LIMING: DOES IT PAY?

Carrie A.M. Laboski and J.B. Peters
University of Wisconsin-Madison, Madison, WI
and
UW Soil and Forage Analysis Laboratory, Marshfield, WI

Introduction

Soil pH affects the activity of soil microorganisms and many of the chemical reactions that occur in the soil. The availability of N, P, K, S, Ca, Mg, and Mo increases as soil pH increases from pH 5.0 to 7.0. The availability of Fe, Mn, B, Cu, and Zn, on the other hand, decreases. Chlorine is relatively unaffected by soil pH. The effect of pH on the availability of N arises mainly from the influence of soil pH on microbial activity. Most of the N and S in soil resides in the organic fraction and is released in available form as crop residues are decomposed by microorganisms. The effect of pH on the availability of the other nutrients is governed by the chemical reactions that take place between these nutrients and soil colloids. Thus, the prudent use of aglime is the cornerstone of a good soil fertility program.

Alfalfa

The benefit of achieving and maintaining a nearly neutral soil pH for alfalfa production is well known. *Rhizobium* species, the bacteria that fix nitrogen in nodules of leguminous plants, do best above a soil pH of 6.5.

Figure 1. Alfalfa yield response to changes in soil pH at three Wisconsin locations (average 1998 to 2001).

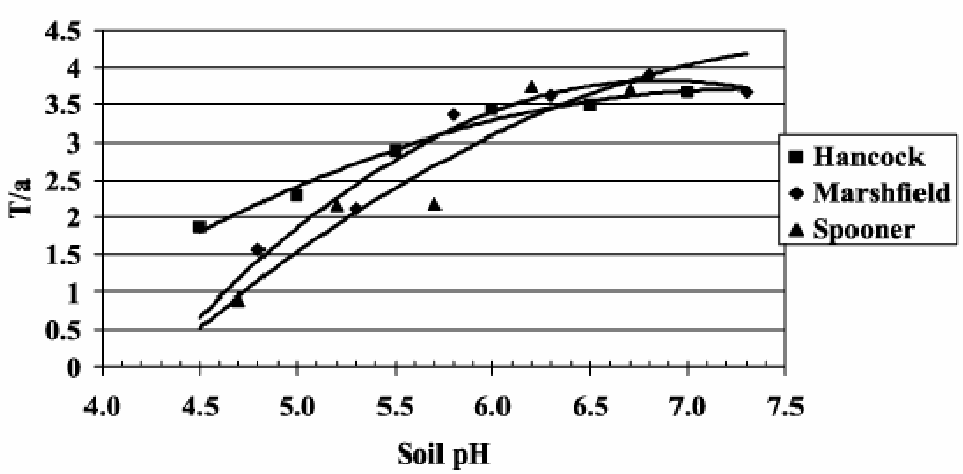


Figure 1 shows the results of a recent Wisconsin study that confirms that, in areas of the state where soil pH is inherently acidic, the pH should be adjusted into the 6.5 to 7.0 range if alfalfa is to be grown. In this study, the average annual dry matter yields when the soil pH was at least 6.5 or higher were approximately 187%, 250%, and 410% of the yields found at the lowest treatment levels (pH 4.5 to 4.8) for the Hancock, Marshfield, and Spooner locations, respectively. A significant interaction between soil pH and K application rates was observed for dry matter yield at all three locations. This interaction showed that there was little yield response to K at the lower pH levels, but if the soil was limed adequately, substantial response to top-dressed K was observed (Peters et al., 2003). With rapidly increasing K costs, this interaction is even more important than it has been in the past.

Corn

The benefit of liming for corn production has traditionally been seen as less dramatic. The effect of soil pH on corn grain and silage dry matter yields varies with the growing season and appears to be more pronounced when the crop is under moisture or other stresses.

The impact of changing soil pH levels on corn yield has been studied over the past 30 years at several locations in Wisconsin including the Arlington, Hancock, Marshfield, and Spooner Agricultural Research Stations. Additional work was done during this past growing season. The yield of corn silage was maximized as soil pH was increased to pH 6.0 to 6.3 (Table 1). In all of the other long-term data, it appears that our current UW recommendation of maintaining a soil pH of at least 6.0 when corn is to be grown is very appropriate (Figure 2).

