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/

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For more information

Cornell University Cooperative Extension

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

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