *Agronomy Fact Sheet #5: Soil pH for Field Crops.*

Now answer the following question:

Question (1):

- List the ways in which proper pH management can improve crop management.

Answer (1):

- Increases availability of essential nutrients.
- Decreases accumulation of aluminum to toxic levels.
- Improves the effectiveness of some types of herbicides.
- Improves soil structure which can lead to better root and plant health.
- Increases nutrient cycling efficiency due to increased microbial activity.

Save the File and Keep Information Organized

Teaching Guide: *Take-home message: keeping data/information organized and identified improves management and effectiveness of an extension program or a farm.*

Action 1: Enter the information shown below in the heading section of the calculator. This type of basic information is important especially when dealing with multiple farms or fields. Attention to these details up front will save potential frustration, confusion, and time later on.

Farm Name:	Robert Biddle Inc.
Farm Address:	1354 Smith Street
Date:	6/5/2010
Field Name:	A7

Once you have entered the information, the Lime Guidelines for Fields Crops in New York spreadsheet should look like Figure 3.

Nutrient Management Spear Program
Cornell University Department of Animal Science

Lime Guidelines for Field Crops in New York
v1 .0 November 2010

Farm name:	Robert Biddle Inc.
Farm address:	1345 Smith Street
Field name:	A7
Date:	6/5/2010

Figure 3: After adding data listed above the Lime Guidelines for Field Crops in New York spreadsheet should list important identification information for the lime recommendation.

Action 2: Save the file as "Biddle-A7" by using the „Save as" option in Excel. Navigating to this function will depend on which version of Microsoft Excel you have. Refer to Figure 4 to see where the „Save as" function is located on your version of Excel.

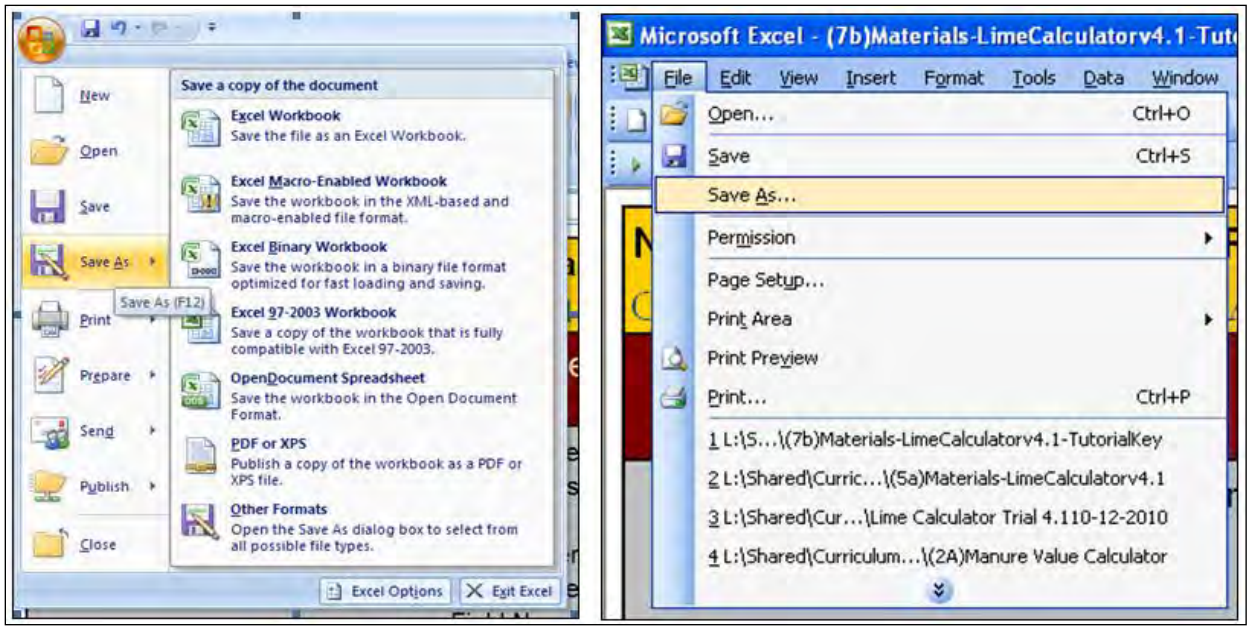


Figure 4: The 'Save As' function located in two different versions of Microsoft Excel.

Determine the Desired and Minimum Rotation pH

Teaching Guide: *Discussions can be held about the importance of looking at the entire rotation for pH management. Lime takes time to react and forward planning is critical.*

In this step, select Crops cells in white. A drop down arrow will appear to the right of the cell. By selecting this arrow, a menu will appear and allow you to select the crop grown in that year. Within the menu, a scroll bar is present to allow for more selections.

Action 3: Input Corn Silage for the two previous years as well as this year. For the next three years, input alfalfa. Be sure to use establishment for the first year of alfalfa. Once entered, the crop rotation should display as shown by Figure 5.

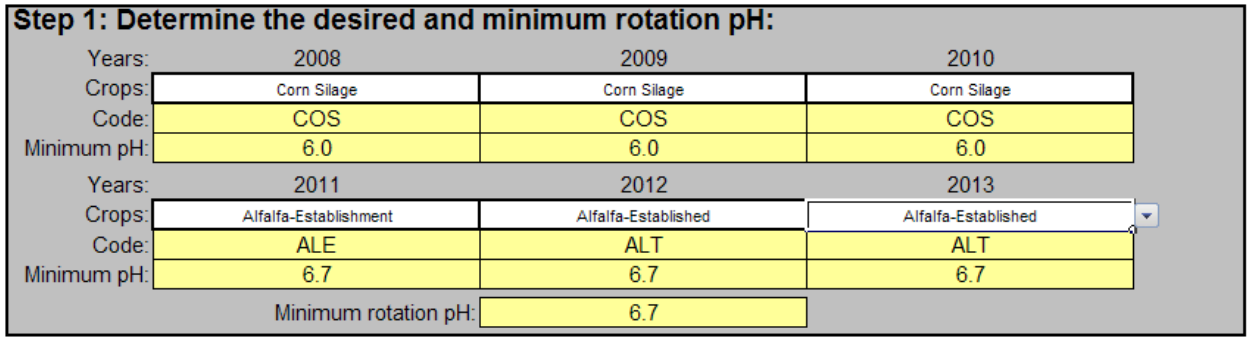


Figure 5: Entering multiple years of crops allows the calculator to pick an appropriate minimum pH for the entire rotation.

Once the entire rotation is selected, a minimum rotation pH is automatically calculated. Minimum rotation pH is the highest desired pH in the rotation. This rotation gives you a minimum rotation pH of 6.7.

Question (2):

- Given the recommended pH ranges for field crops, when might be the best time(s) to test for soil pH in a field that rotates between four years of corn and four years of alfalfa?

Answer (2):

- After the third year of corn is harvested.
- One year prior to seeding any pH sensitive crop like alfalfa or soybeans
- Whenever a pH level is unknown or soil test analysis is out of date.

Determine if Lime is Needed

Teaching Guide: *Discuss a common misconception that a lime recommendation can be made when the desired pH and soil pH are known. Soil pH only tells us if lime is needed or not. Soil pH does not indicate HOW MUCH lime is needed.*

A pH measurement can determine if lime is needed. A quick in-field pH kit can be a useful, low cost tool for identifying if the pH of the surface layer or plow layer is in-line with the crop needs.

Action 4: Enter a soil pH of 6.2 into the white cell labeled, *Soil pH from Soil Analysis*. A calculated response will be given based on the minimum desired pH for the rotation and soil pH analysis as shown in Figure 6.

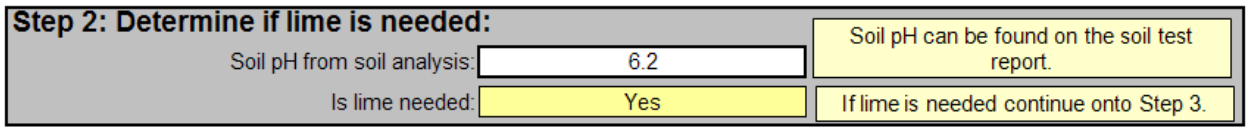


Figure 6: Step 2 in the calculator determines if lime is needed.

Important: If the box labeled *Is lime needed* reads "No", no lime application is needed. If box reads "Yes", lime application is needed, continue onto Step 3.

With the Rotation that has been entered, a lime application is needed.

Question (3):

- How does the farm tillage system impact how to sample to determine if lime is needed?

Answer (3):

- In minimum or no-till system, lime will need to be surface applied without the option for incorporation. It will take longer for the lime to react and move through the soil profile For this reason, frequent (once a year) testing of the surface 0-1 inch layer of soil is desired (in addition to a 0-6 inch sample) and more frequent corrective action is needed. For tilled systems, a single 0-8 inch depth sample is sufficient.

Determine How Much Lime is Needed

Teaching Guide: *Discuss why different soils may need different amounts of lime to change the pH the same amount: soil buffering capacity, what soil characteristics impact buffering capacity, different ways buffering capacity may be reported by a laboratory.*

An estimate of the soil"s buffering capacity is needed to determine how much lime is needed. Read though the following Agronomy Fact Sheets which can be found in the Appendix.

- *Agronomy Fact Sheet #6: Lime Recommendations for Field Crops.*
- *Agronomy Fact Sheet #48: Buffer pH to Derive Lime Guidelines.*

This calculator is built to calculate lime needs using the modified Mehlich buffer pH.

Action 5: Input a modified Mehlich Buffer pH of 6.0 into the white cell labeled, *Buffer pH from Soil Analysis*. Now, enter a tillage depth of 7 inches into the white cell labeled, *Tillage Depth.* The spreadsheet will then calculate the recommended lime rate (Figure 7). This recommended rate will be in tons per acre of lime with 100% effective neutralizing value (ENV).

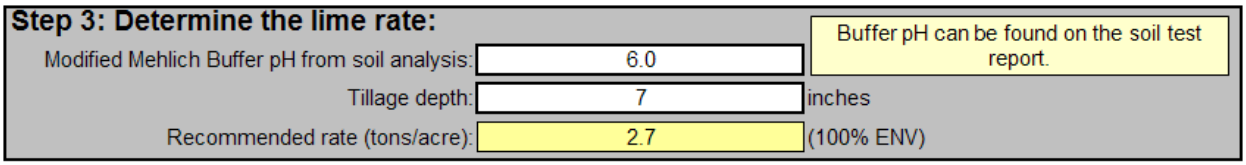


Figure 7: Step 3 returns a recommended application rate for lime with a 100% effective neutralizing value.

Question (4):

- What soil characteristics impact how much lime is needed to change pH?

Answer (4):

- Texture (clay content) and organic matter.

Question (5):

- List two common ways laboratories report the buffering capacity of the soil.

Answer (5):

- Exchangeable acidity.
- Buffer pH.

Question (6)

- In the example above, what would the recommended rate be if the buffer pH was 5.9?

Answer (6)

- 4.0 tons/acre.

Question (7)

- In the example above, what would the recommended rate be if the buffer pH was 5.9 and the tillage depth was 9 inches?

Answer (7)

- 5.0 tons/acre.

NOTE: Change buffer pH back to 6 and tillage depth to 7 before proceeding.

Question (8):

- Why does tillage depth matter?

Answer (8):

- The calculations are calibrated to a 6 to 8 inch tillage depth, more soil would be mixed with the lime at deeper tillage depths and therefore more lime will be needed to react with the additional soil to change the pH the desired amount.

Adjust Recommended Rates for Actual Lime Characteristics

Teaching Guide: *Discuss different lime materials: physical and chemical differences and how these characteristics impact how much lime is needed; calcium carbonate equivalents to measure liming capacity (common example is gypsum as a liming material), how fineness impacts the reaction rate.*

The sale of agricultural liming materials is regulated by state governments. In New York State the Department of Agriculture and Markets (NYSDAM) permits and tracks the sale of agricultural lime. Prior to continuing on with this section take a couple minutes and read the following Agronomy Fact Sheet and the New York State 2010 Ag Lime Sale Application packet found in the Appendix of this document.