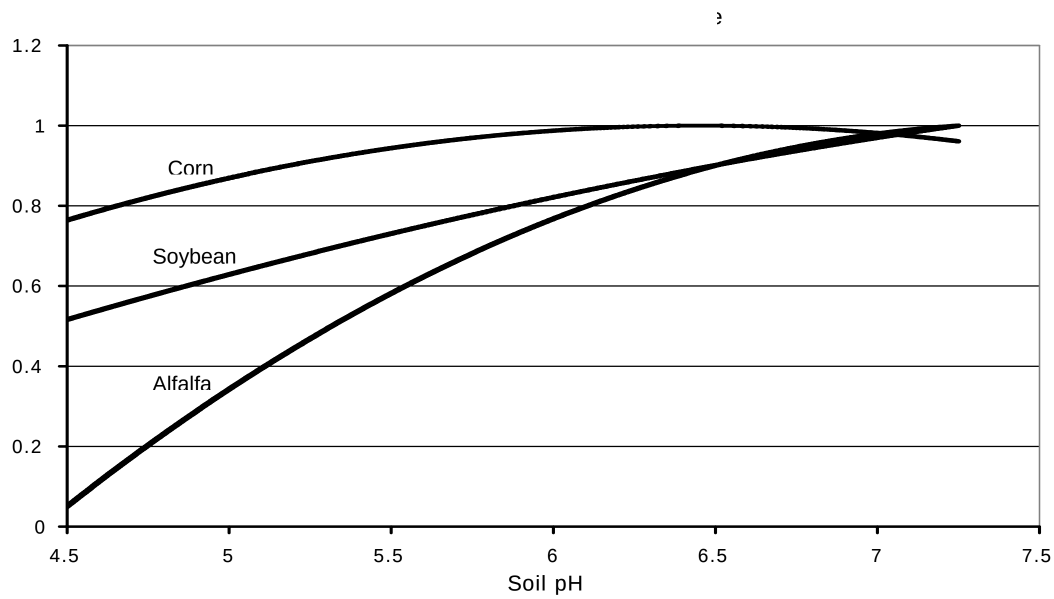
Table 1. Corn silage yield response to soil pH levels at Marshfield and Spooner, WI in 2005.

Target	——— Silage yield ———	
soil pH	Marshfield	Spooner
	t/A, dry matter	
4.7 to 4.8	5.59	5.88
5.2 to 5.3	5.94	6.48
5.7 to 5.8	6.10	6.35
6.2 to 6.3	6.52	7.66
6.7 to 6.8	6.43	7.00
$LSD_{0.05}$	0.82	0.85

Soybeans

Since many of Wisconsin's soybeans are grown on soils with some degree of acidity, soil pH can have a significant impact on nutrient uptake and yield. Recent Wisconsin research (Peters et al., 2005) has confirmed that there can be a significant yield benefit when the soil is limed to a pH of at least 6.3 for soybean production (Figure 2).

Figure 2. Effect of soil pH on crop yield response



Economics of Liming

Aglime, fertilizer, animal waste applications, and cultural practices work together to enhance soil productivity and increase profits. With commodity prices not keeping pace with the skyrocketing price of purchased nutrients and other production costs, producers are faced with some very important decisions. When input dollars are limited, as they are in most cases, it is easy to cut back on lime due to the relatively longer payback time when compared to N, P, or K. Ongoing research at three University of Wisconsin Agricultural Research Stations during the past eight years has included studies involving alfalfa, soybean, and corn for grain and silage production.

In an effort to document the economic benefit of liming, the potential payback must be allocated over an entire rotation. A typical rotation for much of the dairy producing areas of Wisconsin includes three years of alfalfa, two years of corn, and one year of soybeans. The payback from applying various rates of lime to soils at three different research stations was determined in Table 2. Yields achieved during this six-year rotation on the sandy loam soil at Spooner indicate that when the soil pH is very acidic (<5.0) an application of 3.75 t/A of lime costing approximately $94 resulted in about $441 of additional income. Adding an additional 4.75 tons of lime to increase the soil pH from moderately acidic (pH=5.7) to nearly neutral (pH=6.7) resulted in an additional net return of $487.

Table 2. Economic return from liming for a six-year rotation.

