EFFECT OF SOIL CALCIUM:MAGNESIUM RATIOS ON POTASSIUM UPTAKE AND COTTON YIELDS

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Abstract

An investigation of the effects Ca:Mg ratio on plant nutrient uptake and yield in 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. Soil samples were collected and analyzed prior to and after the growing season. Cotton tissue was tested for nutrient content at first square, first bloom and first open boll. Results from 1999 showed that soil Ca:Mg rations did not have a significant effect on potassium or micronutrient uptake. Cotton yields were not significantly different between treatments.

Introduction

Two soil test interpretation concepts are currently being used in the United States (Eckert 1987). The most widely used is the Sufficiency Level concept. Critical levels of individual nutrients are identified in the soil below which crops will likely respond to fertilizers and above which they likely will not respond (Eckert 1987). Fertilizer applications are made to maintain nutrients at soil test levels greater than these critical values. The second type of soil test interpretation is called the Basic Cation Saturation Ratio concept. Fertilizer recommendations are made to achieve an ideal ratio of calcium (Ca), magnesium (Mg), and potassium (K) in the soil (Eckert 1987). At low Ca:Mg ratios, Mg is believed to have an antagonistic affect on plant K uptake. The importance of these theories lies in the way that each affects fertilizer management recommendations.

The Basic Cation Saturation Ratio 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 rather than a specific ratio for optimum production in Missouri soils. In 1999, an experiment was begun to study the relationships between cations ratios in the soil, plant uptake and yield.

Materials and Methods

An experiment was conducted in 1999 at the University of Missouri Lee Farm, Portageville, MO. A randomized complete block design with four replications was used. Magnesium sulfate and calcium sulfate 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. An additional set of soil samples was collected after harvest. The results of the post harvest soil samples 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 (Table 2), first bloom (Table 3), and first open boll (Table 4). At harvest, lint was mechanically harvested for yield. Fiber quality is shown in Table 5.

Results and Discussion

The gypsum and epsom salt treatments significantly altered the soil Ca:Mg ratios in plots. However, the differences in soil Ca:Mg ratio did not significantly affect the plant concentration of potassium at any of the three growth stages. Fiber analysis did not show any consistent trends despite the significant difference in uniformity (Table 5). Additionally, yield results did not show significant differences between treatments.

Acknowledgements

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References

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

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	Sulfuric Acid	0.8	5.8	9.4	2495	266	592
6	$MgSO_4$	1.7	6.1	7.5	2322	311	542
7	$MgSO_4$	3.7	6.2	7	2389	344	589
8	$MgSO_4$	5.6	6.3	4	2128	534	508
9	$MgSO_4$	7.4	6.1	3.8	2086	552	578
10	$MgSO_4$	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.

Trt #	Material	Tons/ acre	Soil Ca:Mg Ratio	Ca	Mg	K
					%	
1	$CaSO_4$	5.6	11.7	1.90	.37	4.00
2	$CaSO_4$	3.7	11.6	2.20	.45	3.94
3	$CaSO_4$	1.7	10.5	2.15	.46	3.82
4	Untreated	0	10.2	1.97	.38	4.02
5	Sulfuric Acid	0.8	9.4	2.00	.43	4.13
6	$MgSO_4$	3.7	7	1.91	.44	3.80
7	$MgSO_4$	1.7	6.8	1.86	.43	4.11
8	$MgSO_4$	5.6	4	2.04	.46	4.03
9	$MgSO_4$	7.4	6.1	1.91	.43	4.22
10	$MgSO_4$	9.3	3.8	1.91	.49	4.30
$LSD_{(0.05)}$				NS	NS	NS
$CV_{(\%)}$				12	14	12

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

Table 3. Effect of Ca:Mg ratio on tissue concentrations of Ca, Mg, and K at first bloom growth stage.

Trt #	Material	Tons/ acre	Soil Ca:Mg Ratio	Ca	Mg	K
					%	
1	$CaSO_4$	5.6	11.7	1.50	.31	2.63
2	$CaSO_4$	3.7	11.6	1.57	.33	3.13
3	$CaSO_4$	1.7	10.5	1.45	.30	2.90
4	Untreated	0	10.2	1.54	.33	2.89
5	Sulfuric Acid	0.8	9.4	1.53	.38	3.12
6	$MgSO_4$	3.7	7	1.74	.38	2.77
7	$MgSO_4$	1.7	6.8	1.63	.44	3.04
8	$MgSO_4$	5.6	4	1.46	.47	3.10
9	$MgSO_4$	7.4	6.1	1.63	.52	3.01
10	$MgSO_4$	9.3	3.8	1.51	.45	3.36
$LSD_{(0.05)}$				NS	0.06	0.39
$CV_{(\%)}$				15	12	9

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

Table 4. Effect of Ca:Mg ratio on first open boll tissue analysis.

Trt #	Material	Tons/ acre	Soil Ca:Mg Ratio	Ca	Mg	K
					%	
1	$CaSO_4$	5.6	11.7	0.90	.35	2.32
2	$CaSO_4$	3.7	11.6	1.05	.39	2.41
3	$CaSO_4$	1.7	10.5	0.92	.35	2.51
4	Untreated	0.0	10.2	1.41	.60	2.78
5	Sulfuric Acid	0.8	9.4	0.91	.35	2.13
6	$MgSO_4$	3.7	7	0.78	.33	1.90
7	$MgSO_4$	1.7	6.8	1.18	.54	2.57
8	$MgSO_4$	5.6	4	1.00	.48	2.34
9	$MgSO_4$	7.4	6.1	0.81	.35	2.45
10	$MgSO_4$	9.3	3.8	0.94	.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 ratio on cotton fiber properties.

Trt #	Material	Micro	Uniform.	Strength	Elong	Lint Yield lb/A
1	$CaSO_4$	4.55	83.28	29.20	5.70	1034
2	$CaSO_4$	4.68	81.43	27.58	5.48	836
3	$CaSO_4$	4.53	83.58	28.65	5.68	1012
4	Untreated	4.50	84.00	28.80	6.00	972
5	Sulfuric Acid	4.38	83.28	28.68	6.05	876
6	$MgSO_4$	4.68	81.43	27.58	5.48	1042
7	$MgSO_4$	4.48	83.48	28.28	5.95	976
8	$MgSO_4$	4.45	82.95	28.75	6.05	1039
9	$MgSO_4$	4.78	82.83	28.85	5.98	961
10	$MgSO_4$	4.63	83.08	28.60	5.93	1007
$LSD_{(0.05)}$		NS	1.15	NS	NS	NS
$CV_{(\%)}$		5	1	3	6	16

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