# Southern Regional Fact Sheet

**March, 2007** **SERA-IEG-6*7**

## A MODIFICATION TO THE ADAMS-EVANS SOIL BUFFER SOLUTION

A good soil fertility program includes adjusting soil pH for optimum plant growth. Soil pH affects important factors such as availability of plant nutrients, microbial activity and root growth. Low soil pH is usually associated with toxic levels of aluminum, manganese, and low availability of phosphorus and molybdenum. Soil acidity problems are corrected by applying ground agricultural limestone to soil to neutralize acidity and increase base saturation with calcium and magnesium.

Soil pH is usually measured in a 1:1 soil-water suspension. A soil pH value indicates whether lime is needed but will not indicate the amount of lime required to change the pH to a targeted value or range, which is referred to as the lime requirement. One method of determining the lime requirement is by measuring change in pH of a buffer solution when mixed with soil. Both water-soil pH and buffer pH change are used to determine the lime requirement. The amount of liming material needed depends on the amount of soil acidity to be neutralized and the neutralizing value of a liming material.

Most buffer solutions were developed before stringent environmental regulations, and some contain toxic chemicals that can be hazardous to humans, animals and the environment in general. The widely used Adams-Evans buffer solution (Adams and Evans, 1962) contains p-nitrophenol, a toxic substance (Science lab.com, 2007). Thus, replacing p-nitrophenol has become necessary due to costs associated with its use and disposal in addition to societal growing interest for green chemistry. Monobasic potassium phosphate was considered as a replacement in the modified Adams-Evans buffer solution (Huluka, 2005). Monobasic potassium phosphate has similar buffering capacity as p-nitrophenol but without any known toxicity.

### COMPOSITION OF THE MODIFIED ADAMS-EVANS BUFFER SOLUTION

The modified Adams-Evans buffer solution contains the same chemicals, though in differing quantities, as the original Adams-Evans solution except the p-nitrophenol. The original Adams-Evans buffer consists of 20 gram (g) *p*-nitrophenol, 15 g boric acid ($H_3BO_3$), 74 g potassium chloride (KCl) and 10.5 g potassium hydroxide (KOH) dissolved in one liter of water (Adams and Evans, 1962). The modified Adam-Evans buffer contains 20 g monobasic potassium phosphate ($KH_2PO_4$), 17 g $H_3BO_3$, 74 g KCl, and 12.5 g KOH dissolved in one liter of water (Huluka, 2005). Both solutions are adjusted to pH 8.00 $\pm$ 0.10 using either diluted KOH or hydrochloric acid (HCl). The modified buffer solution is stable at room temperature under normal conditions without any sign of microbial growth. The modified buffer solution is colorless and, thus does not stain clothing and lab wares as opposed to the *p*-nitrophenol solution that is yellowish/orange. Monobasic potassium phosphate easily dissolves in water, and is much cheaper, easily available, and environmentally friendly compared to *p*-nitrophenol. The pH reading in the modified buffer is more stable than the original buffer indicating rapid completion of acid displacement and neutralization of soil acidity. The buffer pH readings are usually made 30 minutes after the modified buffer is mixed with soil samples and no significant change has been observed from 6 to 48 hours. However, stirring with an automatic stirrer while reading the buffer pH affects the values to some degree. Since stirring is a standard protocol in the Adams-Evans buffer procedure, it is recommended with the modified buffer as well.

## COMPARISONS

Four hundred seven soil samples from different counties in Alabama were randomly selected from samples sent to the Auburn University Soil Testing lab for routine analysis. After soil-water pH was measured, buffer pH was determined by adding either the original Adams-Evans or the modified buffer solutions following routine lab protocols (Huluka, 2005). Lime requirement made by each buffer method to adjust soil pH to 6.5 and 7.0 are compared (Table 1). This table assumes an 8-inch plow depth and an agricultural limestone with a 67% calcium carbonate equivalent (CCE). Thus, Adams-Evans lime requirement values are multiplied by 1.5 (=1/0.67). A relationship between lime required by the Adams-Evans and the modified Adams-Evans buffer solutions to adjust the soil pH to 6.5 is also presented (Figure 1). The $CaCO_3$ used on the axes in the figure is to indicate agricultural limestone that will be equivalent to $CaCO_3$.

## RESULTS

Soil samples were sorted by water pH in decreasing order and the corresponding average Adams-Evans or the modified Adams-Evans buffer values are given in Table 1. Soil buffer pH values are affected by the buffering capacity of soils, therefore soils with identical water pH values can have different buffer pH values. Lime requirements (in increments of 1000 lbs per acre) to change soil pH to 6.5 and 7.0 for soils that had water pH values ranging from 4.4 to 6.9 by the two buffers, were identical except for a few samples at relatively low water pH and buffer pH values. Either doubling the amount of the buffer or proportionally decreasing the amount of soil used may help correct this discrepancy. Since liming materials are recommended and applied in tons increments of 1000 lbs per acre (0.5 tons per acre) to be cost effective, the modified buffer does mimic the original buffer for making lime recommendation.