- *Agronomy Fact Sheet #6: Liming Materials.*
- *2010 Agricultural Lime Registration Packet.*

The ENV of a liming material is calculated by multiplying a liming material‟s CCE (sometimes referred to as Total Neutralizing Value (TNV)) and a lime materials “fineness factor”. Fineness is determined by a industry-wide standard test of the percent of material passing through a 100

mesh screen and a 20 mesh screen (the 100 and 20 values refer to the number of wire strands per inch on the screen so a 100 mesh screen has much smaller holes than a 20 mesh screen).

Percent ENV can be found on a lime label and entered into the white cell labeled Reported %ENV. If %ENV is not available, leave %ENV blank and enter the values for percentage of material passing through 20 and 100 mesh screens. Next, input the value for CCE. The spreadsheet will calculate the fineness factor and determine the %ENV.

Percent ENV can be used to compare actual costs of liming material. If a material will need to be applied at a heavier rate because more of it is needed to change the soil pH, then this should be considered when comparing which lime material to purchase. The calculator allows the user to compare liming material on a "cost per effective neutralizing value" and to choose which material to continue on with for the final lime recommendation.

Important: If %ENV is available, this value is preferred. Leave %ENV blank if mesh and CCE values are used. Use either value, but use only one! The mesh and CCE values maybe left in cells if the %ENV is used, yet the %ENV must be blank for the calculator to use the mesh and CCE values.

Action 6: Enter lime material characteristics for two different liming materials as shown in Figure 8.

Step 4: Adjust rates for lime source characteristics (%ENV) and evaluate costs.

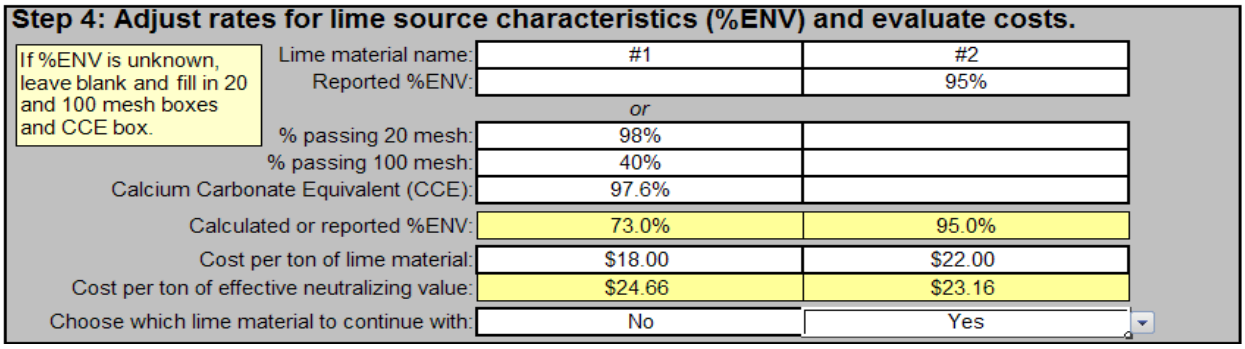
If %ENV is unknown, leave blank and fill in 20 and 100 mesh boxes and CCE box.

	#1	#2
Lime material name:		
Reported %ENV:		95%
or		
% passing 20 mesh:	98%	
% passing 100 mesh:	40%	
Calcium Carbonate Equivalent (CCE):	97.6%	
Calculated or reported %ENV:	73.0%	95.0%
Cost per ton of lime material:		
Cost per ton of effective neutralizing value:	$0.00	$0.00
Choose which lime material to continue with:	No	Yes

Figure 8: Either % ENV or mesh ratings and CCE can be used to make adjustments for the actual liming power of purchased materials and comparison of true costs of each material.

Choose a Lime Material Based on Cost per Effective Neutralizing Value

Action 7: Enter the cost for Lime material #1 of $18.00 per ton and $22.00 per ton for Lime material #2. Which material is the least cost option for liming? Choose that lime material option by selecting "yes" under that column (Figure 9).



Step 4: Adjust rates for lime source characteristics (%ENV) and evaluate costs.

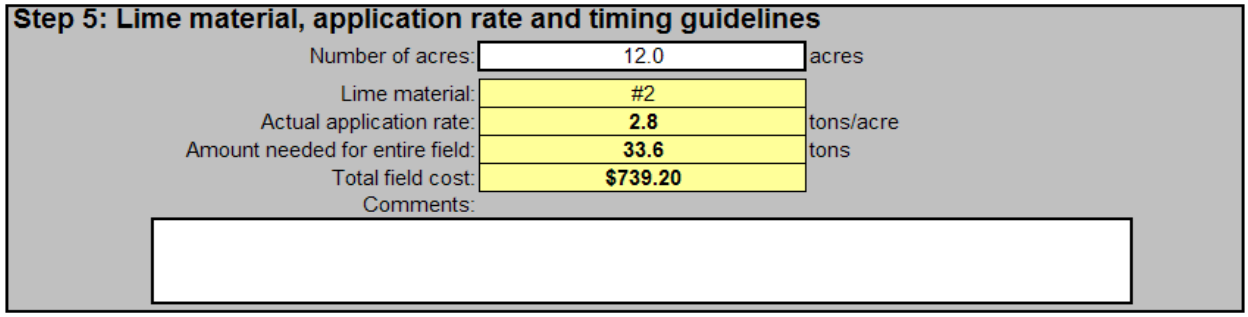
If %ENV is unknown, leave blank and fill in 20 and 100 mesh boxes and CCE box.

Lime material name:	#1	#2
Reported %ENV:		95%
	or	
% passing 20 mesh:	98%	
% passing 100 mesh:	40%	
Calcium Carbonate Equivalent (CCE):	97.6%	
Calculated or reported %ENV:	73.0%	95.0%
Cost per ton of lime material:	$18.00	$22.00
Cost per ton of effective neutralizing value:	$24.66	$23.16
Choose which lime material to continue with:	No	Yes

Figure 9: Choosing a liming material allows the calculator to finalize application calculations.

Choosing a lime material based on cost per effective neutralizing power will give the least cost option for changing pH.

Action 8: Enter 12 acres for the total acres for the field. The amount needed for the whole farm and for total cost of the material is given (Figure 10).



Step 5: Lime material, application rate and timing guidelines

Number of acres:	12.0	acres
Lime material:	#2	
Actual application rate:	**2.8**	tons/acre
Amount needed for entire field:	**33.6**	tons
Total field cost:	**$739.20**	
Comments:		

Figure 10: Lime rate per acre, total tons of lime needed and the cost for the whole field.

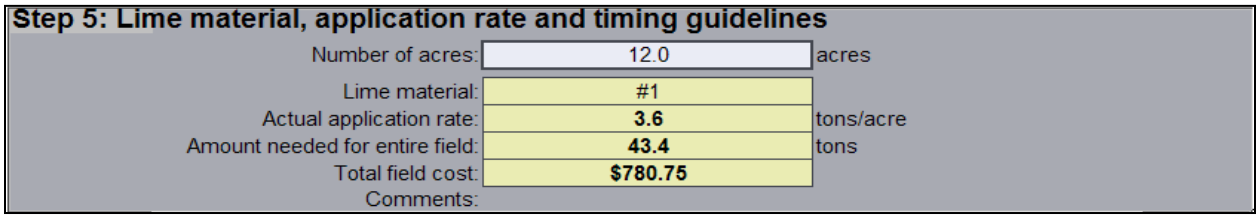
For our Field A7, 34 tons of lime will be need to be added before the establishment of alfalfa. The application rate is 2.8 tons per acre. This application will bring the soil pH to 6.7, which is necessary for successful growth of alfalfa.

Question (9):

- Now go back up and choose liming material #1. What are the total field costs for using this material? How much material has to be added per acre? (Un-choose lime material #2 or else the values will not show).

Answer (9):

- See answer key in Figure 11.



Step 5: Lime material, application rate and timing guidelines

Number of acres:	12.0	acres
Lime material:	#1	
Actual application rate:	**3.6**	tons/acre
Amount needed for entire field:	**43.4**	tons
Total field cost:	**$780.75**	
Comments:		

Figure 11: Answer key for question #9.

Application Recommendations

Teaching Guide: *Identify the factors that should be considered when determining timing of a lime application. Review the rotation, discuss seasonal variability in soil p, and talk about the reaction time of different liming materials. In addition, discuss maximum application amounts and planning for split applications.*

The calculator provides a place for further comments or more application recommendations.

Action 9: Read through the following Agronomy Fact Sheet (found in the Appendix) and fill in the comment box with more instructions on the best time to apply the needed lime.

- *Agronomy Fact Sheet #54: Timing of Lime Application for Field Crops.*

Question (10):

- Push the save button. Print the document for the answer to this question or for future referencing and/or for keeping in farm records.

Answer (10):

- See Figure 12 for the answer key to question (10).

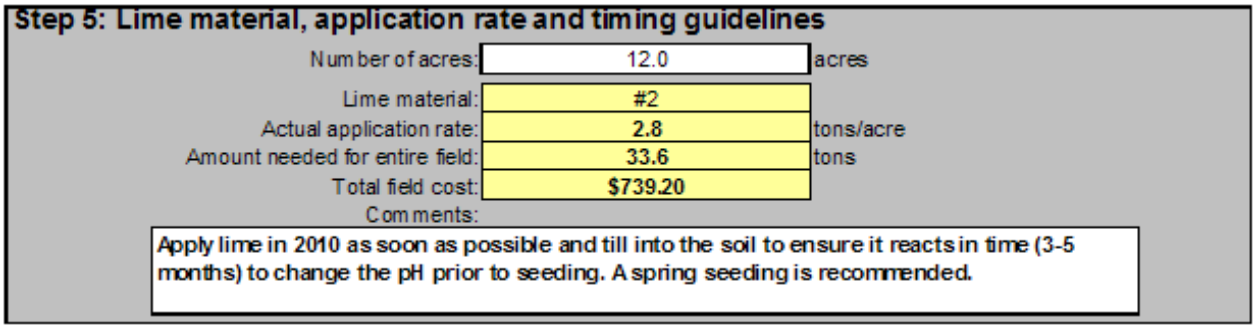


Figure 12: Answer to question 10.

Comparing Limestone Material

A new company in your area is selling a lime material very cheaply at $15.00/ton. You have been paying $30.00/ton for lime from another dealer who has not been giving you any deals lately. You decide to look into it a little further and you gather the following material specifications:

	Good Deal Lime	Old Lime
Cost/ton	$15/ton	$30/ton
%ENV	Not available	95
% Passing 20 mesh	95.7	Not available
% Passing 100 mesh	75.6	Not available
%TNV (or %CCE)	42	Not available

Question (11):

- Should you switch or not, explain your answer?

Answer (11):

- No, I would not switch because the old lime is still a better deal because less is needed to change the pH due to the high %ENV in this product and so in the end it will cost less than the NEW lime (see Figure 13 for the answer key to question 11).

Step 4: Adjust rates for lime source characteristics (%ENV) and evaluate costs.

If %ENV is unknown, leave blank and fill in 20 and 100 mesh boxes and CCE box.

Lime material name:	Good Deal Lime	Old Lime
Reported %ENV:		95%
	or	
% passing 20 mesh:	96%	
% passing 100 mesh:	76%	
Calcium Carbonate Equivalent (CCE):	42.0%	
Calculated or reported %ENV:	36.9%	95.0%
Cost per ton of lime material:	$15.00	$30.00
Cost per ton of effective neutralizing value:	$40.67	$31.58
Choose which lime material to continue with:	No	Yes

Step 5: Lime material, application rate and timing guidelines

Number of acres:	12.0	acres
Lime material:	Old Lime	
Actual application rate:	**2.8**	tons/acre
Amount needed for entire field:	**33.6**	tons
Total field cost:	**$1,008.00**	

Comments:

Apply lime in 2010 as soon as possible and till into the soil to ensure it reacts in time (3-5 months) to change the pH prior to seeding. A spring seeding is recommended.

Answer key to question 11.

Question (12):

- How low of a price would you suggest to the Good Deal Lime dealer to make it a lower price per effective neutralizing power?

Answer (12):

- The price would have to be $11.00 or lower.

Step 4: Adjust rates for lime source characteristics (%ENV) and evaluate costs.

