FIELD EVALUATION OF SOIL ACIDITY EFFECTS ON THE GROWTH OF ANNUAL AND PERENNIAL RYEGRASSES

N. Miles
KwaZulu-Natal Department of Agriculture, Private Bag X9059, Pietermaritzburg 3200, South Africa

ABSTRACT

Soil acidity limits pasture establishment and productivity in the moister eastern half of South Africa. Sound lime requirement guidelines based on soil test data are required. In the study reported here, lime responses of annual (*Lolium multiflorum*) and perennial (*Lolium perenne*) ryegrasses were evaluated in irrigated field trials located on acidic, highly weathered soils. Annual ryegrass (yield response to lime 27 to 32%) was found to be markedly more tolerant of soil acidity than perennial ryegrass (yield response 68%). Acid saturations of up to 20% had little impact on the yield of annual ryegrass, while yield of perennial ryegrass declined sharply with increases in soil acid saturation above 0%. Annual ryegrass was more sensitive to acidity during the establishment phase of growth leading up to the first harvest, relative to growth during the remainder of the season.

KEYWORDS

Annual ryegrass, perennial ryegrass, lime, soil acidity

INTRODUCTION

In the eastern half of South Africa, animal production is improved by the replacement of low-quality natural grassland with introduced pasture spp. Annual (*Lolium multiflorum*) and perennial (*Lolium perenne*) ryegrasses are important components of these betterment programmes, providing much-needed forage during the dry winter months.

Production of ryegrasses relies heavily on irrigation and high fertilizer inputs (350 to 500 kg N ha^{-1} per season). In these capital intensive situations it is critically necessary to efficiently manage natural limitations to production. These limitations generally involve excess soil acidity (exacerbated by N inputs) and low soil P status. Although the acid stress tolerance of ryegrasses has been studied (Edmeades et al., 1991; Hillard et al., 1992), definite information on the lime requirements of this crop is presently lacking. This paper reports on the yield responses of annual and perennial ryegrasses grown under cutting regime to lime applications made on naturally acidic soils.

METHODS

Separate annual (cv Midmar) and perennial (cv Ellett) ryegrass field trials were established on typic Hapludox soils in KwaZulu-Natal (29°38'E, 29°02'S, altitude 1450 m, rainfall 1166 mm and evaporation 1436 mm). The annual ryegrass trial was located on a sandy clay loam (topsoil clay content 330 g kg^{-1}, organic C 28 g kg^{-1}, pH (KCl) 4.04 and exchangeable Al+H 2.85 $cmol_c L^{-1}$) and the perennial ryegrass trial on a sandy clay (topsoil clay content 410 g kg^{-1}, organic C 36 g kg^{-1}, pH (KCl) 4.20 and exchangeable Al+H 2.06 $cmol_c L^{-1}$).

Confounded unreplicated factorial (4^3) designs were used in both trials. Factors were lime, P and K for annual ryegrass, and lime, N and P for perennial ryegrass. Lime was incorporated 4 to 6 weeks prior to pasture establishment; rates are listed in Table 1. In both trials, other essential elements not included as factors (K, S, B, Cu, Zn and Mo) were supplied uniformly over the experimental areas at rates considered to be adequate. Responses to lime were evaluated at non-limiting levels of P and at seasonal N rates in the range 300 to 600 kg N ha^{-1} (N was applied at establishment and after each harvest). Annual ryegrass experimentation was during two consecutive seasons (February to November), while perennial ryegrass was grown for a single season (February to February). Cutting was at intervals of 4 to 5 weeks, and 6 to 8 weeks in the case of the summer growth of perennial ryegrass. Both trials were irrigated regularly so as to ensure that moisture was not limiting.

Topsoil (0-100 mm) samples were taken at the first harvest. Soil samples were analyzed for pH (KCl) and exchangeable cations. In the ensuing discussion, use is made of acid saturation [(Al+H/ Ca+Mg+K+Al+H)100, where ion concentrations are expressed on an equivalents basis] as an index of soil acidity. In developing the yield-acid saturation relationships reported here, use was made of relative yield, where the highest yield in response to lime applications was taken as 100%.

