LIME GUIDELINES FOR FIELD CROPS

USER'S MANUAL

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Nutrient Management Spear Program

Collaboration among the Cornell University Department of Animal Science, PRODAIRY and Cornell Cooperative Extension

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Contents

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1. 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 and lime will need to be applied for optimum field crop production.

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).

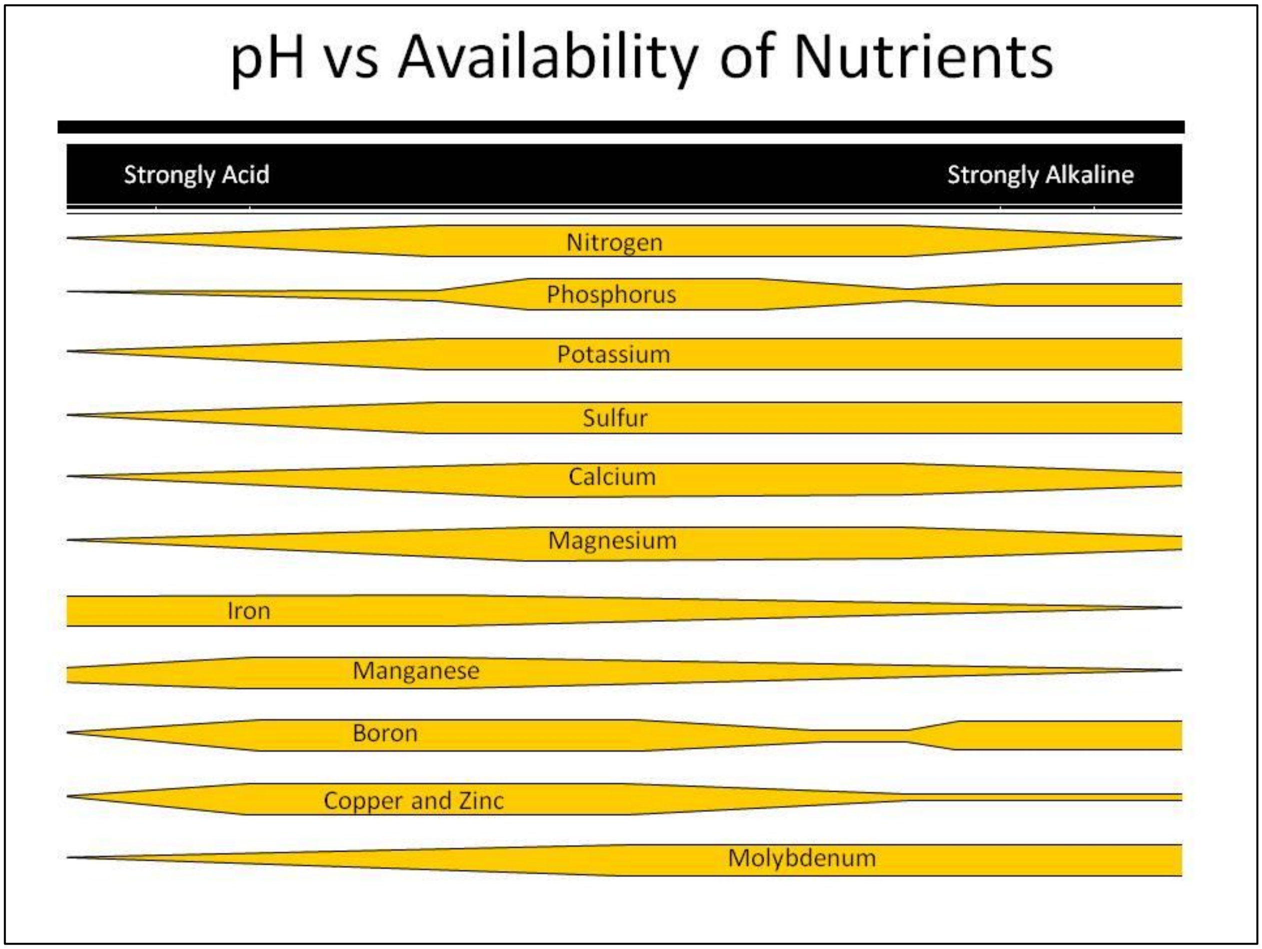

Figure 1: Availability of plant nutrients as soil pH changes.