If %ENV is unknown, leave blank and fill in 20 and 100 mesh boxes and CCE box.

Lime material name:	Good Deal Lime	Old Lime
Reported %ENV		95%
	or	
% passing 20 mesh:	96%	
% passing 100 mesh:	76%	
Calcium Carbonate Equivalent (CCE)	42.0%	
Calculated or reported %ENV:	37.0%	95.0%
Cost per ton of lime material:	$11.00	$30.00
Cost per ton of effective neutralizing value:	$29.76	$31.58
Choose which lime material to continue with:	No	Yes

Figure 14: Answer key to question 12.

Question (13):

- Are there other considerations than just price per effective neutralizing power that may need to be considered when deciding between the two liming materials?

Answer (13):

- Yes, trucking costs associated with hauling more material to the field since it would take more tons per acre of the NEW lime to create the same change in pH.

Determining Lime Rate and Application Strategies

You are sitting down in early November to look at your fields and start planning for next year. You have a field that has been in corn for the last five years and needs to switch out of corn to break a disease cycle. Soybeans are what you had in mind because the market projections look good for soy next year followed by oats with an alfalfa seeding. The soil pH is 6.0 and the buffer pH is 5.6 and tillage depth is 7 inches.

Question (14):

- Should you plant soybeans on this field next year?

Answer (14):

- No, soybeans and alfalfa need a fairly high pH otherwise seed germination and general crop vigor will be severely impacted and this field is too low for either soy or alfalfa and the quantity of lime will require a split application and at least two plowings and at least 6 months to react with the lime (see Figure 15).

Step 1: Determine the desired and minimum rotation pH:

Years:	2008	2009	2010
Crops:	Corn Silage	Corn Silage	Corn Silage
Code:	COS	COS	COS
Minimum pH:	6.0	6.0	6.0
Years:	2011	2012	2013
Crops:	Soybeans	Alfalfa-Establishment	Alfalfa-Established
Code:	SOY	ALE	ALT
Minimum pH:	6.7	6.7	6.7
	Minimum rotation pH:	6.7	

Step 2: Determine if lime is needed:

Soil pH from soil analysis:	6	Soil pH can be found on the soil test report.
Is lime needed:	Yes	If lime is needed continue onto Step 3.

Step 3: Determine the lime rate:

Modified Mehlich Buffer pH from soil analysis:	5.6	Buffer pH can be found on the soil test report.
Tillage depth:	7	:hes
Recommended rate (tons/acre):	7.3	(100% ENV)

Figure 15: Answer key to question 14.

Question (15):

- Are there other rotation options that could meet your need for breaking out of corn while working to raise the pH?

Answer (15)

- By looking at Table 1 in the Appendix (or fact sheet #48) one crop combination that would not require lime now but would also allow for application of lime and a few years to work it in is: 2011 - Oats with Legumes (OAS), Clover Grass Established (CGT), Clover Grass Established (CGT). The low modified Mehlich buffer pH on this field will always make it expensive to try and change the pH because it will take a lot of lime to make this change (Figure 16).

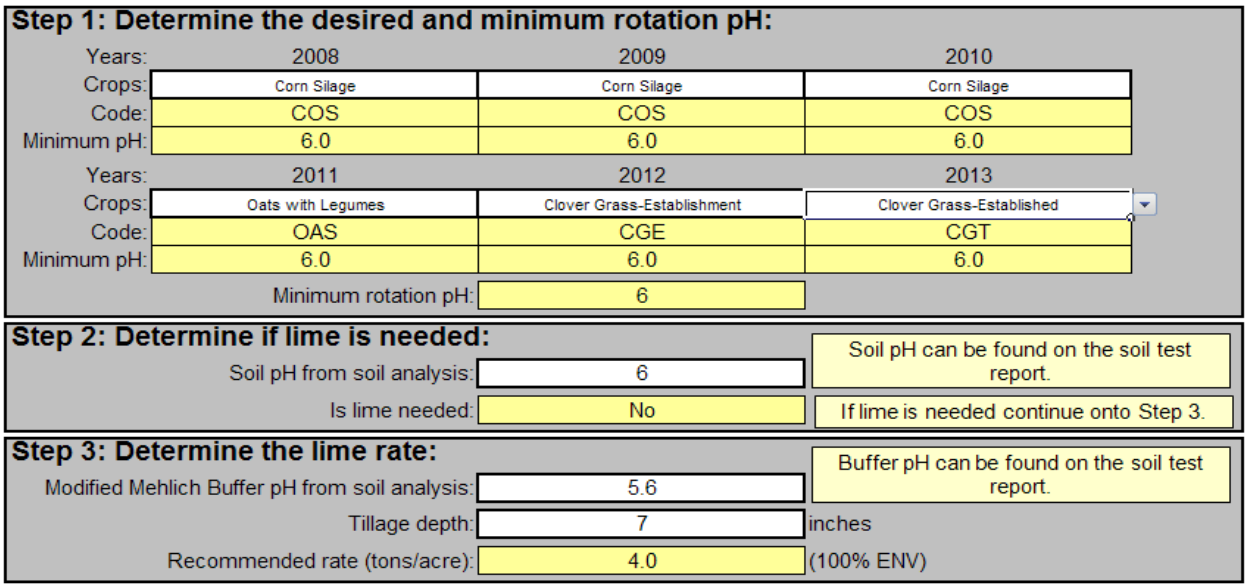


Figure 16: Answer key to 15.

Question (16):

- Describe how you would apply the lime (timing, application strategy, etc.).

Answer (16):

- The lime could be applied in split applications of 4 tons plowed into the soil when the oats and clover are seeded and then 3 tons applied to the surface in the fall of 2012 after the last cutting is removed from the field. Alternatively this could be a field in which alfalfa or soy is never planted.

Farm Advising

You have been the crop advisor for a small dairy farm for a number of years. You stop by the farm one afternoon and the farm manager tells you he has found a cheap lime source that is also supplying some micronutrients. It is wood ash from a nearby plant and the farmer tells you he can get it for $6.00 per ton. He tells you he plans on applying 3-4 tons per acre for two years to corn ground just prior to seeding to alfalfa (he has a standard 4 years of corn and 4 years of alfalfa rotation). You are curious to find out more about it. The farmer shows you the pile of fine-textured ash and you grab a sample and get it analyzed. The results are interesting (Figure 17 (Figure 12 in the Tutorial Workbook).

Question (17):

- Use the laboratory analyses (Figure 12) and all that you have learned in this module as well as the calculator to come up with what you might say to the farmer the next time you are on the farm (HINT: it is fine-textured so make some liberal estimates on the fineness factors of the material).

Answer (17):

- This material will not work very well to change pH.
- Prior to seeding a pH test should be pulled to check if the pH is in line for alfalfa and not assume the 6-8 tons of material applied per acre in the previous two years took care of any pH issues- he may not like the results of his seedings on fields that actually need to raise the pH.
- This material is prohibitively costly in addition to impractical to use as a lime source because the low %ENV would dictate that many multiple tons be applied per acre.

	Cornell Nutrient Analysis Laboratory									
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fax 607-2557656										
Email: soiltest@cornell.edu										
Web:http://cnal.cals.cornell.edu/soiltest										
lime analysis										
FN22010										
Data submission:06/12/2009										
Date reported:07/16/2009										
< det = below detection limit										
Sample			**Maletta**				**Chemical Composition**			
							Element	**Concentration mg /Kg**		
							data on as received base			
							Sample Name Malette			
							Al	**4261.80**		
							P	**1129.54**		
							S	**1393.70**		
							Ti	**99.18**		
							Mn	**884.79**		
Moisture (%)			**2.67**				**Fe**	**4178.33**		
							Co	**2.36**		
							Ni	**1.01**		
CaCO3 equivalent (%)*			**12.68**				**Cu**	**10.43**		
CaCO3 equivalent (%)**			**12.35**				**Mo**	**<det**		
							Pb	**<det**		
							Cd	**2.91**		
							Na	**618.36**		
							Mg	**2396.01**		
							K	**6186.63**		
							Ca	**20556.90**		
							As	**<det**		
							V	**7.80**		
							B	**27.33**		
							Cr	**5.11**		
							Zn	**436.26**		
							Sr	**88.86**		
							Li	**1.86**		
***Analysis based on dry sample. (ie. sample - moisture content)**							**Be**	**<det**		
****Analysis based on wet sample. (ie. sample + moisture content)**							**Ba**	**203.88**		
*****Amount needed to be equivalent to 1 ton of limestone**										

Figure 17 (Figure 12 in tutorial workbook): Laboratory analyses of the wood ash in question 17.

Step 1: Determine the desired and minimum rotation pH:

Years:	2008	2009	2010
Crops:	Corn Silage	Corn Silage	Corn Silage
Code:	COS	COS	COS
Min pH:	6.0	6.0	6.0
Years:	2011	2012	2013
Crops:	Alfalfa-Establishment	Alfalfa-Established	Alfalfa-Established
Code:	ALE	ALT	ALT
Min pH:	6.7	6.7	6.7

Minimum rotation pH: 6.7

Step 2: Determine if lime is needed:

Soil pH from Soil Analysis:	6.5	Soil pH can be found on the CNAL lab analysis.
Is lime needed:	Yes	If lime is needed continue onto Step 3.

Step 3: Determine the lime rate:

Buffer pH from Soil Analysis:	6.2	Buffer pH can be found on the CNAL lab analysis.
Tillage Depth:	7	in. (1-12in.)
Recommended rate (tons/acre):	1.3	(100% ENV)

Step 4: Adjust rates for lime source characteristics (%ENV) and evaluate costs.

If %ENV is unknown, leave blank and fill in 20 and 100 mesh boxes and CCE box.

Lime Material Name	Wood Ash: Cheap Lime + Micros	
Reported %ENV:		
or		
% passing 20 Mesh:	99.0%	
% passing 100 Mesh:	98.0%	
Calcium Carbonate Equivalent(CCE):	12.7%	
Calculated or Reported %ENV:	12.5%	
Cost per ton of lime material	$6.00	
Cost per ton of effective neutralizing power	$47.99	
Choose which lime material to continue with	Yes	

Step 5: Lime Material, Application Rate and Timing Guidelines

Number of Acres:	1.0	
Lime Material	Wood Ash: Cheap Lime + Micros	
Actual Application Rate:	**14.1**	**tons/acre**
Amount Needed for Entire Field :	**14.1**	**tons**
Total Cost:	**$84.89**	

Figure 18: Answer key for question 17.

Teaching Guide

This exercise should illustrate actual conditions that farm advisors are often planning under. They often need to make recommendations based on 100% ENV and then allow the crop manager to make adjustments to the recommendations when material is purchased. The Lime Guidelines for Field Crops calculator can help make recommendations, teach the importance of making adjustments from 100% ENV, and also provide the crop manager an easy way to compare the cost of different materials and make the necessary adjustments to lime recommendations.

Whole Farm pH Management Plan

Action 10: Put together a pH management plan for this farm by completing the Lime Report:

ID	Acres	Current Crop	Future Crop 1	Future Crop	Future Crop	Soil pH	Buffer pH	Tillage Depth
			Yr 1	Yr 2	Yr 3			inches
Home 1	25.0	SOY	COG	COG	COG	5.3	6.0	7
Home 2	10.0	COG	COS	SOY	OAS	5.4	5.9	7
Home 3	15.0	COG	ALE	ALT	ALT	5.8	6.1	7
Home 4	11.0	ALT	COS	COG	COG	5.3	5.8	7
Home 5	4.0	COS	COG	COG	ALE	5.3	5.4	7
Back 1	12.0	AGT	COS	COS	COG	5.7	6.0	7
Back 2	12.0	ALT	ALT	ALT	COG	6.0	6.0	7
Back 3	7.0	COG	SOY	ALE	ALT	7.0	6.2	7
Back 4	10.0	COG	SOY	ALE	ALT	7.0	5.2	7

ID	Lime (T/ac)	Lime (tons)	Application Notes
Home 1	2.7	66.5	Soy requires a minimum pH of 6.7 for optimal growth
Home 2	4.0	40	Soy requires a minimum pH of 6.7 for optimal growth
Home 3	1.3	20	Alfalfa requires a minimum pH of 6.7 for optimal growth
Home 4	5.3	58.5	Consider a seeding of grass or clover in place of alfalfa on this field, Ag Lime needed = 5.3 T/a
Home 5	10	40	Consider a seeding of grass or clover in place of alfalfa on this field, Ag Lime needed = 10 T/a!!!
Back 1	2.7	31.9	Alfalfa requires a minimum pH of 6.7 for optimal growth
Back 2	2.7	31.9	Alfalfa requires a minimum pH of 6.7 for optimal growth
Back 3	0.0	0.0	
Back 4	0.0	0.0	
TOTAL		288.7	Apply lime in fall or early spring a minimum of 4-6 months prior to crop with the highest pH requirement .Crops with highest pH requirement are highlighted in pink. If the application is greater than 6 T/a then apply in two applications allowing 6-12 months for first lime application to react prior to seeding crop with highest pH requirement. All recommendations are based on 100% ENV, divide the tons needed by the %ENV of the lime material purchased to get rates for different lime materials available for purchase.