Table 1. Lime requirement to raise soil pH to 6.5 and 7.0 for Adams-Evans and the modified Adams-Evans buffer solutions.

| Water pH | Buffer pH AE1* Mean | AE1* Range | n | AE2** Mean | AE2** Range | Lime recomm. (1000 lb/A )*** pH=6.5 AE1 | pH=6.5 AE2 | pH=7.0 AE1 | pH=7.0 AE2 |
|---|---|---|---|---|---|---|---|---|---|
| 6.9 | 7.73 | 7.73-7.73 | 1 | 7.76 | 7.76-7.76 | 0 | 0 | 0 | 0 |
| 6.8 | 7.80 | 7.68-7.88 | 6 | 7.75 | 7.62-7.91 | 0 | 0 | 0 | 0 |
| 6.7 | 7.78 | 7.71-7.87 | 5 | 7.74 | 7.67-7.83 | 0 | 0 | 1 | 1 |
| 6.6 | 7.72 | 7.62-7.84 | 9 | 7.65 | 7.46-7.84 | 0 | 0 | 1 | 1 |
| 6.5 | 7.76 | 7.63-7.85 | 13 | 7.69 | 7.44-7.85 | 0 | 0 | 1 | 1 |
| 6.4 | 7.78 | 7.60-7.88 | 14 | 7.74 | 7.36-7.88 | 0 | 0 | 1 | 1 |
| 6.3 | 7.77 | 7.57-7.83 | 14 | 7.76 | 7.57-7.83 | 0 | 0 | 1 | 1 |
| 6.2 | 7.72 | 7.51-7.85 | 22 | 7.70 | 7.33-7.88 | 1 | 1 | 2 | 2 |
| 6.1 | 7.68 | 7.47-7.85 | 28 | 7.66 | 7.31-7.92 | 1 | 1 | 2 | 2 |
| 6.0 | 7.66 | 7.38-7.83 | 35 | 7.65 | 7.31-7.87 | 1 | 1 | 2 | 3 |
| 5.9 | 7.65 | 7.44-7.88 | 23 | 7.64 | 7.42-7.94 | 2 | 2 | 3 | 3 |
| 5.8 | 7.66 | 7.45-7.79 | 23 | 7.65 | 7.47-7.42 | 2 | 2 | 3 | 3 |
| 5.7 | 7.66 | 7.47-7.84 | 14 | 7.69 | 7.56-7.92 | 2 | 2 | 3 | 3 |
| 5.6 | 7.66 | 7.48-7.83 | 25 | 7.70 | 7.52-7.85 | 2 | 2 | 3 | 3 |
| 5.5 | 7.62 | 7.37-7.79 | 24 | 7.64 | 7.16-7.86 | 2 | 2 | 3 | 3 |
| 5.4 | 7.63 | 7.29-7.77 | 21 | 7.67 | 7.32-7.83 | 2 | 2 | 3 | 3 |
| 5.3 | 7.54 | 7.21-7.76 | 18 | 7.58 | 7.32-7.77 | 3 | 3 | 4 | 4 |
| 5.2 | 7.59 | 7.42-7.84 | 26 | 7.62 | 7.41-7.94 | 3 | 3 | 4 | 4 |
| 5.1 | 7.56 | 7.06-7.88 | 25 | 7.59 | 7.11-7.96 | 3 | 3 | 4 | 4 |
| 5.0 | 7.55 | 7.34-7.87 | 17 | 7.60 | 7.42-7.99 | 3 | 3 | 4 | 4 |
| 4.9 | 7.49 | 7.32-7.75 | 7 | 7.57 | 7.36-7.72 | 4 | 3 | 5 | 4 |
| 4.8 | 7.53 | 7.32-7.60 | 10 | 7.61 | 7.44-7.83 | 4 | 4 | 5 | 4 |
| 4.7 | 7.57 | 7.52-7.60 | 6 | 7.64 | 7.58-7.74 | 4 | 4 | 4 | 4 |
| 4.6 | 7.53 | 7.34-7.81 | 5 | 7.62 | 7.47-7.90 | 4 | 4 | 5 | 4 |
| 4.5 | 7.51 | 7.35-7.64 | 3 | 7.52 | 7.69-7.25 | 4 | 4 | 5 | 4 |
| 4.4 | 7.50 | 7.39-7.57 | 3 | 7.61 | 7.54-7.66 | 5 | 4 | 5 | 4 |

AE1*=Adams-Evans buffer; AE2**= Modified Adams-Evans buffer; ***1000 lbs/A (=0.5 ton/A)

Lime recommendations determined by the original and the modified Adams-Evans buffers to adjust soil pH to 6.5 were linearly related as shown in the Figure 1. The slope of the line was almost one (0.99) indicating a 1:1 positive relationship with highly significant correlation ($R^2$=0.88).