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).

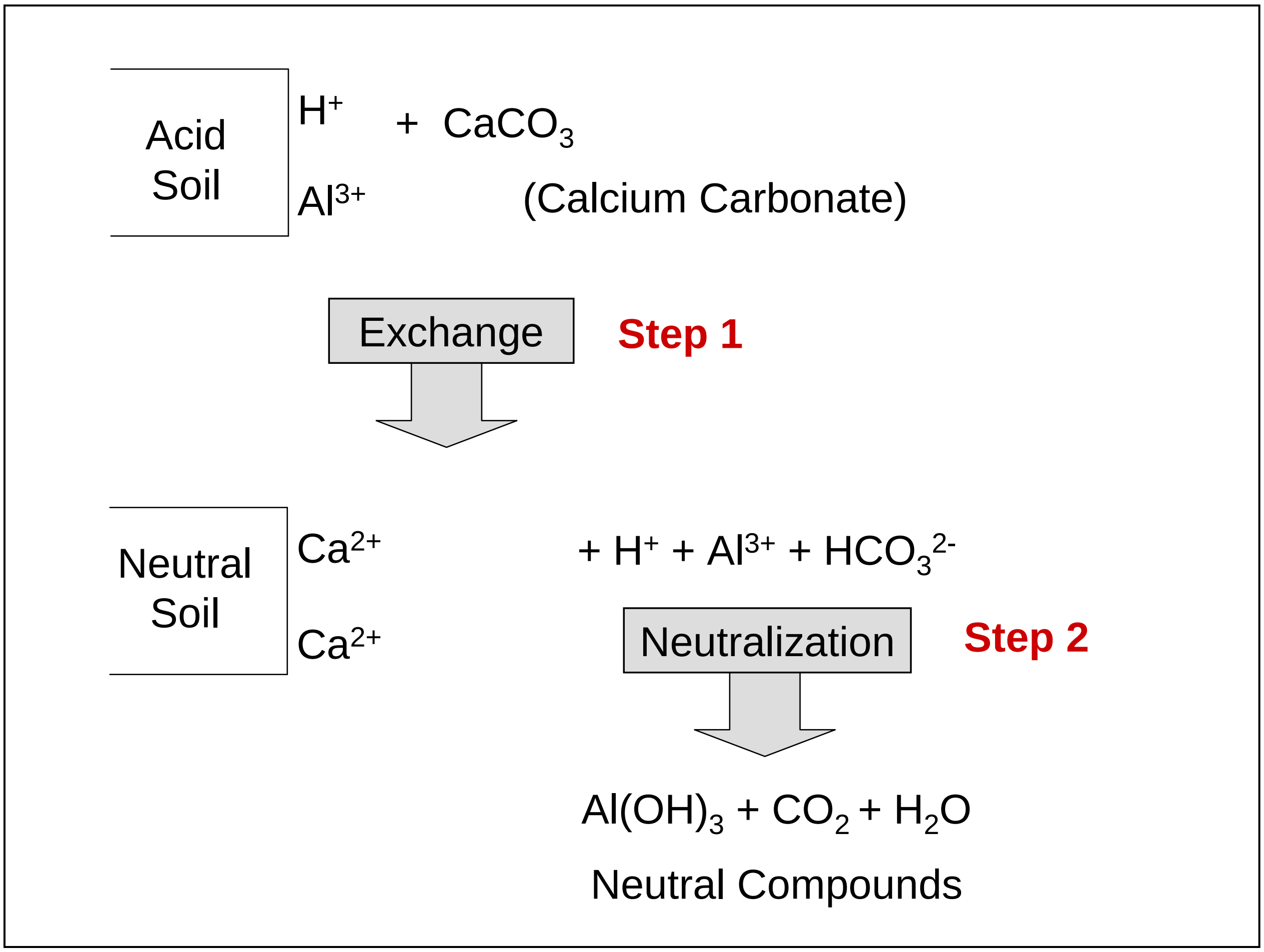

Figure 2: Two-step reaction of agricultural lime (in this case $CaCO_3$) with the soil.