Figure 19: Lime report.

Question (18):

- What adjustments will the crop manager need to make to use these recommendations?

Answer (18):

- They will need to adjust them for the actual % ENV of the material they purchase.

Appendix

Table 1: Crops, Cornell crop codes, desired pH and minimum pH.

Crops	Cornell Crop Code	Desired pH	Minimum pH
Alfalfa/Trefoil/Grass Mixture-Establishment	ABE	7.0	6.7
Alfalfa/Trefoil/Grass Mixture-Established	ABT	7.0	6.7
Alfalfa/Grass Mixture-Establishment	AGE	7.0	6.7
Alfalfa/Grass Mixture-Established	AGT	7.0	6.7
Alfalfa-Establishment	ALE	7.0	6.7
Alfalfa-Established	ALT	7.0	6.7
Birdsfoot trefoil/Clover-Establishment	BCE	6.5	6.4
Birdsfoot trefoil/Clover-Established	BCT	6.5	6.4
Birdsfoot trefoil/Grass-Establishment	BGE	6.5	6.4
Birdsfoot trefoil/Grass-Established	BGT	6.5	6.4
Birdfoot trefoil Seed-Establishment	BSE	6.5	6.4
Birdsfoot trefoil Seed-Established	BST	6.5	6.4
Birdsfoot trefoil-Establishment	BTE	6.5	6.4
Birdsfoot trefoil-Established	BTT	6.5	6.4
Spring Barley	BSP	6.5	6.4
Spring Barley with Legumes	BSS	6.5	6.4
Wheat	WHT	6.5	6.4
Triticale Peas	TRP	6.5	6.4
Sunflower	SUN	6.5	6.4
Buckwheat	BUK	6.2	6.0
Clover Grass-Establishment	CGE	6.2	6.0
Clover Grass-Established	CGT	6.2	6.0
Clover Seed Production-Establishment	CSE	6.2	6.0
Clover Seed Production-Established	CST	6.2	6.0
Corn Silage	COS	6.2	6.0
Corn Grain	COG	6.2	6.0
Crownvetch-Establishment	CVE	6.2	6.0
Crownvetch-Established	CVT	6.2	6.0
Grasses Intensively Managed-Establishment	GIE	6.2	6.0
Grasses Intensively Managed-Established	GIT	6.2	6.0
Grasses-Establishment	GRE	6.2	6.0
Grasses-Established	GRT	6.2	6.0
Pasture	PGE	6.2	6.0
Pasture Improved Grasses	PGT	6.2	6.0
Pasture Intensively Grazed-Establishment	PIE	6.2	6.0
Pasture Intensively Grazed-Established	PIT	6.2	6.0
Pasture with Legumes-Establishment	PLE	6.2	6.0
Pasture with Legumes-Established	PLT	6.2	6.0
Pasture Native Grasses	PNT	6.2	6.0
Rye Cover Crop	RYC	6.2	6.0
Rye Seed Production	RYS	6.2	6.0

Crops	Cornell Crop Code	Desired pH	Minimum pH
Millet	MIL	6.2	6.0
Oats with Legumes	OAS	6.2	6.0
Oats	OAT	6.2	6.0
Sorghum Forage	SOF	6.2	6.0
Sorghum Grain	SOG	6.2	6.0
Sorghum/Sudangrass Hybrid	SSH	6.2	6.0
Sudangrass	SUD	6.2	6.0
Soy	SOY	7.0	6.7
Wheat with Legumes	WHS	6.2	6.0

Table 2: Lime adjustments for depth in tilled systems.

Actual tillage depth	Tillage depth for equation	Multiplier for equation
----------Inches----------	----------Inches----------	
0-1	6	1.00
0-2	6	1.00
0-3	6	1.00
0-4	6	1.00
0-5	6	1.00
0-6	6	1.00
0-7	8	1.33
0-8	8	1.33
0-9	10	1.67
0-10	10	1.67
0-11	10	1.67
0-12	10	1.67

Table 3: Buffer pH reference table.

Modified Mehlich Buffer pH	Desired rotation pH (minimum pH)			
	7.0 (6.7)	6.8 (6.6)	6.5 (6.4)	6.2 (6.0)
	tons/acre (100%ENV)			
5.0	11.0	10.0	8.5	6.5
5.1	10.0	9.0	7.5	6.0
5.2	9.0	8.0	7.0	5.5
5.3	8.0	7.5	6.0	5.0
5.4	7.5	6.5	5.5	4.0
5.5	6.5	6.0	4.5	3.5
5.6	5.5	5.0	4.0	3.0
5.7	4.5	4.0	3.0	2.5
5.8	4.0	3.5	2.5	1.5
5.9	3.0	2.5	2.0	1.0
6.0	2.0	1.5	1.0	0.5
6.1	1.0	1.0	0.5	0.5
6.2	1.0	0.5	0.5	0.5
6.3	1.0	0.5	0.5	0.5
6.4	1.0	0.5	0.5	0.5
6.5	1.0	0.5	0.5	0.5

Agronomy Fact Sheets

Soil pH for Field Crops

The pH of a soil is among the most important soil characteristics for crop production. The pH of a soil is a measure of the activity of hydrogen (H^+) ions in the soil solution usually obtained by shaking soil with distilled water. Mathematically, the pH is the negative logarithm of the hydrogen ion activity of a soil which means that for each unit increase in pH there is a 10 times change in acidity (so a soil with a pH of 5 is 10 times more acid than a soil with a pH of 6 and 100 times more acid than a soil with a pH of 7). A soil with a pH value of 7 or greater is called an alkaline or basic soil. If the pH is less than 7, the soil is called acidic.

As soils become increasingly acidic (decreasing pH), important nutrients like phosphorus become less available to plants (Figure 1). Other elements, like aluminum, become more available and may actually become toxic to the plant, resulting in reduced crop yields. Liming to optimum pH not only increases the availability of essential nutrients, but also supplies additional calcium and magnesium, improves soil conditions for microorganisms, increases the effectiveness of triazine herbicides, and improves soil structure.

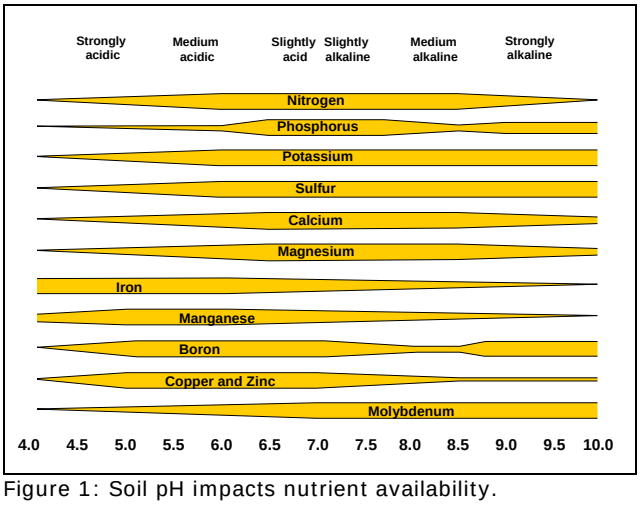

Figure 1: Soil pH impacts nutrient availability.

The pH of most calcareous soils (soils containing free calcium carbonates such as Honeoye, Lima, Ontario, and Kendaia soils) in the New York lime belt (soils commonly found along Interstate 90 from Buffalo to Albany) ranges from 7-8.5. Non-calcareous agricultural soils in New York vary from pH 4.5 to 7.

In humid climates such as we have in New York State, the leaching of calcium, magnesium, potassium and sodium ions naturally causes a decrease in pH over time because they leave the soil clays dominated by H^+ and aluminum ions (Al^{3+}). Human activity can change the pH of a soil too; the addition of most nitrogen fertilizers and organic nutrient sources (compost and manure) leads to formation of nitric acid (HNO_3) and/or sulfuric acid (H_2SO_4). Both are strong acids that cause an increase in soil acidity (i.e. a decrease the pH of the soil).

The soil pH ranges recommended for field crops are given in Table 1. It is important to test soil to determine if the pH is within the desired range. If a desirable pH is not maintained, increased yield expected from new varieties can not be realized. Extra fertilizer can not fix a problem caused by low pH either.

Table 1: Ranges and recommended soil pH for optimal growth of various field crops in New York.

Crop Species	Normal growth pH range	Recommended pH range
Alfalfa	6.5 to 7.5	6.6 to 7.0
Barley	6.3 to 7.0	6.3 to 6.5
Birdsfoot trefoil	6.0 to 7.0	6.3 to 6.5
Clovers	5.8 to 7.0	5.8 to 6.2
Corn	5.8 to 7.0	5.8 to 6.2
Grasses	5.8 to 7.0	5.8 to 6.2
Oats	5.8 to 7.0	5.8 to 6.2
Soybeans	6.5 to 7.5	6.6 to 7.0
Wheat	6.3 to 7.0	6.3 to 6.5

Testing for soil pH

It is recommended to test each field for soil pH and fertility at least once in 3 years or twice per rotation. Take a minimum of 10-15 sub-samples from across a field (identified as a

unit differing from its neighbors in crop growth, soil type or past management usually not more than 10 acres in size). Grid-based sampling is recommended for larger fields where lime may be needed because for such fields, variable rate lime application of lime can have economic and environment benefits. Sampling should be done at least once in a rotation or every 5 to 8 years. A description of grid sampling can be found in the Cornell Guide for Integrated Field Crop Management (www.fieldcrops.org – 2.10.6).

Under minimum or no-tillage systems, the surface inch of the soil may become acid more rapidly than the original 0-8 inch plow layer. Thus, in no-tillage systems, the pH values of two soil layers (0-1 and 0-6 inches) should be determined. If soil pH of the surface 0-1 inch depth is low, but the pH of the 0-6 inch layer is adequate, lime addition is recommended to raise the pH of the soil surface. If both layers are strongly acidic, avoid no-tillage methods for the establishment of legumes until lime has been given 6 to 9 months to react with the soil. If the surface (0-1 inch depth) pH is adequate, but the 0-6 inch soil zone has a low pH, legumes could be no-till seeded into the soil without waiting as long for the lime to react as when both zones have a low soil pH.

For the most accurate pH determination, the soil sample should be submitted to an analytical laboratory such as the Cornell Nutrient Analysis Laboratory. A pH measurement is included if a general soil fertility assessment is requested. The pH of the soil can also be tested in the field using a Cornell pH test kit (Figure 2). For an experienced user, this field pH kit is accurate within 0.2 pH units.

When the soil pH is below 6, a complete soil test is recommended for the most accurate pH and lime recommendations. Soil pH kits, soil sample bags and instructions for the complete soil test can be obtained from your local Cornell Cooperative Extension office or directly from the laboratory:

Cornell Nutrient Analysis Laboratory
G01 Bradfield Hall, Cornell University
Ithaca, NY 14853
http://www.css.cornell.edu/soiltest

Order forms can be obtained from the website or by contacting the laboratory by phone: 607-255-4540, fax: 607-255-7656, or e-mail: soiltest@cornell.edu.

Figure 2: Cornel pH test kit allows for rapid assessment of soil pH.

A pH measurement tells us if lime is needed. The amount to be added depends on the capacity of the soil to buffer changes in pH with the addition of lime and the composition of the liming materials. This will be explained in more detail in fact sheets #6 (lime recommendations) and #7 (liming materials).

