Influences of Base Saturation Ratios on Creeping Bentgrass Establishment

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INTRODUCTION

Various turf consultants and soil testing laboratories recommend application of base saturation ratio (BSR) theory in turf management. The BSR theory maintains that optimal soil conditions for plant growth are not achieved until soils are adjusted to "ideal" base saturations and exchangeable cation ratios. These ideal conditions begin with 80 to 90% occupancy ("saturation") of soil cation exchange sites with the "basic" cations calcium, magnesium, potassium, and sodium. Then, the first three cations have to occupy the cation exchange sites as follows: 65 to 85% Ca, 6 to 12% Mg, and 2 to 5% K. Finally, the ratio of exchangeable Ca to Mg needs to be around 6.5 to 7.0.

Kussow (2000) reviewed literature pertaining to the BSR theory and noted that:

1. Crop responses to changes in soil base saturation and soil pH do not differ.

2. Crops are much more responsive to changes in the amounts of exchangeable cations in soil than their percent saturations.

Kussow (2000) also reviewed research on crop responses to variations in cation saturations and ratios and concluded that there are no ideal base saturations, cation saturations, or cation ratios that maximize crop yields. He then went on to quote research showing that once soil supplies of cations are adequate, plants take up only what they need and do not respond to cation saturations or ratios on the exchange sites. Finally, Kussow (2000) pointed out that there are no published research reports regarding turfgrass responses to soil base or cation saturations or cation ratios.

The purpose of the present study was to determine if and when soil base saturation, cation saturation, and cation ratios influence the growth and nutrient status of turfgrass. The study was restricted to creeping bentgrass during its first few weeks of growth.

METHODS

A pH 5.1 sandy loam soil whose particle size distribution meets

Table 1. Soil chemical properties.

Treatment	pH	Actual CEC	Exchangeable cations K	Ca	Mg	Na	H†
		cmol(+)/kg ‡					
10	5.08	2.61	0.12	1.70	0.43	0.24	4.12
11	5.00	2.98	0.19	1.62	0.79	0.32	3.69
12	4.94	3.08	0.17	1.92	0.52	0.39	3.61
20	5.72	4.31	0.07	3.43	0.48	0.36	2.27
21	5.78	4.55	0.16	3.13	0.89	0.34	2.09
22	5.77	4.05	0.15	3.09	0.53	0.31	2.53
30	6.44	5.82	0.05	4.91	0.47	0.38	0.81
31	6.51	5.65	0.15	4.38	0.88	0.22	0.98
32	6.54	5.61	0.15	4.55	0.56	0.42	0.93

† = pH 7.0 CEC of 6.61 cmol(+)/kg – Σ exchangeable cations.
‡ cmol(+)/kg = meq/100 g.

Table 2. Soil base and cation saturations† and ratios.

Treatment	Base saturation	Cation saturations K	Ca	Mg	Ratio Ca:Mg
	%	%			
10	38	1.8	26	6.5	4.0
11	44	2.9	24	12.0	2.0
12	45	2.6	29	7.9	3.7
20	66	1.0	52	7.3	7.1
21	68	2.4	47	13.5	3.5
22	62	2.3	47	8.0	5.8
30	88	0.8	74	7.1	10.4
31	85	2.3	66	13.3	5.0
32	86	2.3	69	8.5	8.1

† AT pH 7.0 CEC of 6.61 cmol(+)/kg.

USGA standards for a putting green root zone was first limed with colloidal $CaCO_3$ to establish three different pH levels. The soil at each pH was then leached with solutions containing different quantities of Ca, Mg, and K. The end result was soil pH values of 5.0, 5.8, and 6.5 and, at each pH, three different combinations of exchangeable Ca, Mg, and K (Table 1).

The relationship between soil pH and cation exchange capacity (CEC) was then used to calcu- late a CEC of 6.61 cmol(+)/kg (6.61 meq/100 g) at pH 7.0. This CEC was then used to calculate percent base saturation and the saturations of Ca, Mg, and K (Table 2).