The quality of a liming product is determined by its 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.

2. Use of Calculator

In this calculator white cells (boxes) are open for data entry and yellow cells (boxes) are calculated values. The yellow cells present results based on data entered into white cells. Yellow cells are locked and cannot be manipulated.

Information regarding the farm, such as address or field name may be put into the heading section of the calculator (Figure 3).

Nutrient Management Spear Program

Cornell University Department of Animal Science

NMSP

Lime Guidelines for Field Crops in New York

v1 .0 November 2010

Farm name:	
Farm address:	
Field name:	
Date:	

Figure 3: Farm and field identification information for lime recommendations.

3. Determine the desired and minimum rotation pH

In this step, crops are selected from the white cells to form a crop rotation. A drop down arrow will appear to the right of the cell. By selecting this arrow, a menu will appear allowing you to select the crop grown in that year. Within the dropdown menu, a scroll bar is present to allow for more selections.

For each crop selected, a minimum pH is automatically selected by the calculator from a reference list (Table 1). Minimum rotation pH is the highest desired pH in the rotation (Figure 4). Considering the entire rotation for determining lime requirements allows for strategic timing of lime applications.

Step 1: Determine the desired and minimum rotation pH:

Years:	2008	2009	2010
Crops:	Millet	Oats	Wheat with Legumes
Code:	MIL	OAT	WHS
Minimum pH:	6.0	6.0	6.0
Years:	2011	2012	2013
Crops:	Birdsfoot trefoil/Clover-Establishment	Birdsfoot trefoil/Clover-Established	Corn Silage
Code:	BCE	BCT	COS
Minimum pH:	6.4	6.4	6.0
	Minimum rotation pH:	6.4	

Figure 4: Minimum pH is determined for the rotation.

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

Crops	Cornell Crop Codes	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

Crops	Cornell Crop Codes	Desired pH	Minimum pH
Rye Seed Production	RYS	6.2	6.0
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

4. Determine if lime is needed

A soil pH measurement can determine if lime is needed. Input soil pH from the soil analysis into the white cell labeled, *Soil pH from Soil Analysis*. A response will be given based on minimum rotation pH and soil pH analysis (Figure 5).

If the box labeled *Is lime needed* reads “No”, no lime application is needed. If box reads “Yes”, lime application is needed; continue with Step 3 (Figure 5).

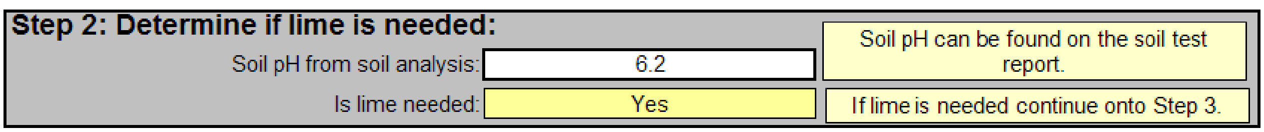

Figure 5: The calculator gives a clear answer if lime is needed or not based on the current rotation plan and current soil pH analysis.

5. Determine the lime rate

An estimate of the soil’s buffering capacity is needed to determine how much lime is needed.