Take-home message

Monitor soil pH on a regular basis (once every 3 years or twice during a rotation) for optimum crop management and yield.

Additional resources

- Cornell Guide for Integrated Field Crop Management: www.fieldcrops.org.
- Cornell University Agronomy Fact Sheet #1 (Soil sampling for field crops); #6 (Lime recommendations); #7 (Liming materials). nmsp.css.cornell.edu/publications/factsheets.asp.
- Cornell Nutrient Guidelines for Field Crops: nmsp.css.cornell.edu/nutrient_guidelines.
- Cornell Nutrient Analysis Laboratory: www.css.cornell.edu/soiltest.

For more information

Cornell University
Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu
Quirine M. Ketterings, Greg Albrecht, Jen Beckman

2005

Lime Recommendations for Field Crops

For optimum production of field crops in New York, it is important to test fields for soil pH at least once every 3 years and to add lime if the pH is below the optimum range for the crops in the rotation. However, a pH measure only tells us if lime is needed, not how much is needed. In this fact sheet, we will explain how lime recommendations are calculated.

What Happens When We Lime

Soil particles are negatively charged and have many different sites where positively charged particles can attach. These sites are referred to as cation exchange sites because they attach positively charged cations such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), hydrogen (H^{+}) and aluminum (Al^{3+}). Cations can be classifed as basic (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) or acid (such as H^{+} and Al^{3+}). If released into the soil solution, basic cations will raise the pH. Acid cations will lower pH when released into the soil solution. In order to raise the soil pH, the acid cations have to be removed from the cation exchange sites and neutralized. When a liming material such as calcium carbonate is added to the soil, the calcium replaces the H^{+} and/or Al^{3+} on the exchange sites and the carbonate acts to neutralize the H^{+} and Al^{3+}.

Different Forms of Soil Acidity

The amount of lime to be added depends on soil texture and organic matter content which affect the soil's capacity to buffer changes in pH. A soil with a large buffer capacity (more clay size particles and/or organic matter) will need more lime to neutralize acidity than a soil with a small buffer capacity. The buffer capacity of the soil is determined by its total acidity which is the sum of three different forms of soil acidity:

1. Active acidity (pH).
2. Salt-replaceable acidity.
3. Residual acidity.

Active acidity reflects the hydrogen (H^{+}) ion activity in the soil solution and is measured as the soil's pH. To neutralize only the active acidity, very little calcium carbonate would be needed. However, such a change would be very short-lived because of the existence of salt-replaceable and residual acidity. Salt-replaceable acidity and residual acidity can be described as the soil's capacity to resist change in the soil solution pH. Salt-replaceable acidity is the H^{+} and Al^{3+} activity in solution when shaken with a neutral (pH 7) salt solution. The amount of lime needed to neutralize this acidity is much greater than what would be needed to neutralize the active acidity. Residual activity is associated H^{+} and Al^{3+} ions that are bound non-exchangeably to organic matter and clays. This acidity needs the greatest amounts of lime to be neutralized. Because the active acidity (pH) is only a fraction of the total potential acidity in the soil, a pH measurement can only tell you whether or not lime addition is needed, not how much is needed. We need a measure of the soil's "buffer capacity" to determine the amount of lime needed to increase the pH.

Measuring Exchangeable Acidity

In the Cornell Nutrient Analysis Laboratory, the buffer capacity of a soil is determined by its amount of exchangeable acidity (EA). Exchangeable acidity is the total potential acidity present in the soil between its actual pH and pH 8.2.

Determining Lime Recommendations

Lime recommendations depend on:

1. Current and desired pH.
2. Exchangeable acidity.
3. Base saturation of the soil at the current and at the desired pH.
4. Tillage depth.

Base saturation is the amount of basic cations divided by the total cation exchange capacity (total number of cation exchange sites). So, if the base saturation is 0.75, 75% of the cation exchange capacity is occupied by Ca^{2+}, Mg^{2+}, K^{+} and/or Na^{+} while 25% is exchangeable acidity. For soils with a pH of 6.0 or lower, the lime recommendation is determined by the

exchangeable acidity, base saturation at the original pH and at the desired pH, and the tillage depth (TD, inches):

$$\text{Lime Req.} = EA * 0.5 * \frac{(BS_{desired} - BS_{original})}{(1 - BS_{orginal})} * (TD/6)$$

Where the pH of the soil is 6.1 or higher, the exchangeable acidity is negligible but there is still residual acidity. For these soils, the exchangeable acidity measurement needs to be replaced by estimated cation exchange capacity (CEC). The base saturation at the current pH and the desired pH can be determined from Table 1. Estimated CEC for different soils are given in Table 2.

Table 1: Base saturation as affected by soil pH.

pH	Base Saturation (fraction)	pH	Base Saturation (fraction)
<4.5	0.00001	6.3	0.675
4.5	0.021	6.4	0.695
4.6	0.035	6.5	0.710
4.7	0.050	6.6	0.730
4.8	0.073	6.7	0.740
4.9	0.102	6.8	0.755
5.0	0.135	6.9	0.770
5.1	0.171	7.0	0.795
5.2	0.228	7.1	0.812
5.3	0.320	7.2	0.830
5.4	0.420	7.3	0.847
5.5	0.480	7.4	0.863
5.6	0.515	7.5	0.880
5.7	0.540	7.6	0.900
5.8	0.570	7.7	0.925
5.9	0.600	7.8	0.950
6.0	0.620	7.9	0.975
6.1	0.635	>7.9	1.000
6.2	0.655		

Table 2: Cation exchange capacity (CEC) is determined by the soil management group (SMG).

SMG	General Description	CEC $cmol_c/kg$
1	Fine-textured soils developed from clayey lake sediments and medium- to fine-textured soils developed from lake sediments.	25
2	Medium- to fine-textured soils developed from calcareous glacial till, medium- to moderately fine-textured soils developed from slightly calcareous glacial till mixed with shale, and medium-textured soils developed in recent alluvium.	20
3	Moderately course textured soil developed from glacial outwash or recent alluvium and medium textured acid soil developed on glacial till.	18
4	Course- to medium-textured soils formed from glacial till or glacial outwash.	16
5	Course- to very course-textured soils formed from gravelly or sandy glacial outwash or glacial lake beach ridges or deltas.	12
6	Organic or muck soils with more than 80% organic matter.	12

Lime Recommendations for No-Till

The lime equation shows that the lime recommendation will increase if the tillage depth is greater than 6 inches. In a no-till system soil is not mixed and the pH values of two soil layers (0-1 and 0-6 inches) need to be considered. Depending on the results, three management options are possible:

- If the pH of the surface 0-1 inch is low, but the pH of the 0-6 inch zone is adequate, add 1 to 1½ tons of lime per acre to raise the pH of the soil surface.
- If both layers are strongly acidic do not use no-tillage methods for the establishment of legumes until lime has been given 6 to 9 months to react with the soil.
- If the surface (0-1 inch depth) pH is adequate, but the 0-6 inch soil zone has a low pH, legumes might be no-till seeded with a slightly lower overall pH or without waiting as long for the lime to react as when both zones have a low soil pH.

In Summary

Soil pH will tell us if lime is needed. Lime recommendations will vary from one field to another depending on current pH and desired pH, the capacity of the soil to buffer changes in pH (expressed as exchangeable acidity of CEC), and tillage depth. The Cornell Nutrient Analyses Laboratory (CNAL) will generate lime recommendations based on soil analyses and crop rotations and report them on a 100% Effective Neutralizing Value (ENV) basis. To determine actual application rates, recommended lime rates need to be divided by the ENV of the liming material (see Agronomy Fact Sheet #7 for details on liming materials).

Additional Resources

- Agronomy Fact Sheet #1 (Soil sampling for field crops); #5 (Soil pH); #7 (Liming materials). nmsp.css.cornell.edu/publications/factsheets.asp.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu
Quirine Ketterings, Kristen Stockin, Jen Beckman, Jeff Miller
2006

Liming Materials

Introduction

A liming material can bring the pH of a soil to optimum levels for crop production if used properly. Liming materials also provide calcium (Ca) and/or magnesium (Mg) to the soil for plant uptake. In Agronomy Fact Sheets 5 and 6, soil pH and lime recommendations were discussed. In this Fact Sheet, considerations of quality, cost, availability, and material handling will be discussed to enable selection of the liming material that best fits the lime requirements of the farm.

Liming Material Quality Parameters

Materials that can cause an increase in pH include carbonates, oxides or hydroxides of calcium and magnesium. When looking at liming materials it is often hard to distinguish one material from another. Quality standards used to differentiate liming materials include Total Neutralizing Value (TNV), Calcium Carbonate Equivalence (CCE), Fineness, and Effective Neutralizing Value (ENV). Water is sometimes added to dry limestone to improve the handling characteristics of the ground limestone. The moisture content of agricultural limestone does not influence its effectiveness but a moisture content between 4 and 5% will improve the spreading uniformity and reduces the off site movement of very fine particles (<100 mesh).

Total Neutralizing Value (TNV)

This is the percentage of the material that can neutralize acid expressed as the calcium carbonate equivalence (CCE) of the product.

Calcium Carbonate Equivalence (CCE)

This standard compares the liming material to pure calcium carbonate ($CaCO_3$). Some materials such as hydrated lime and burned lime will have a CCE higher than 100%. Pure magnesium carbonate ($MgCO_3$) will neutralize about 1.2 times more acidity than $CaCO_3$ so dolomitic limestone will have a higher CCE than calcitic limestone (Table 7). All liming materials include some inert material that will not be able to increase the pH of the soil. The inclusion of such inert material will reduce the CCE of the material as compared to pure materials.

Table 1: Calcium carbonate equivalent (CCE) of a few common liming materials.

Common name	Chemical formula	CCE
Calcitic limestone	$CaCO_3$	100
Dolomitic limestone	$CaMg(CO_3)_2$	109
Burned lime, quick lime	CaO	179
Hydrated or slaked lime	$Ca(OH)_2$	136

Assuming 100% pure material.

Fineness

The rate of reaction of a liming material is determined by the particle sizes of the material; 100% of lime particles passing a 100-mesh screen will react within the 1st year while only 60% of the liming materials passing a 20-mesh sieve (but held on 100 mesh sieve) will react within a year of application. Material that does not pass the 20 mesh sieve is not expected to react within a 1 year following application. So, to be of practical use, limestone CCE equivalents need to be adjusted for the fineness of the material. To determine the fineness of a limestone the following calculations need to be done:

- Subtract the % passing a 100 mesh sieve from the % passing a 20 mesh sieve and multiply this difference with 0.60.
- Add the % passing the 100 mesh sieve and divide the sum by 100.

Thus, the fineness of a material of which 70% passes a 100 mesh sieve and 97% passes a 20 mesh sieve is {(97-70)*0.60 +70}/100=0.86.

Effective Neutralizing Value (ENV)

The ENV is the fraction of the material's CCE that will react with soil acidity in the first year of application. The ENV is calculated by multiplying a liming material's CCE and its fineness. As an example: a liming material with CCE of 90% and a fineness of 0.86 has an ENV of 90*0.86= 77.4.

Liming Material Identification

In New York, the Department of Agriculture and Markets (NYSDAM) regulates agricultural liming materials. Liming materials are defined as "all materials and all calcium and magnesium products in the oxide, hydrate, carbonate, silicate form or combinations thereof and intended for use in the correction of soil acidity…". Liming materials must be registered with the NYSDAM. This process ensures that the product will meet minimum quality standards set by NYSDAM: a liming material must have ≥60% CCE, ≥80% must pass a 20 mesh sieve, and ≥30% should pass a 100 mesh sieve (this implies the ENV should be ≥36%). Liming materials sold in bags must have a label that includes:

- Name and address of the company registering the product.
- Brand name.
- Type of material (limestone, marl, oxide, hydrate, shells, industrial by-products).
- TNV as expressed by the CCE.
- Minimum fineness at delivery.
- Amount and types of foreign material in the package if any.
- If the product has been damaged or otherwise changed after original packaging, a label must be provided explaining the kind and degree of alteration.
- Net weight being sold.
- A guarantee of the weight % of Ca and Mg.
- Particle size distribution (100, 20 mesh).