	Soil pH		
Spooner	4.7	5.7	6.7
Lime needed, t/A	0	3.75	4.75
Lime cost (@ $25/t), $/A	0	93.75	118.75
Avg. annual alfalfa yield 1998-2001, DM t/A	0.90	2.18	3.69
Alfalfa value $/A (@ $100/ton)	90	218	369
Soybean 2004 yield, bu/A	7.5	21.4	27.5
Soybean value $/A @ $5.00/bu	37.50	107.00	137.50
Corn 2005 silage, DM t/A	5.88	6.35	7.00
Corn silage value $/A @ $70/t DM	411.60	444.50	490.00
Corn 2005 grain yield, bu/A	148.1	171.4	163.4
Corn grain value $/A @ $2.10/bu	311.01	359.94	343.14
Gross return for 6-yr rotation, $/A	1030.11	1471.69	1958.89
Net for additional lime, $/A		441.58	487.20
	Soil pH		
Hancock	5	6	7
Lime needed, t/A	0	2.75	3.25
Lime cost (@ $25/t), $/A	0	68.75	81.25
Avg. annual alfalfa yield 1998-2001, DM t/A	1.87	2.89	3.49
Alfalfa value $/A (@ $100/ton)	187	289	349
Soybean 2004 yield, bu/A	48.9	50.0	50.8
Soybean value $/A @ $5.00/bu	244.50	250.00	254.00
Corn 2005 silage, DM t/A	6.86	8.18	8.80
Corn silage value $/A @ $70/t DM	480.20	572.60	616.00
Corn 2005 grain yield, bu/A	181.2	207.5	200.5
Corn grain value $/A @ $2.10/bu	380.52	435.65	421.05
Gross return for 6-yr rotation, $/A	1666.22	2056.50	2256.80
Net for additional lime, $/A		390.28	200.31

	Soil pH		
Marshfield	4.8	5.8	6.8
Lime needed, t/A	0	7.00	9.75
Lime cost (@ $25/t), $/A	0	175.00	243.75
Avg. annual alfalfa yield 1998-2001, DM t/A	1.56	3.37	3.90
Alfalfa value $/A (@ $100/ton)	156	337	390
Soybean 2004 yield, bu/A	26.4	36.1	38.2
Soybean value $/A @ $5.00/bu	132.00	180.50	191.00
Corn 2005 silage, DM t/A	6.23	6.67	6.95
Corn silage value $/A @ $70/t DM	436.10	466.90	486.50
Corn 2005 grain yield, bu/A	149.0	150.0	169.0
Corn grain value $/A @ $2.10/bu	312.90	315.00	354.90
Net return for 6-yr rotation, $/A	1349.00	1798.40	1958.65
Return for additional lime, $/A		449.40	160.25

NOTE: Marshfield soybean and corn silage yields are average of two sites.
Hancock 1997 yields using optimum N rate.
Marshfield corn grain data from 2002.

At Hancock, the greatest return was found with the first increment of lime for this very sandy soil. Adding 2.75 t/A to increase soil pH from approximately 5.0 to 6.0 resulted in a net return of $390. Applying an additional 3.25 t/A to increase soil pH from 6.0 to 7.0 yielded a net return of another $200.

The imperfectly drained silt loam soils at Marshfield require significantly more lime to reduce acidity than was seen at the other two locations. To increase soil pH from 4.8 (native level) to 5.8 (moderately acidic) requires about 7.0 t/A. This resulted in a net return of nearly $450/A. Adding another 9.75 t/A to further increase soil pH to the target level for alfalfa production (6.8) resulted in an additional net return of $160/A.

In all cases net, return from liming was calculated by subtracting the cost of the lime from the additional crop yield realized when lime was added. No other adjustments to production costs were made in these calculations.

A cost/benefit analysis similar to the one in Table 2 can be calculated for any crop rotation using local prices for lime and grain and/or hay.

Summary

It is important that during this period of rising fertilizer prices that the liming program not be completely neglected. Base your decision to lime on the current soil pH value from a recent soil test, and know what crops you plan to grow on a field in the next rotation (four to six years). In general, the three major agronomic crops (alfalfa, corn, and soybeans) will respond to liming in many situations. In general, the magnitude of the response is alfalfa>soybean> corn (Figure 1). In all cases, crops will be more able to respond to fertilizer inputs if the soil pH is in the recommended range. Please keep in mind that lime should be thoroughly incorporated for maximum effectiveness and allow two to three years for complete reaction (Peters and Kelling, 1998).

References

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