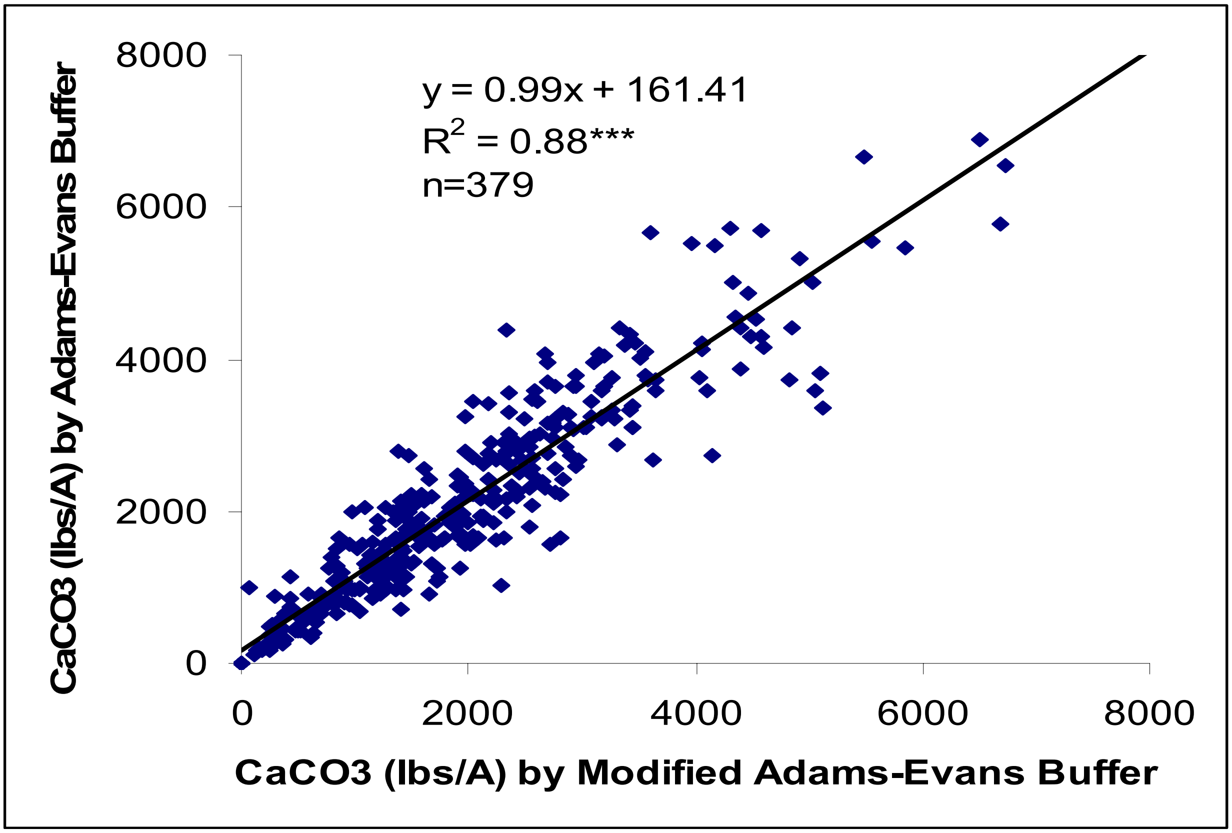


Figure 1. The relationship between $CaCO_3$ required by the Adams-Evans and the modified Adams-Evans buffer solutions to adjust soil pH to 6.5.

## CONCLUSION

The modified Adams-Evans buffer is expected to perform well for soils that have low cation exchange capacity (CEC), low organic matter and are highly unbuffered. As for any other buffer solution, caution should be exercised when using this buffer for soils with significantly different chemical and/or physical properties. The modified Adams-Evans buffer is as effective as the original solution for lime recommendation, more suitable to work with in the lab, and is environmental friendly. Non-toxic or less toxic buffer solutions will continue to play a pivotal role for quantifying liming needs since they are relatively fast, cheap and accurate.

## REFERENCE

1. Adams, F.; Evans, C.E. 1962. A rapid method for measuring lime requirement of red-yellow podzolic soils. Soil Science Society of America Proc. *26:* 355-357.

2. Huluka, G. 2005. A modification to the Adams-Evans soil buffer determination solution. Communications in Soil Science and Plant Analysis. 2005-2014.

3. Science lab.com, *Para Nitrophenol: Material Safety Data Sheet*. http://www.sciencelab.com/xMSDS-P_Nitrophenol-9927375; Accessed on March 6, 2007.

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