Materials sold in bulk must have:

- A guarantee of the %ENV.
- The weight of the bulk material necessary to equal one ton of lime with 100% ENV.

Various Liming Materials

Ground limestone is usually mined and then pulverized or ground into finer particle sizes to increase the ENV of the material. Ground limestone usually contains $CaCO_3$ and some impurities. However, some limestones will also include $MgCO_3$. Ground limestones make up the majority of lime that is sold in NY. Ground limestone with less than 1-6% Mg is called "calcitic limestone". If the limestone has 6% Mg or more it is called "Dolomitic Limestone".

Burned lime (also called quicklime) is ground limestone that has been exposed to high temperatures to remove carbon dioxide. Calcium oxide (CaO) is what remains after the process. Pure calcium oxide has a CCE of 178% and reacts quickly (powdery lime material). Magnesium oxide (MgO) will also be present if it was present in the ground limestone prior to being cooked. Burned lime must be handled carefully as it quickly reacts with water creating hydrated lime and releasing large amounts of heat.

Hydrated lime is calcium hydroxide ($Ca(OH)_2$). This is a very fast acting and powdery lime material. This material is caustic and can easily burn plants that are already established. Finely ground hydrated lime can have an ENV of 120-135% and if too much is applied the soil pH could quickly rise beyond the targeted pH.

Marls are composed of sea shell fragments, and $CaCO_3$. They are often found and used around coastal areas. Marls tend to react similarly to ground limestones.

Cost Effectiveness

The best way to economically compare two lime products is to look at the cost per ton of ENV obtained by dividing the cost per ton of limestone by the ENV. If the ENV is not listed (as is the case with some packaged lime products) the ENV needs to be calculated from the CCE and particle size distribution.

In Summary

Liming materials vary greatly in quality. To select the most economic liming material, compare products based on cost per ton ENV.

Additional Resources:

- Agronomy Fact Sheet #1 (Soil sampling), #5 (Soil pH); #7 (Lime recommendations for field crops): http://nmsp.css.cornell.edu/publications/factsheets.asp
- Lime guidelines for field crops in New York: http://nmsp.css.cornell.edu/nutrient_guidelines/.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu

Peter Carey, Quirine Ketterings, and Mike Hunter

2006

Buffer pH to Derive Lime Guidelines

Introduction

Lime is recommended if the soil pH is below the optimum range for the crops in the rotation, where the minimum pH of the rotation is determined by the crop with highest desired pH. A pH measurement can only tell us whether or not liming of the soil should be considered. We need a measure of the soil's "buffer capacity" or ability to counteract a pH change upon lime addition to determine how much lime is needed. In Agronomy Factsheet #6 (Lime Recommendations for Field Crops) it is explained how lime recommendations can be derived from a measure of the soil's exchange acidity. In 2009, we introduced a new recommendation system based on a buffer pH measurement. In this factsheet we explain how to derive lime recommendations based on buffer pH measurements.

Buffer pH

The laboratory methodology used to determine exchangeable acidity (EA) at Cornell University until 2009 produces a toxic waste. It is also a time-consuming and hence expensive analysis. In the past several decades researchers conducted lime studies to develop and evaluate analytical alternatives to the EA method. Requirement was that the alternative methods would be (1) accurate and (2) rapid, and therefore better suited for routine soil analyses. Several buffers were introduced (e.g. SMP buffer, Sikora buffer, Mehlich buffer, Modified Mehlich buffer). Using 43 New York State agricultural soils, we tested if these buffers could accurately predict lime needs. The modified Mehlich buffer (which contains $CaCl_2$ instead of $BaCl_2$) was selected as the most accurate, non-toxic, alternative to the exchangeable acidity method.

Calculating Lime Rates using the Modified Mehlich Buffer pH

Lime recommendations can be calculated once the initial soil pH, target rotation (crops) pH and the soil's buffer pH are known. The process involves five simple steps:

Step 1: Determine the desired and minimum rotation pH:

A rotation is defined as a 6-year crop sequence (3 years past, 3 years ahead). The desired pH for common field crops grown in New York State is shown in Table 1. The crop with the highest desired pH will determine the desired/target pH for the entire rotation. For example, for a three year corn and three year alfalfa/grass rotation, the crop with the highest desired pH is alfalfa/grass and, as a result, the desired pH for the rotation is 7.0.

Table 1: Minimum and desired pH for common field crops in New York State.

Crops	Cornell crop codes	Desired pH	Minimum pH
Alfalfa, alfalfa/grass, alfalfa/trefoil	ABE,ABT,AGE, AGT,ALE,ALT	7.0	6.7
Soybeans	SOY	7.0	6.7
Birdsfoot trefoil	BCE,BCT,BGE, BGT,BSE,BST, BTE,BTT	6.5	6.4
Barley	BSP, BSS	6.5	6.4
Wheat	WHT	6.5	6.4
Triticale	TRP	6.5	6.4
Sunflower	SUN	6.5	6.4
Buckwheat	BUK	6.2	6.0
Clover	CGE,CGT,CLE, CLT,CSE,CST	6.2	6.0
Corn	COS,COG	6.2	6.0
Crownvetch	CVE,CVT	6.2	6.0
Grass	GIE,GIT,GRE, GRT	6.2	6.0
Pasture	PGE,PGT,PIE, PIT,PLE,PLT, PNE,PNT	6.2	6.0
Rye	RYC, RYS	6.2	6.0
Millet	MIL	6.2	6.0
Oats	OAS,OAT	6.2	6.0
Sorghum, sorghum sudangrass	SOF,FOG, SSH,SUD	6.2	6.0
Wheat with legume	WHS	6.2	6.0

Step 2: Determine if lime is needed:
No lime is recommended if the soil pH is above the desired pH. No lime is recommended if the soil pH is below the desired pH but above the minimum pH as applications would not be economical (but test the soil again in 2-3 years). If the soil pH is lower than the minimum rotation pH, go to step 3.

Step 3: Determine the lime rate:
If the soil pH is less than the minimum rotation pH, the recommended lime rate can be read from Table 2 using the soil's buffer pH and the desired rotation pH (note: soil pH will tell you if lime is needed; buffer pH tells you how much is needed). For example, if the buffer pH is 5.5 and desired rotation pH is 6.5, 4.5 tons/acre lime is recommended. Lime rates in Table 2 assume liming material with 100% Effective Neutralizing Value (ENV).

Table 2: Lime recommendations for soil with a pH less than the minimum pH for the rotation.

Modified Mehlich Buffer pH	Desired rotation pH (minimum pH)			
	7.0 (6.7)	6.8 (6.6)	6.5 (6.4)	6.2 (6.0)
	------ tons/acre (100%ENV) -------			
5.0	11.0	10.0	8.5	6.5
5.1	10.0	9.0	7.5	6.0
5.2	9.0	8.0	7.0	5.5
5.3	8.0	7.5	6.0	5.0
5.4	7.5	6.5	5.5	4.0
5.5	6.5	6.0	4.5	3.5
5.6	5.5	5.0	4.0	3.0
5.7	4.5	4.0	3.0	2.5
5.8	4.0	3.5	2.5	1.5
5.9	3.0	2.5	2.0	1.0
6.0	2.0	1.5	1.0	0.5
6.1	1.0	1.0	0.5	0.5
6.2	1.0	0.5	0.5	0.5
6.3	1.0	0.5	0.5	0.5
6.4	1.0	0.5	0.5	0.5
6.5	1.0	0.5	0.5	0.5
6.6	1.0	0.5	0.5	0.5

Step 4: Adjust rates for tillage depth.
The recommendations listed in Table 2 assume a 6 to 7 inch tillage depth. For an 8-inch tillage depth, multiply the rates listed in Table 2 by 1.33. For a 10+ inch tillage depth, multiply the rate listed in Table 2 by 1.67.

Step 5: Adjust rates for lime source characteristics (%ENV).
The recommendations listed in Table 2 are on a 100% ENV basis. To adjust for specific materials, divide the recommended lime rate by the percent ENV reported for the lime source. For example, if the recommended lime rate is 4.5 tons/acre and the lime source available is 75% ENV, 4.5 / 0.75 = 6 tons of this liming material should be applied per acre. This is explained in more detail in Agronomy Factsheet #7 (Liming Materials).

In summary

Soil pH management is important for economic and environmentally sound crop production. A soil pH can tell us if lime is needed for a specific rotation. To determine lime rates, a measurement of the soil's buffering capacity is needed. Although direct measures of a soil's exchangeable acidity will always be most accurate to determine lime needs, reliable estimates of lime needs can be obtained from soil buffer pH measurements using the Modified Mehlich buffer. If the soil pH is less than the minimum target pH for the rotation, lime rates can be read from Table 2.

Additional Resources

- Agronomy Factsheet #5 (Soil pH for Field Crops), #6 (Lime recommendations), and #7 (Liming Materials). Nutrient Management Spear Program Agronomy Fact Sheet Series: http://nmsp.cals.cornell.edu/
- Nutrient Guidelines for Field Crops in New York: http://nmsp.cals.cornell.edu/nutrient_guidelines/

Disclaimer

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

Quirine Ketterings, Renuka Rao, Kevin Dietzel, Patty Ristow

2010

Timing of Lime Application for Field Crops

Liming of soils to an optimum pH is important for both crop production and nutrient management. Agronomy fact sheets 5 and 7 addressed pH and liming materials. In agronomy fact sheet 6 the different forms of acidity were explained and it was shown how to derive a lime recommendation from a soil measurement of exchangeable acidity and knowledge of the initial field pH and the crop rotation. In fact sheet 48 we explained how to derive a lime recommendation from a buffer pH measurement. This agronomy fact sheet provides guidance on the timing of sampling for pH management and timing of lime applications for field crop rotations.

Seasonal Fluctuations in Soil pH

Soil temperature and moisture change during a growing season and these changes can impact soil properties such as the pH of a soil. Research has shown that soil pH values tend to be lower in drier summer months and higher in wet spring and winter months (Figure 1).

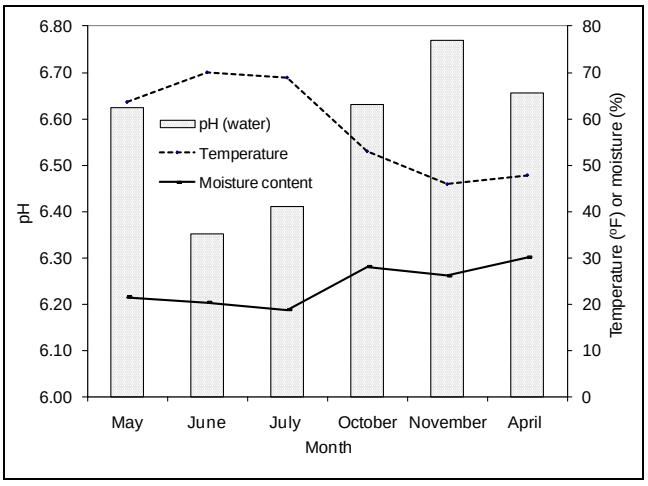

Figure 1: Soil pH tends to be lower in the warmer and drier summer months than in the rest of the year.

This fluctuation in pH can occur for several reasons. First, as the soil dries in the summer months, the salt concentration increases. Soluble cations such as Ca, Mg and K replace exchangeable H^+ or Al^{3+} ions on the surfaces of the soil particles. The H^+ or Al^{3+} ions enter the soil solution which then becomes more acid. In wet months, salt concentrations tend to be lower. In drier conditions oxidation processes (such as conversion of ammonium to nitrate, decomposition of organic matter) can generate acidity as well. In addition, microbial respiration in the warmer months produces more CO_2 which forms carbonic acid, a weak acid that also contributes to a decrease in soil pH. On the other hand, CO_2 is more soluble at lower temperatures so the net effect of CO_2 on soil pH can be variable.

The seasonal trends in soil pH are shown in Figure 1. This figure summarizes the pH trends of twenty New York corn fields and shows an average fluctuation of 0.4 pH unit.