The treated soils were weighed into pots, fertilized with turf starter fertilizer, and seeded with 'Penncross' creeping bentgrass at the rate of 1.5 lb PLS/M. The pots were then arranged on a greenhouse bench into four randomized complete blocks.

Starting at 2 weeks after seeding, the bentgrass was clipped weekly at a height of 0.5 inch for a total of 8 weeks. The clippings were oven-dried, weighed, and ground for analysis. Analysis of the clippings was performed by the Soil and Plant Analysis Laboratory.

Six weeks into the study, the bentgrass began showing mild symptoms of K deficiency in several of the treatments. This prompted application of the equivalent of 0.15 cmol(+)/kg of K as K_2SO_4 and collection of data for 2 additional weeks.

RESULTS AND DISCUSSION

Bentgrass growth, when measured in terms of clipping eight, was not significantly related to soil percent base saturation (Fig. 1). In fact, the top three weights were recorded at base saturationsranging from 45 to 88%.

Soil Ca:Mg ratios likewise had no consistent or significant influence on bentgrass growth (Fig. 2). If one were to identify an optimum Ca:Mg ratio from this figure, it would be in the range of 2.0 to 5.8 and not the values of 6.5 to 7.0 touted by the BSR theory.

In this study, because we used only one soil, we cannot separate any possible effects of percent cation saturation from the effects of the actual amounts of exchangeable cations on bentgrass growth. Thus, it is immaterial whether we refer to soil Ca, Mg, and K as their percent saturations or as the amounts exchangeable.

There were no significant influences of the amounts of exchangeable Ca or Mg on bentgrass clipping weights. This observation indicates that soil exchangeable Ca as low as 1.62 cmol(+)/kg or 24% saturation supplied all of the Ca the bentgrass required. The lowest values for Mg in the study were 0.43 cmol(+)/kg (Table 1), or a saturation of 6.5% (Table 2). The bentgrass showed no growth response to any higher values.

Soil K levels exhibited a significant influence on bentgrass clipping weight (Fig. 3). While not a strong relationship, indications from this figure are that in this study the optimum soil K level was about 0.15 cmol(+)/kg, or a saturation of around 2.2%, which is within the range specified by BSR theory.

Bentgrass clipping Ca concentrations ranged from 0.57 at 24% soil Ca saturation to 1.87% at 74% soil Ca saturation. According to Jones (1980), the Ca sufficiency range for turfgrass is 0.5 to 1.2%. This, plus the fact that we saw no bentgrass growth response to increasing soil Ca levels, suggests that soil Ca levels can be slightly less than 24% saturation or 1.62 cmol(+)/kg (around 320 ppm) without adversely affecting bentgrass growth during establishment.

Magnesium concentrations in the bentgrass clippings ranged from 0.22 to 0.45%. Jones (1980) cites 0.2 to 0.6% as being adequate. Given that all of our treatments appeared to supply adequate amounts of Mg, it is understandable why we saw no growth response to the different levels of soil Mg, all of which were within or above the percent saturation range specified by BSR theory.

Clipping K concentrations ranged from 1.48 to 3.08% before supplemental fertilizer K was added to the pots. After the K addition, clipping K concentrations ranged from 2.72 to 3.32%. All of these are considered adequate by Jones (1980), but he points out that his adequacy range of 1.0 to 2.5% K may not apply to all turfgrasses. While our data do not clearly define a range of adequate tissue K levels, indications were that for bentgrass the adequacy range begins at about 2.2% K. This requirement was met in all treatments wherein soil K levels exceeded 0.15 cmol(+)/kg of exchangeable K, which equates to about 60 ppm K or 2.3% saturation in our soil. Clipping K concentrations reach a maximum of around 3.2% when exchangeable K levels were in excess of 0.32 cmol(+)/kg or 125 ppm.

Soil base saturation and Ca:Mg ratios were found to have no influence on bentgrass clipping Mg and K concentrations. This tends to dispel the notion that adequate Mg and K nutrition cannot be achieved unless the soil contains the proper ratios of exchangeable Ca, Mg, and K. On the contrary, this is further evidence that as long as soil Ca, Mg, and K are present in adequate amounts, their ratios are, at best, of minor importance.