Enter the Buffer pH from the soil analysis into the white cell labeled, *Buffer pH from Soil Analysis*. Based on the buffer pH and the desired pH the calculator will select the recommended amount of lime from a reference table (Table 2). Now, enter the tillage depth at which this location will be tilled, into the white cell labeled, *Tillage Depth*. Lime requirements are adjusted depending on tillage depth. Because deeper tillage results in mixing of a larger amount of soil with the liming material, for the same desired increase in pH, lime rates must be increased as tillage depth increases (Table 3). From 0-6 inches of tillage, a depth of 6 inches is used in the equation, multiplying the lime requirement by 1. For 7-9 inches of tillage, a depth of 8 inches is used in the equation, multiplying the lime requirement by 1.33. For 10-12 inches of tillage, a depth of 10 inches is used in the equation, multiplying the lime requirement by 1.67.

A recommended lime rate is be calculated and reported in tons per acre (Figure 6). This is a value standardized for 100% Effective Neutralizing Value (ENV).

Table 2: Reference values used by the calculator to determine quantity of lime needed.

	Desired rotation pH (minimum pH)			
Modified Mehlich Buffer 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

Table 3: Reference table used by the calculator to adjust quantity of lime needed for tillage depth.

Options: inches	Tillage depth for equation	Multiply
1	6	1
2	6	1
3	6	1
4	6	1
5	6	1
6	6	1
7	8	1.33
8	8	1.33
9	10	1.67
10	10	1.67
11	10	1.67
12	10	1.67

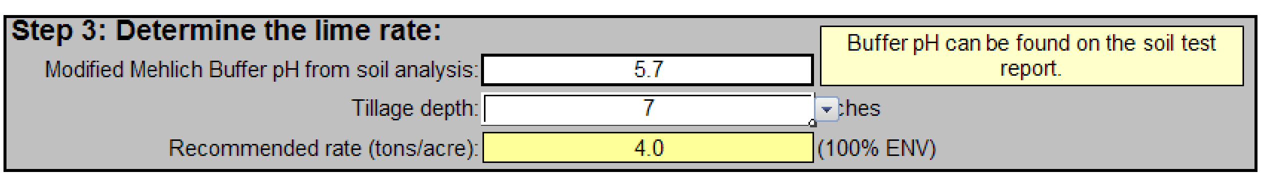

Figure 6: A lime rate is returned that includes adjustments for tillage depth.

6. Enter lime source characteristics

Step 3 returns a lime rate for a material with 100% ENV however most liming materials have a lower percent ENV and the actual applied rate for these materials should be adjusted up to achieve the desired pH changes. The %ENV of a liming material is calculated by multiplying a liming material's CCE and its fineness factor. Input %ENV from a lime label into the white cell labeled *%ENV*. If %ENV is not available, leave %ENV blank and input the values for percentage of material passing through 20 and 100 mesh screens. Next, input the value for *Calcium Carbonate Equivalent (CCE)* (Figure 7). When the cost of the material is also entered, the calculator returns the true cost per acre to use the material to change the soil pH. Cost information can be used to choose between two different liming materials. Once a liming material is chosen, the amount needed per acre can be determined (Step 5).

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 7: Information gathered from tag of purchased lime material such as %ENV or mesh test and CCE values can be used to calculate the cost per ton of effective neutralizing power.

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

7. Application rate, timing and method guidelines

Once a liming material is selected and acreage is entered the calculator can determine the amount of material that will need to be added per acre to change the pH the desired amount. The farm manager or advisor can also enter in additional comments on application timing and method. The *Actual Application Rate* will automatically be calculated. This value is given in *tons per acre*. The *Amount Needed for Entire Field* will also be automatically calculated. This value is given in total tons needed for location, based on number of tons per acre and number of acres. The calculator is pre-formatted for easy printing.

Step 5: Lime material, application rate and timing guidelines

Number of acres:	12.0	acres
Lime material:	#2	
Actual application rate:	**4.2**	tons/acre
Amount needed for entire field:	**50.4**	tons
Total field cost:	**$1,108.80**	
Comments:		

Figure 8: The calculator allows space for delivering specific lime recommendations with cost information.