Timing of Sampling and Lime Application

To neutralize only the active acidity (measured as pH), very little lime is needed and the conversion is rapid. However, such a change would be very short-lived because of the existence of salt-replaceable and residual acidity (see fact sheet 6). The amount of lime needed to neutralize salt-replaceable acidity is much greater. As water flows through the soil profile, lime will be carried downward and gradually increase the subsoil pH. This process of pH increase of the soil profile can take years and the only practical method to speed up this process is by mixing lime directly with soil, most commonly through tillage.

Conventional tillage systems

For rotations that include alfalfa or soybeans (crops that have an optimum pH of 7.2), and where the soil pH is 6.0 or less, lime should be applied at least six months before seeding for the lime to react with the entire plow layer. Ideally, lime is applied the spring before alfalfa or soybean is planted to ensure optimal pH in the seeding year. Soil testing for pH management should occur prior to the last crop before alfalfa or soybean, preferably in the fall. For example, in a 4 year corn and 4 year alfalfa rotation the optimal time to sample for soil pH and buffer pH is post harvest in

corn year 3. This allows for lime application that fall or in the spring, prior to the 4th year of corn planting allowing for two plowing cycles.

Lime will react more rapidly if it is worked into the soil, so if there is insufficient time for an adequate reaction with the entire plow layer (i.e. less than two plowings), at least one-half of the recommended lime rate should be added to the surface and disked in before the seeding to provide a favorable pH in the soil zone near the legume seed to encourage good establishment. Smaller applications necessary to maintain a pH above 6.2 or 6.5 can be made at any time before a seeding and can be either applied to the surface or plowed down.

If the soil pH is 5.5 or below, a less sensitive crop such as corn or clover should be planted for a year before planting alfalfa and split applications of lime should be considered. For fields that do not have legumes in the rotation but require lime to maintain a pH of 6.2 or 6.5 for corn, grass or small grains, it is recommended to do the lime application directly after second or third cutting of hay when soils are dry and best able to support heavy lime application equipment, thus minimizing the risk of soil compaction. Also, as the sod re-grows, it will help prevent runoff of the lime should heavy rains occur on fields that are prone to runoff.

No-till systems

Good lime to soil contact will help maximize the effectiveness of liming material. In no-till systems, lime moves into the soil profile at a very slow rate because it is surface applied and not mechanically mixed into the soil and surface. Similarly, it will likely take more time for the entire soil profile to increase in pH upon broadcasting of lime in reduced tillage or vertical tillage systems. Therefore, these systems need to be closely monitored for pH changes over time; soil samples should be taken more frequently and more frequent lime additions might be needed. For no-till or reduced tillage systems, the pH values of two soil layers (0-1 and 0-6 inches) need to be considered and it is recommended to sample the soil for pH, at least a year prior to rotation to a pH sensitive crop like alfalfa or soybeans. As was listed in agronomy fact sheet 6, depending on the results of the pH measurements, there are three management options, each with their own guidance for timing of application:

- If the pH of the surface 0-1 inch is low, but the pH of the 0-6 inch zone is adequate, add 1 to 1½ tons of lime per acre to raise the pH of the soil surface.
- If both layers are strongly acidic do not use no-tillage methods for the establishment of legumes until lime has been given 6 to 9 months to react with the soil.
- If the surface (0-1 inch depth) pH is adequate, but the 0-6 inch soil zone has a low pH, legumes might be no-till seeded with a slightly lower overall pH or without waiting as long for the lime to react as when both zones have a low soil pH.

For a given amount of acidity, a corresponding amount of liming material is needed regardless of the fineness of the material but lime particles passing a 100-mesh screen will react within the 1st year versus a longer reaction time for larger particles. So, if a quick change in pH is needed, a lime source with a high fineness factor (powdery liming material) is recommended.

In Summary

Timing of sampling for soil pH and timing of lime application are two important aspects of proper lime management for optimal crop production.

Additional Resources

- Cornell agronomy fact sheets #1 (Soil sampling for field crops), #5 (Soil pH), #6 (Lime recommendations for field crops), #7 (Liming materials), and #48 (Buffer pH to derive lime guidelines) downloadable from: http://nmsp.cals.cornell.edu/publications/factsheets.asp.

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

Quirine Ketterings, Karl Czymmek, Murray McBride

2010

PI-45A

STATE OF NEW YORK
DEPARTMENT OF AGRICULTURE AND MARKETS
10B AIRLINE DRIVE
ALBANY, NEW YORK 12235

Division of Plant Industry
Phone: (518) 457-2087
Fax: (518) 457-1204

Enclosed is a copy of the Sale of Agricultural Liming Materials Law, Article 9A of the Agriculture and Markets Law, an application for a license to sell a brand of agricultural liming material in New York State, a certificate of registration form for individual brands and the limestone effective neutralizing value (ENV) score card. This license is for a two-year period ending December 31, 2010.

Please complete the license application, the certificate of registration and, the limestone ENV score card for each brand to be sold. The limestone ENV score card details the calculations used by NYSDAM to calculate your ENV if claimed. The ENV as stated on your certificate of registration must be calculated by this method in order for your application to be processed by NYSDAM. This is in rule with Article 9-A, §142-cc. (9).

Please include with your application a copy of the product label for review. Also, please state the Brand name of your product in exact wording as you intend to label your lime product. Information on your certificate of registration must be entered correctly. It cannot be changed once a license is issued. The license cannot be sold or transferred.

The application, copies of the certificate of registration and limestone ENV score card should be returned to this office along with your registration fee ($40.00 per individual brand). Please make your check or money order payable to "The New York State Department of Agriculture and Markets".

We have enclosed a return envelope for your convenience. If you have any questions or need any assistance, please feel free to contact us.

Sincerely,

Jan Morawski

Mr. Jan Morawski
Commodity and Biotechnology Specialist

Enclosures

New York State
Department of Agriculture and Markets
Division of Plant Industry
Albany, New York 12235

CIRCULAR 1026

ARTICLE 9A
OF THE
AGRICULTURE AND MARKETS LAW
relating to
SALE OF AGRICULTURAL LIMING MATERIALS
Revised 2005

ARTICLE 9-A
SALE OF AGRICULTURAL LIMING MATERIALS

Section

Section 142-aa. Definitions and standards.

(a) "Agricultural liming material", means all materials and all calcium and magnesium products in the oxide, hydrate, carbonate or silicate form or combinations thereof and intended for use in the correction of soil acidity, including such forms of material designated as burned lime, hydrated lime, carbonate of lime, agricultural limestone, slag and marl.

(b) "Brand" means each agricultural liming material identified by and differing from others either in name, trademark, descriptive designation or other method of marking, composition, and total neutralizing value or fineness.

(c) "Total neutralizing value" means the neutralizing value of an agricultural liming material expressed as calcium carbonate equivalence as determined in accordance with methods adopted by the commissioner.

(d) "Fineness" means the percentage by weight of the material which will pass sieves of specified number or mesh as established by the commissioner. Fineness shall be measured in reference to a twenty mesh, sixty mesh, and a one hundred mesh sieve, in accordance with methods adopted by the commissioner.

Section 142-bb. Prohibition.

1. No person shall sell, offer or expose for sale, barter give or otherwise supply in this state as an agricultural liming material, except as provided in subdivision two of this section, any product which does not have a minimum total neutralizing value of sixty per centum calcium carbonate equivalence and, except hydrated lime and burned lime, a minimum fineness of eighty per centum passing a twenty mesh sieve and thirty per centum passing a hundred mesh sieve nor for which a certificate of registration has not been filed and a license has not been issued pursuant to this article; nor shall he or she permit any claim or guarantee to be indicated upon any label, tab, or package or accompanying statement to the effect that such material possesses a higher specification than such material does in fact contain; nor shall he or she sell, offer or expose for sale, barter, give or otherwise supply any such material adulterated with any substance injurious to the growth of plants (other than weeds) or animals or humans when applied in accordance with directions for use accompanying the product; nor shall he or she sell, offer or expose for sale any agriculture liming material in this state without a label or accompanying statement and weigh slip as required by section one hundred forty-two-cc.

2. Insofar as it shall be used as an agricultural liming material in this state, no person shall sell, offer or expose for sale, barter, give or otherwise supply in this state as wood ash, any product which does not have a minimum total neutralizing value of thirty per centum calcium carbonate equivalence and otherwise satisfy the requirements set forth in subdivision one of this section.

Section 142-cc. Label or accompanying statement and weigh slip.

No agricultural liming material shall be sold, offered, or exposed for sale, bartered, given or otherwise supplied in this state unless there shall be affixed to each package in a conspicuous place on the outside thereof a plainly printed, stamped or otherwise marked label, tag or statement or in the case of bulk sales or transfers there shall be provided a certified weigh slip plainly printed, stamped or otherwise marked, which shall certify as follows:

1. The name, principal office address and plant location of the manufacturer, producer or distributor.

2. The identification of the product as to the type of liming material.

3. The brand under which it is sold or supplied.

4. A statement expressing the minimum total neutralizing value stated as calcium carbonate equivalence and the minimum fineness, at time of delivery.

5. The net weight of the material.

6. The kind and amount of adulterant or foreign material therein, if any, expressed by weight of the material.

7. In the case of any material which has been damaged, hydrated, adulterated or otherwise changed subsequent to the original packaging, labeling, or loading thereof and before delivery to the consumer, a plainly marked notice to that effect shall be affixed by the vendor to the package or accompanying statement, such notice to identify the kind and degree of such damage, hydration, adulteration or other change therein.

8. A guarantee of the calcium and magnesium content expressed as a percentage by weight of each such element.

9. For agricultural liming material sold in bulk, a guarantee of the percentage of its effective neutralizing value, as determined in accordance with regulations adopted by the commissioner. Such value shall also be expressed separately as the weight of such bulk material necessary to equal one ton of agricultural liming material having an effective neutralizing value of one hundred percent.

At every site, from which agricultural liming products are delivered in bulk, and at every place where consumer orders for bulk deliveries are placed, there shall be conspicuously posted a copy of the statement required by this section for each brand of material.

Section 142-dd. Certificate to be filed.

Before any person shall sell, offer or expose for sale, barter, give, or otherwise supply in this state any product labelled as agricultural liming material, he or she shall, for each brand thereof, file biennially with the commissioner, upon forms supplied by the commissioner, a certificate for the registration of each such brand, stating the name, principal office address and plant location of the manufacturer or shipper, the type of liming material, the brand name, the minimum specifications as to total neutralizing value, the calcium and magnesium content, effective neutralizing value and fineness. Such certificate shall constitute a warranty by the supplier to the receiver that the material will meet the minimum specifications stated therein at the time of delivery.

Section 142-ee. License and fee.

Each certificate filed pursuant to section one hundred forty-two-dd shall be accompanied by an application, upon forms supplied by the commissioner, for a license to supply such material under the brand name specified therein, and there shall be transmitted therewith a copy of the label and of the statement proposed to accompany such material in compliance with section one hundred forty-two-cc, together with a license fee of forty dollars for each such brand. Such application shall incorporate by reference the data contained in the accompanying certificate for the brand for which the license is sought. Upon compliance with the provisions of this article, the applicant shall be issued a license for the supplying of such qualifying brand of agricultural liming material, which license shall expire on the thirty-first day of December of the year following the year in which it is issued, but no such license shall be issued for the supplying of any such material which does not meet the minimum standards herein provided for, nor for the supplying thereof under a brand descriptive designation or with a label or accompanying statement which is or tends to be misleading or deceptive as to quality, analysis or composition. Any such license so issued may be revoked by the commissioner, after notice to the licensee by mail or otherwise and opportunity to be heard, when it appears that any statement or representation upon which it is issued is false or misleading. The action of the commissioner in refusing to grant a license, or in revoking a license, shall be subject to review by a proceeding under article seventy-eight of the civil practice law and rules, but the decision of the commissioner shall be final unless within thirty days from the date of the order embodying such action such proceeding to review has been instituted.

Whenever a manufacturer, producer or distributor shall have been licensed to supply a particular brand of material hereunder, no agent, seller or retailer of such brand shall be required to file a certificate or obtain a license for such brand during a period for which such license is in effect, nor upon such goods which were acquired during a period for which a license was in effect and remaining undistributed in subsequent years.

Section 142-ff. Reports and fees.