SUMMARY AND CONCLUSIONS

Creeping bentgrass was grown for 8 weeks in a sandy loam soil treated to provide base saturations of 38 to 86%, Ca saturations of 24 to 74%, Mg saturations of 6.5 to 13.3%, K saturations of 0.8 to 5.2% and Ca:Mg ratios of 2.0 to 10.4. There were no significant influences of soil percent base saturation or Ca:Mg ratio on clipping production or clipping concentrations of Mg and K. Maximum clipping production was observed at percent Ca saturations above 24%, well below the optimum of 65 to 80% saturation stipulated by base saturation ratio theory. There was no response to a percent Mg saturation of greater than 6.5 (the lowest in the study) to a K saturation above 2.3%.

In working with a single soil, one cannot differentiate between the influences of percent cation saturation and the amount of exchangeable cation present on plant growth or nutrient content. Relationships between clipping weights and Ca, Mg, and K concentrations and between exchangeable soil Ca, Mg, and K clipping percent Ca, Mg, and K were used to identify optimum growing conditions. Indications were that soil containing at least 320 ppm exchangeable Ca and 60 ppm exchangeable K will meet the nutritional requirements of creeping bentgrass during establishment. Conditions of the study did not allow for clear definition of the minimal soil Mg requirement, but it appeared to be around 70 ppm.

The results of this study failed to validate the BSR theory. On the contrary, there was considerable evidence that application of the theory in turfgrass management can easily lead to applications of Ca or Mg that have no remunerative value. Rather, turfgrass managers should focus on the amounts of exchangeable Ca, Mg, and K in soil and not their saturation percentages.

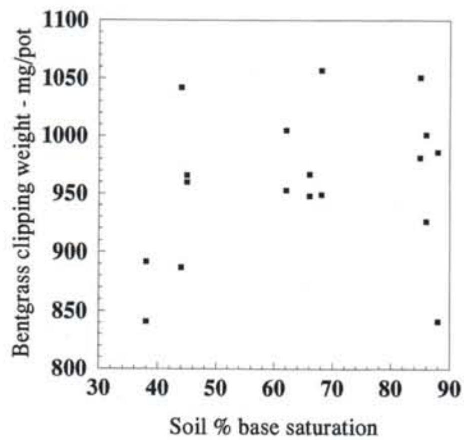

Figure 1. Relationship between soil percent base saturation and bentgrass clipping weights.

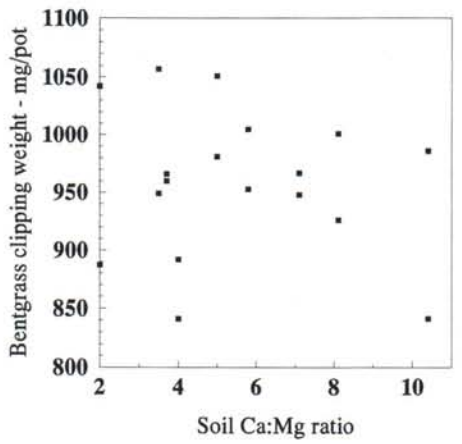

Figure 2. Relationship between soil Ca:Mg ratio and bentgrass clipping weights.

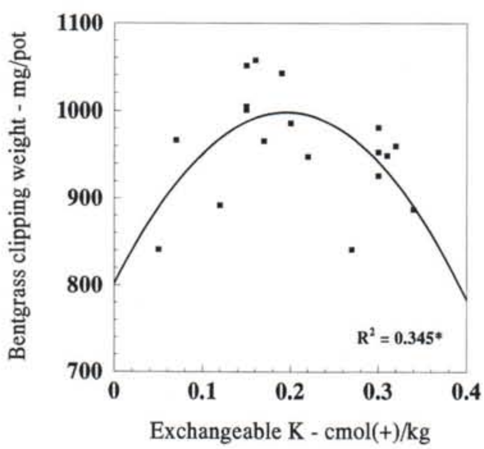

Figure 3. Relationship between exchangeable soil K and bentgrass clipping weights.

REFERENCES

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