CALCIUM/MAGNESIUM RATIOS AND RED OR WHITE LIME FOR COTTON PRODUCTION

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Abstract

An investigation of the effects Ca:Mg ratio on plant nutrient uptake and yield of cotton is being conducted at the University of Missouri-Delta Center, Portageville, MO. Different rates of gypsum ($CaSO_4$) and epsom salt ($MgSO_4$) were applied to plots to create Ca:Mg ratios ranging from 3.8 to 11.7. In 2000, a second experiment was initiated on an acid soil to investigate the effects of Mg content in liming material. In both experiments, cotton tissue was tested for nutrient content at first square, first bloom and first open boll. Results from the 2000 Ca:Mg experiment showed that soil Ca:Mg ratios significantly altered on potassium(K) and calcium (Ca) tissue concentrations. The significant differences were more evident later in the season but did not cause significant differences in yield. Analysis of data from the lime study did not show significant differences in tissue nutrient contents among lime treatments despite different rates of pH change. Red (dolomitic) lime did not increase soil pH as quickly are white (calcitic) lime. However, both liming materials increased cotton yields significantly on an acid soil as compared to the untreated check.

Introduction

Two interpretation concepts of soil test are currently being used in the United States (Eckert 1987). The Sufficiency Level concept is the more widely used. Critical levels of individual nutrients are identified in the soil. Below these levels crops will likely respond to fertilizers and above which they likely will not respond (Eckert 1987). Fertilizer applications are designed to maintain nutrients at soil test levels above the critical values. The second type of soil test interpretation is called the Basic Cation Saturation Ratio concept(BCSR). Fertilizer recommendations, based on BSCR, are made to achieve an ideal ratio of calcium (Ca), magnesium (Mg), and potassium (K) in the soil (Eckert 1987).

The Basic Cation Saturation Ratio(BCSR) concept has recently received attention in Missouri. This method of soil test interpretation was developed through a series of publications in the late 1940's based on work done in alfalfa. The ideal ratio promoted in these early works was for saturation of the cation exchange complex at 65% Ca, 10% Mg, 5% K, and 20% hydrogen (H) (Eckert 1987). Nearly a decade later, Graham (1959) presented the saturation ranges of 65-85% Ca, 6-12% Mg, 2-5% K. The ranges were presented as an option to specific ratios for optimum production in Missouri soils.

The importance of these theories is that each affects fertilizer and lime management recommendations. In 1999, an experiment was begun to study the relationships between cations ratios in the soil, plant uptake and cotton yield. Additionally due to particular interest in liming as a means of altering Ca:Mg rations a second study was initiated in 2000. Dolomitic ($CaMg(CO_2)_2$) lime contains Mg while calcitic($Ca_2(CO_2)$), lime contains little if any Mg. Calcitic or white lime generally has a lower calcium carbonate equivalence (CCE) than dolomitic or red lime due to the means of calculation. In Missouri, a combination of CCE and fineness are used to evaluate lime materials. This evaluation is called the Effective Neutralizing Material (ENM)(Slaton 1999). As a result less dolomitic lime is needed to meet the liming requirement of fields. Additionally the Mg content may be used to alter the Ca:Mg ratio of a soil, as per BSCR.

Methods and Materials

Two sets of experiments were conducted at the University of Missouri Lee Farm, Portageville, MO. Experiment I has been through three years of data collection, its focus is on the effects of varied soil Ca:Mg ratios. Experiment II is in the second year of data collection and focuses on differences in cotton response to lime materials with varied Mg content. In each experiment, a randomized complete block design with four replications was implemented.

In Experiment I, magnesium sulfate, (Epsom salt), and calcium sulfate (gypsum) were used to establish variations in Ca:Mg ratio. Treatments are listed in Table 1. Initial soil ratios were verified using soil tests prior to crop establishment in 1999. The results of soil samples taken prior to the 2000 growing season are shown in Table 1. Tissue samples were collected at three growth stages and analyzed using H_2SO_4 and H_2O_2 digestion with a Hach Digesdahl. The growth stages were first square , first bloom, and first open boll. At harvest, lint was mechanically harvested for yield. Fiber qualities parameters were XXXXX.

Treatments in Experiment II consisted of an untreated check, a calcite lime application, a dolomitic lime application, and an application of the same calcitic lime with and MgSO4 in an amount equal to the Mg applied to with the dolomitic lime. More information on the lime used can be found in Table 6. Each application of lime was calculated so that an equal application was used based on ENM. Lime treatments were applied to the soil surface and incorporated with tillage immediately before planting. Soil samples were collected from each plot weekly and analyzed for pH. Lint was mechanically harvested for yield. Lint samples from each plot were sent to the International Textile Research Center for fiber quality analysis using a high volume instrument.

Results and Discussion

The gypsum and Epsom salt treatments significantly altered the soil Ca:Mg ratios. In 1999, data did not show any trends despite the occasional significant differences. The significant differences observed tended to vary with growth stage or occur sporadically across the continuum of ratios. During the 2000-growing season a trend in Ca content occurred at first bloom. Here the higher Ca/Mg soil had significantly elevated Ca content compared to the untreated check. Treatments with Ca/Mg soil ratios less than 7.0 had significantly less Ca in plant tissue than the untreated check. It is unlikely that Ca deficiency would occur in the reduced Ca content treatments.