RESULTS AND DISCUSSION

Highly significant increases in soil pH, decreases in exchangeable acidity (Al+H) and increases in yield accompanied lime applications (Table 1). In the case of annual ryegrass, liming resulted in a 27 to 32% increase in yield, and although yield peaked at the highest lime rates, the major portion of the yield increase in both seasons was in response to the first lime increments (which eliminated more than half of the exchangeable acidity). With perennial ryegrass, a 68% yield response to lime was measured, despite the soil being appreciably less acidic than that on which the annual ryegrass was grown. Furthermore, in contrast to annual ryegrass, a leveling-off in the perennial ryegrass yield response was not indicated, with each successive lime increment resulting in significant yield increases.

Relative yield-soil acid saturation relationships for annual and perennial ryegrasses are presented in Figure 1.Comprehensive long-term field research has shown that for a moderately acid-tolerant species such as maize, soil acid saturation is a more reliable predictor of soil acidity effects on plant growth than is pH (Farina and Channon,1991). In the case of annual ryegrass, there is clear evidence of greater sensitivity to acidity during the establishment phase of growth leading to the first harvest, relative to growth during the remainder of the season. After the first harvest, however, yields remained above 80% of the maximum even at acid saturations approaching 60%. It is noteworthy that annual ryegrass and other pasture species have, in local research programmes, been found also to have substantially higher soil P requirements during the establishment phase of growth relative to requirements for subsequent regrowth (Miles, 1991). Relative yields of perennial ryegrass declined sharply with increases in acid saturation above 0%, with this pattern of response being fairly consistent during the season. Evidence of greater sensitivity to soil acidity of perennial ryegrass relative to annual ryegrasses is consistent with the findings of Edmeades et al.(1991) who showed that the solution Al activity associated with a 50% reduction in yield was 2 to 3 times higher for several annual ryegrass cultivars relative to Ellett.

The investigations reported here reflect important differences between the annual and perennial ryegrass cultivars studied in terms of their respective soil acidity tolerances. In the case of the annual ryegrass, considerable acid tolerance is suggested, and clearly, acid saturations of up to 20% have, even taking into account the higher initial sensitivity during establishment, little impact on yields. For the perennial ryegrass, on the other hand, the reported data suggest the possible need to lime to a pH higher than that at which all exchangeable acidity is eliminated, in order to optimize yields. These differences in response to acidity represent major differences in input costs for the production of these pastures on acid soils.

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Table 1
Lime effects on soil pH, soil exchangeable Al+H and the dry matter yields of ryegrasses (soil samples were taken 4 to 6 weeks after pasture establishment).

Annual ryegrass								**Perennial ryegrass**			
Season 1				Season 2							
Lime[y] t ha^{-1}	pH (KCl)	Al+H cmol$_c$L^{-1}	Yield t ha^{-1}	Lime[y z] t ha^{-1}	pH (KCl)	Al+H cmol$_c$L^{-1}	Yield t ha^{-1}	Lime[x] t ha^{-1}	pH (KCl)	Al+H cmol$_c$L^{-1}	Yield t ha^{-1}
0	4.03	2.52	10.4	0	3.98	2.84	11.9	0	4.34	1.61	7.3
1.5	4.28	1.04	11.9	2	4.43	0.68	14.5	4	4.64	0.58	9.3
3.0	4.57	0.45	12.6	4	5.15	0.08	15.1	8	5.03	0.14	11.0
4.5	5.08	0.11	13.3	6	5.60	0.04	15.7	12	5.43	0.04	12.3
$LSD_{0.05}$	0.29	0.22	1.9	-	0.13	0.11	1.7	-	0.12	0.15	1.1

[y] Lime as calcium hydroxide [x] Dolomitic lime
[z] Lime re-applied to plots treated in season 1

Figure 1
Relationships between soil acid saturation and the yields of annual and perennial ryegrasses