1. Every licensee shall, on or before the first day of February in each year report the net tonnage, including zero tonnage if applicable, of each brand of agricultural liming materials sold, bartered, given, or otherwise supplied by him or her in the state during the preceding calendar year. Such report shall be made in duplicate upon forms supplied by the commissioner. One such copy shall be transmitted to the commissioner and the other copy shall be retained by the licensee. Such reports shall be confidential and no information therein shall be disclosed in such a way as to divulge the operation of any person.

2. Failure to comply with the requirements of this section within the time limit shall subject the licensee to revocation of all current licenses held by him or her and the denial of all future license applications until compliance herewith, after hearing and subject to review as provided in section one hundred forty-two-ee.

Section 142-gg. Sampling and analyzing.

1. It shall be the duty of the commissioner or his or her duly authorized agent to sample each different brand of agricultural liming material distributed within the state, to such an extent as he or she may deem necessary to determine compliance with the provisions of this article.

A sample to be designated official shall be one taken in the presence of the supplier or a person responsible to the supplier. Such sample shall, in the presence of the witness, be divided into two representative samples, each sealed, and one of such sealed samples shall be tendered, and if accepted, delivered to the witness; the other sealed sample the commissioner shall analyze or cause to be analyzed.

2. The results of the analysis of each official sample shall be promptly reported by the commissioner to the registrant. In the event an official sample shall analyze below the guarantee, the registrant may within twenty days submit evidence that the sample was non-representative or erroneous. If no satisfactory evidence is so submitted, the report of analysis shall become official.

3. The commissioner shall publish or cause to be published at least annually the results of all analyses indicating the information required to be shown on labels and statements pursuant to section one hundred forty-two-cc of this article and such other information as the commissioner shall deem advisable.

Section 142-hh. Stop orders.

Whenever the commissioner or representatives of the commissioner shall find any agricultural liming material suspected of being supplied in violation of any of the provisions of this article, the commissioner or his or her representatives may issue a written "stop order" to the owner or custodian of any such suspect lot and enforce the same against any such person. Any such order may direct that the agricultural liming material be removed from distribution and retained at the establishment having custody. Any person aggrieved by a "stop order" shall be entitled to a hearing thereon within ten days of a demand therefor. It will be a violation of this section for the owner or custodian of any agricultural liming material, affected by a "stop order" to sell, barter, give away, use or otherwise remove such material from the place of retention without prior written approval of the commissioner or his or her authorized representative.

PL41(Rev. 4/04)

FOR OFFICE USE ONLY

Receipt No._____

Fee _____

Estab. No _____

New York State
Department of Agriculture and Markets
Division of Plant Industry
10B Airline Drive
Albany, NY 12235

APPLICATION FOR A LICENSE TO SELL A BRAND OF AGRICULTURAL LIMING MATERIAL

INSTRUCTIONS

Complete application in full.

An incomplete application will be returned.

Make checks payable to "Department of Agriculture and Markets".

Return in enclosed envelope.

Mailing address and/or business information.

BUSINESS NAME:_____

_____

ADDRESS:_____

_____

_____

IMPORTANT: In the box below, indicate the person to receive analytical reports, tonnage reports, and deficiency or penalty notifications. Include mailing address and/or business information only if different from above.

CONTACT PERSON: _____

BUSINESS NAME: _____

ADDRESS: _____

_____

LICENSE FEE: $40.00 per brand.

The undersigned applies for a license to sell a brand of agricultural liming material pursuant to the provisions of Article 9-A of the Agriculture and Markets Law.

For the registration period ending:

_____

Telephone No._____

Fax No. _____

Federal ID No.*_____

Social Security No.*_____

*Reason for not having SS# or Fed ID#(See Back)

_____

_____

_____

Check whether an Individual Ownership, Partnership or Corporation:

☐ INDIVIDUAL OWNERSHIP ☐ PARTNERSHIP ☐ CORPORATION

INDIVIDUAL OWNERS, MEMBERS OF PARTNERSHIP OR OFFICERS OF A CORPORATION:

Name and Title – Attach list if necessary	Home Address

In what state incorporated?_____Date of Incorporation_____
Foreign or out of state corporation, date of filing in New York_____and name and address of New York State Resident upon whom service of process may be made_____

Have you or an officer, director or any stockholder exercising any position of management or control been convicted of a felony and/or misdemeanor in any court of the U.S. or any state or territory? ☐ No ☐ Yes	If yes, please explain:

Enclosed is the license fee for each brand of Agricultural Liming Material described by the attached Certificate of Registration, form PI-41A.

I (We) agree to permit free entry and free access to licensed premises, buildings, and offices to the Commissioner and his agents in pursuance of the manufacture, storage, distribution, sale, and use of Agricultural Liming Material subject to the Commissioner's jurisdiction.

"I understand that the statements made in this application will be accepted for all purposes as the equivalent of an Affidavit and that any false statements made herein, in addition to being the possible basis for a revocation of any license issued as a result of this application, may be punishable as a misdemeanor under the provisions of Section 210.45 of the Penal Law of the State of New York."

Individual, Firm or Corporate Name (See Note)	Date
Signature of Person Executing	Title

NOTE: (a) If applicant is individual doing business under his own name, he must sign on signature line; (b) if co-partnership or assumed name, firm name must be given and one member must sign individually on signature line; (c) if corporation, corporate name must be given in full, with an authorized officer's signature on signature line and title on title line.

*The authority to request the information contained in this document is found in Section 16 of the Agriculture and Markets Law and the specific section or sections of that Law which relate to the license, permit, certificate, approval, registration or permission which you seek. The principal purpose for which this information is collected is to enable the Department of Agriculture and Markets to determine whether or not to issue the requested license, permit, certificate, approval, registration or permission. This information will be used by the Department of Agriculture and Markets for the purpose of evaluating your application and enforcing and administering the Agriculture and Markets Law.

Disclosure of your federal social security and federal employer identification numbers by you is mandatory and is authorized by Section 5 of the Tax Law. The principal purpose for which this information is collected is to enable the Department of Taxation and Finance to identify individuals, businesses and others who have been delinquent in filing tax returns or may have understated their tax liabilities and to generally identify persons affected by the Tax Law administered by the Commissioner of Taxation and Finance for administering the Tax Law and for any other purpose authorized by the Tax Law.

Should you fail to provide all the requested information, your application will not be processed.

PI41A(Rev. 9/97)

STATE OF NEW YORK
DEPARTMENT OF AGRICULTURE AND MARKETS
DIVISION OF PLANT INDUSTRY
ALBANY, NY 12235

OFFICE USE ONLY
Receipt No. _____

AGRICULTURAL LIMING MATERIAL CERTIFICATE OF REGISTRATION

License No. _____

Pursuant to Article 9-A of the Agriculture and Markets law, application has been made for a license to sell the following brand of Agricultural Liming Material for the period ending December 31, ____ .

☐ MANUFACTURER ☐ DISTRIBUTOR

1 a. Name of Manufacturer or Distributor _____

b. Principal Office Address _____

c. Plant Location _____

2. Type of Liming Material (check one):
☐ Agricultural Limestone ☐ Slag ☐ Burned Lime
☐ Hydrated Lime ☐ Marl ☐ Carbonate of Lime

3. Brand Name _____

4. Guaranteed Analysis at Time of Delivery:

(a) Total Neutralizing Value _____ % CACo3 equivalence.

(b) Fineness _____ % by weight passing a 20 mesh sieve.
_____ % by weight passing a 100 mesh sieve.

(c) Calcium (Cal) _____ % by weight.

(d) Magnesium (Mg) _____ % by weight.

(e) Effective Neutralizing Value (Bulk Materials Only) _____%.

LABEL OR ACCOMPANYING STATEMENT

Pursuant to Section 142-cc of the Agriculture and Markets Law, the label or statement proposed to accompany such material will contain all the information set forth above together with the following:

5. Net Weight (bagged) _____

6. Kind and Amount of Adulterant or Foreign Material (if any):
_____

7. Damage, hydration, adulteration or other change subsequent to original packaging, labeling or loading.
identifying kind and degree (if any) _____

THE UNDERSIGNED HEREBY CERTIFIES that the information appearing above is true and correct in every respect; that each package and bulk sale of the above brand of Agricultural Liming Material will be labeled as above or accompanied by a statement or weight slip containing the above information (except that different net weight declaration may be used); that the above certificate constitutes a warranty by the vendor to the purchaser that the material will meet the minimum specifications stated therein at the time of delivery.

Individual, Firm or Corporate Name	Date
Signature	Title

LIMESTONE EFFECTIVE NEUTRALIZING VALUE SCORE CARD

The information needed for the calculations on the limestone effective neutralizing value (ENV) is shown on the label or on/with the delivery sheet for bulk spread limestone. For examples of the calculations of the limestone effective neutralizing value, see back of this page.

Instructions

1. Enter the percentage of limestone passing a 100 mesh sieve on line 1 and again on line 2b; express both as a decimal (% divided by 100).

2. Enter the percentage of limestone passing a 20 mesh sieve on line 2a; express as decimal (% divided by 100). Subtract line 2b from 2a and enter on 2c. Multiply value of 2c by 0.60 and enter on 2d.

3. The fineness score is the sum of the values on line 1 and 2d. Enter on line 3, the fineness score is expressed as a decimal; to obtain percent multiply by 100.

4. Enter the **total neutralizing value** on line 4; express as a decimal (% divided by 100).

5. The **effective neutralizing value** of the limestone is then calculated by multiplying the fineness score from line 3 by the total neutralizing value on line 4. Enter on line 5.

6. Enter the cost per ton of limestone on line 6.

7. To determine the cost of a ton of effective liming material, divide the cost per ton on line 6 by the effective neutralizing value (expressed as a decimal) obtained on line 5. Enter effective cost on line 7.

Score Card

1.	Percentage passing 100 mesh		_____
2.	A. Percentage passing 20 mesh	_____	
	B. Percentage passing 100 mesh	- _____	
	C. Percentage passing 100 mesh	_____ (x 0.60)	
	D. 20 to 100 mesh reaction		+_____
3.	Fineness Score		_____
4.	Total Neutralizing Value	_____	
5.	Effective Neutralizing Value		=========

Cost Effectiveness

6.	Cost per ton of limestone	_____	
7.	Cost per ton of effective neutralizing		=========

LIMESTONE EFFECTIVE NEUTRALIZING VALUE SCORE CARD CALCULATIONS

Limestone #1	Limestone #2
*Total Neutralizing Value . . 78.75% $CaCO_3$ Equivalence	*Total Neutralizing Value . . 104.3% $CaCO_3$ Equivalence
Minimum $CaCO_3$ Derived From Magnesium Sources . . 33.25% $CaCO_3$ Equivalence	Minimum $CaCO_3$ Derived From Magnesium Sources . . 52.2% $CaCO_3$ Equivalence
Fineness	Screen Test
*98% by Weight Passing 20 Mesh	*98% through 20 Mesh
*70% by Weight Passing 100 Mesh	80% through 60 Mesh
	*75% through 100 Mesh

Figure 1. The information was obtained from labels on bagged limestone materials. The lines preceeded by an * are those needed in the evaluation of agricultural limestones by the limestone effective neutralizing value score card. Note that other information may be contained on the label.

Limestone #1

1. Percentage passing 100 mesh			0.70
2. A. Percentage passing 20 mesh	0.98		
B. Percentage passing 100 mesh	- 0.70		
C. Percentage passing 100 mesh	0.28	(x 0.60)	
D. 20 to 100 mesh reaction			+ 0.168
3. Fineness Score			0.868
4. Total Neutralizing Value	0.7875		
5. Effective Neutralizing Value			0.684

Cost Effectiveness

6. Cost per ton of limestone	$15.00		
7. Cost per ton of effective neutralizing			$21.94

Limestone #2

1. Percentage passing 100 mesh			0.75
2. A. Percentage passing 20 mesh	0.98		
B. Percentage passing 100 mesh	- 0.75		
C. Percentage passing 100 mesh	0.23	(x 0.60)	
D. 20 to 100 mesh reaction			+ 0.138
3. Fineness Score			0.888
4. Total Neutralizing Value	1.043		
5. Effective Neutralizing Value			0.926

Cost Effectiveness

6. Cost per ton of limestone	$18.00		
7. Cost per ton of effective neutralizing			$19.43