In 1999 Ca/Mg soil ratios had no significant effect on cotton lint yields. In 2000 there were significant differences in cotton lint yields. There was no trend to these differences however. Significant differences in the fiber quality parameters micronaire and uniformity were found each year. There was no trend to the differences. In 1999 strength was not significantly affected by Ca/Mg soil ratios. In 2000 strength was significantly affected but there was no consistent trend.

In experiment II the soil pH increased for all lime treatments in 2000 (Figure 1). The rate of increase was greater for plots treated with calcitic lime. In 2000 there were no significant differences in cotton lint yields for limed and unlimed treatments. In 2001 cotton lint yields for all lime treatments were significantly greater than the untreated check (Table 7).

Conclusions

Soil Ca/Mg ratios can be changed by gypsum and Epsom salt applications. Tissue concentrations of K, Ca, and Mg are not systematically effected by Ca/Mg soil ratios. Cotton lint yields and fiber quality parameters are not effected by Ca/Mg soil ratios.

Calcitic lime reacts with soil acidity faster than dolomotic lime. Timing of lime applications should be considered in cotton production. Both calcitic and dolomitic lime increased soil pH during the first crop year. In 2000 this increase did not lead to an increase in lint yield. Fall applications of lime should be considered.

Acknowledgement

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References

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Table 1: Experiment I: Effect of different rates of gypsum ($CaSO_4$) and epsom salt ($MgSO_4$) on soil Ca, Mg, and K levels in 1999.

Trt #	Material	Tons/acre	Salt pH	Ca:Mg Ratio	Ca	Mg	K
					-----------lbs/acre------		
1	$CaSO_4$	5.6	6.3	11.7	2868	246	627
2	$CaSO_4$	3.7	6.2	11.6	2572	221	534
3	$CaSO_4$	1.7	6.4	10.5	2502	237	608
4	Untreated	0	6.2	10.2	2472	243	601
5	$MgSO_4$	1.7	6.1	7.5	2322	311	542
6	$MgSO_4$	3.7	6.2	7	2389	344	589
7	$MgSO_4$	5.6	6.3	4	2128	534	508
8	$MgSO_4$	7.4	6.1	3.8	2086	552	578
9	$MgSO_4$	9.3	6.5	3.8	2149	571	602
		$LSD_{(0.05)}$			316	77	NS
		$CV_{(\%)}$			9	16	11

NS = not significant at $P \leq 0.05$.

Table 2. Effect of Ca:Mg ratios on tissue concentrations of Ca, Mg, and K at first square growth stage in 1999 and 2000

Trt #	Material	Tons/ acre	Soil Ca:Mg Ratio	Ca 1999	Ca 2000	Mg 1999	Mg 2000	K 1999	K 2000
				-------------%---------					
1	$CaSO_4$	5.6	11.7	1.90	1.88	0.37	0.37	4.00	4.69
2	$CaSO_4$	3.7	11.6	2.20	1.94	0.45	0.44	3.94	4.56
3	$CaSO_4$	1.7	10.5	2.15	1.83	0.46	0.38	3.82	4.83
4	check	0	10.2	1.97	1.84	0.38	0.40	4.02	4.33
6	$MgSO_4$	3.7	7	1.91	1.94	0.44	0.46	3.80	4.51
7	$MgSO_4$	1.7	6.8	1.86	1.77	0.43	0.44	4.11	4.47
8	$MgSO_4$	5.6	4	2.04	1.94	0.46	0.37	4.03	4.41
9	$MgSO_4$	7.4	6.1	1.91	1.87	0.43	0.44	4.22	4.63
10	$MgSO_4$	9.3	3.8	1.91	1.99	0.49	0.43	4.30	4.78
	$LSD_{(0.05)}$			NS	0.24	NS	0.08	NS	0.45
	$CV_{(\%)}$			12	9	14	14	12	7

NS = not significant at $P \leq 0.05$.

Table 3. Effect of Ca:Mg ratios on tissue concentrations of Ca, Mg, and K at first bloom growth stage in 1999 and 2000

Trt #	Material	Tons/ acre	Soil Ca:Mg Ratio	Ca 1999	Ca 2000	Mg 1999	Mg 2000	K 1999	K 2000
				-------------%---------					
1	$CaSO_4$	5.6	11.7	1.50	1.60	0.31	0.31	2.63	4.74
2	$CaSO_4$	3.7	11.6	1.57	1.42	0.33	0.33	3.13	3.55
3	$CaSO_4$	1.7	10.5	1.45	1.41	0.30	0.34	2.90	4.53
4	check	0	10.2	1.54	1.38	0.33	0.33	2.89	4.74
6	$MgSO_4$	3.7	7	1.74	1.48	0.38	0.33	2.77	4.06
7	$MgSO_4$	1.7	6.8	1.63	1.23	0.44	0.36	3.04	4.47
8	$MgSO_4$	5.6	4	1.46	1.39	0.47	0.34	3.10	4.02
9	$MgSO_4$	7.4	6.1	1.63	1.31	0.52	0.39	3.01	4.36
10	$MgSO_4$	9.3	3.8	1.51	1.10	0.45	0.29	3.36	3.39
	$LSD_{(0.05)}$			NS	0.30	0.06	0.06	0.39	1.30
	$CV_{(\%)}$			15	17	12	13	9	21

NS = not significant at $P \leq 0.05$.

