**Purdue University Department of Agronomy**
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# Low soil pH and limestone recommendations for mineral soils: The confusion of 'Buffer pH'

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## When is limestone needed?

Soil pH, determined in a 1:1 slurry of soil:water, is a measure of the acidity (pH less than 7.0) or alkalinity (pH greater than 7.0) of the soil. In mineral soils (less than 20% organic matter) corn and soybean grow best when soil pH is in the range 6.0 to 6.5. Slightly higher pH, 6.5 to 7.0, is suggested for alfalfa. When initial soil pH is below these ranges, limestone is recommended to increase soil pH.

Although soil pH is the trigger for determining when limestone is needed on mineral soils, it is not used to determine how much limestone is needed to increase pH to the recommended range.

## How much limestone is needed?

The amount of limestone needed to raise soil pH is dependent on the soil's resistance to pH change. Often this concept is referred to as 'buffer capacity'. Generally, the higher the clay, organic matter content, and cation exchange capacity of the soil the higher the buffer capacity. The higher buffer capacity translates into higher rates of limestone to achieve the desired pH.

Quantification of a mineral soil's buffer capacity has traditionally been estimated by the Shoemaker, McLean, and Pratt (SMP)[1] procedure which utilizes a "buffer solution" with an initial pH of 7.5. A buffer solution is a combination of chemicals that are formulated to change pH slowly with increased acidity.

When an acid soil is mixed with the buffer solution, the pH of the soil:buffer mixture increases above that of the soil alone but does not reach the initial pH of the buffer solution. The pH of the soil:buffer mixture is labeled "Buffer pH" on soil test reports (**Fig. 1**) or sometimes "Buffer or lime index" which is buffer pH multiplied by 10.

**Fig. 1.** Soil test report showing soil pH (in a 1:1 soil:water slurry) and buffer pH (by Sikora modification of the SMP method) outlined in red. Samples **A** and **B** have the same soil pH but different buffer pH and are used in the text to show how buffer pH influences the rate of limestone recommended.

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| Magnesium Mg ppm | Calcium Ca ppm | Sodium Na ppm | pH | | Cation Exchange Capacity meq/100g | Percent Base Saturation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Soil pH | Buffer pH | | % K | % Mg | % Ca | % H | % Na |
| 260 M | 850 VL | | 4.6 | 6.3 | 15.0 | 1.2 | 14.4 | 28.3 | 56.0 | |
| 230 M | 750 VL | | 4.6 | 6.4 | 13.0 | 1.1 | 14.7 | 28.8 | 55.3 | |
| 300 H | 950 VL | | 4.9 | 6.4 | 14.6 | 1.0 | 17.1 | 32.5 | 49.3 | |
| 290 H | 900 VL | soil A | 4.7 | 6.3 | 15.5 | 0.9 | 15.6 | 29.1 | 54.3 | |
| 225 H | 700 VL | soil B | 4.7 | 6.5 | 11.5 | 1.4 | 16.3 | 30.4 | 52.0 | |
| 270 H | 800 VL | | 4.8 | 6.5 | 12.4 | 1.2 | 18.1 | 32.3 | 48.4 | |
| 240 H | 750 VL | | 4.8 | 6.5 | 11.9 | 1.4 | 16.8 | 31.5 | 50.4 | |
| 220 M | 700 VL | | 4.5 | 6.3 | 13.9 | 1.0 | 13.2 | 25.2 | 60.5 | |
| 240 H | 750 VL | | 4.7 | 6.4 | 13.1 | 1.3 | 15.2 | 28.6 | 54.9 | |
| 235 M | 900 VL | | 4.8 | 6.4 | 13.8 | 1.2 | 14.2 | 32.5 | 52.1 | |

[1]Most laboratories have recently adopted the Sikora buffer method in which two hazardous chemicals present in the SMP buffer solution were strategically replaced so that the results of the procedure are identical to the SMP procedure.

The term "Buffer pH" is often confusing because the higher the buffer pH value, the lower the soil buffer capacity and the lower the lime recommendation. A high buffer pH value indicates a low soil buffer capacity because the pH of the soil:buffer mixture is closer to the initial pH of the buffer solution (7.5) than it is to the initial pH of the acid soil. Conversely a low buffer pH value indicates the soil was resistant to pH change and lowered the pH of the soil:buffer mixture to a pH more similar to the initial soil pH.

## Determining the lime recommendation

In the example soil test report (**Fig. 1**) soil samples **A** and **B** have identical soil pH, 4.7, but different buffer pH, 6.3 and 6.5, respectively. Remember that the extremely low soil pH of 4.7 simply indicates liming is needed, but does not indicate how much limestone is required.

Soil **A** (buffer pH = 6.3) has a higher buffer capacity than soil **B** (buffer pH = 6.5) because 6.3 is further from the initial pH of the buffer solution (7.5) than 6.5. The limestone recommendation for a target pH of 6.5 is 5.6 tons per acre on soil **A**, whereas only 3.8 tons per acre are recommended on soil **B** to achieve the same target pH. Limestone recommendations for these and other buffer pH values and different target pH are shown in Table 1.

**Table 1.** Recommended limestone rates for field crops grown on mineral soil based on buffer pH and target pH (tons per acre)[1].

| Buffer pH[2] | Target pH | | |
|---|---|---|---|
| | **6.8** | **6.5** | **6.0** |
| **>6.8** | 0.0 | 0.0 | 0.0 |
| **6.8** | 1.4 | 1.2 | 1.0 |
| **6.7** | 2.4 | 2.1 | 1.7 |
| **6.6** | 3.4 | 3.0 | 2.4 |
| **6.5** | 4.5 | **3.8** | 3.1 |
| **6.4** | 5.5 | 4.7 | 3.9 |
| **6.3** | 6.5 | **5.6** | 4.6 |
| **6.2** | 7.5 | 6.5 | 5.3 |

[1] Based on a relative neutralizing value (RNV) of 65% and an 8-inch sampling depth.
[2] Shoemaker-McLean-Pratt or Sikora buffer methods.

**More detailed information on soil pH can be found in:**

Soil Acidity and Liming of Indiana Soils. By C.D. Spies and C.L. Harms. Purdue Agronomy Guide. Online at http://www.extension.purdue.edu/extmedia/AY/AY-267-W.html