Table 4. Effect of Ca:Mg ratios on tissue concentrations of Ca, Mg, and K at first open boll growth stage in 1999 and 2000.

			Soil	Ca		Mg		K	
		Tons/	Ca:Mg	-------------%---------					
Trt #	Material	acre	Ratio	1999	2000	1999	2000	1999	2000
1	$CaSO_4$	5.6	11.7	0.90	---	0.35	---	2.32	---
2	$CaSO_4$	3.7	11.6	1.05	---	0.39	---	2.41	---
3	$CaSO_4$	1.7	10.5	0.92	---	0.35	---	2.51	---
4	check	0	10.2	1.41	---	0.60	---	2.78	---
6	$MgSO_4$	3.7	7	0.78	---	0.33	---	1.9/	---
7	$MgSO_4$	1.7	6.8	1.18	---	0.54	---	2.57	---
8	$MgSO_4$	5.6	4	1.00	---	0.48	---	2.34	---
9	$MgSO_4$	7.4	6.1	0.81	---	0.35	---	2.45	---
10	$MgSO_4$	9.3	3.8	0.94	---	0.44	---	2.61	---
	$LSD_{(0.05)}$			NS	---	NS	---	NS	---
	$CV_{(\%)}$			33	---	33	---	20	---

NS = not significant at $P \leq 0.05$.

Table 5. Effect of Ca:Mg ratios on cotton fiber parameters and lint yields in1999 and 2000.

			Soil	Micronaire units		Uniformity %		Strength gm/tex		Lint yield Lbs./acre	
		Tons/	Ca:Mg								
Trt #	Material	acre	Ratio	1999	2000	1999	2000	1999	2000	1999	2000
1	$CaSO_4$	5.6	11.7	4.6	4.6	83.3	83.4	29.2	27.2	1034	778
2	$CaSO_4$	3.7	11.6	4.7	4.4	81.4	82.7	27.6	28.1	836	734
3	$CaSO_4$	1.7	10.5	4.5	4.6	83.6	82.6	28.7	27.9	1012	821
4	check	0	10.2	4.5	4.7	84.0	83.8	28.8	26.8	972	698
6	$MgSO_4$	3.7	7	4.7	4.3	81.4	82.6	27.6	27.9	1042	704
7	$MgSO_4$	1.7	6.8	4.5	4.4	83.5	82.9	28.3	28.6	976	603
8	$MgSO_4$	5.6	4	4.5	4.5	83.0	82.8	28.8	28.3	1039	786
9	$MgSO_4$	7.4	6.1	4.8	4.7	82.3	82.8	28.9	27.8	961	744
10	$MgSO_4$	9.3	3.8	4.6	4.7	83.1	83.5	28.6	27.1	1007	803
	$LSD_{(0.05)}$			0.4	0.4	1.2	1.2	NS	1.6	NS	175
	$CV_{(\%)}$			5	6	1	1	3	4	16	16

NS = not significant at $P \leq 0.05$.

Table 6. Lime quality and magnesium content of liming materials used in experiment 2

Trt #	Lime Source	EMN/ton	Ton/acre	%Mg	lbs.Mg/acre
1	Untreated	0	0	0	0
2	Calcite	510	2.2	0.5	22
3	Dolomite	620	1.8	11.6	418
4	Calcite + $Mg(SO_4)_2$	510	202	---	418

Table 7. Effect of lime source on cotton lint yields in 2000 and 2001.

		Cotton Lint Yields ----------lbs./acre----------		
Trt #	Lime Source	2000	2001	2-year average
1	Untreated	493	804	649
2	Calcite	583	887	735
3	Dolomite	630	908	769
4	Calcite + $Mg(SO_4)_2$	542	948	745
	$LSD_{(0.05)}$	NS	67	---
	$CV_{(\%)}$	19	5	---

NS = not significant at $P \leq 0.05$.

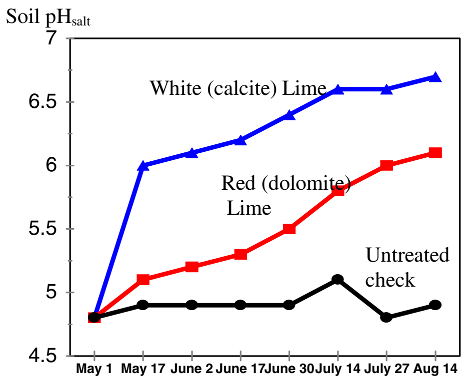

Figure 1. Effect of liming material on soil pH in 2000.