

Research Application Summary

Lime requirement of selected acid soils of Lesotho and response of field beans to lime application

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Abstract

A greenhouse experiment was undertaken to evaluate the effects of lime application (at different rates) on soil pH, exchangeable aluminium (Al^{3+}) and plant response to lime application across four of the strongly acidic soils series of Lesotho. The objective of this study was to develop lime recommendations for management of acid soils in Lesotho by determining the lime requirement of selected soils, determining the effect of lime on biomass and height of beans (*Phaseolus vulgaris*) plants and the effect of liming on available phosphorus. This experiment was a 4 x 6 randomized complete block design with three replications and was a two factor experiment involving only soil and lime. The results of this study indicated that soil pH across all the soils increased with increasing lime addition. However Al^{3+} decreased with more addition of lime on all the soils. Both plants parameters (height and biomass) increased with increase in lime rates but the response was negative as more lime was added, i.e., there was no linear relationship between lime rates and both plant parameters' response ($P > 0.05$). There was no significant effect of lime on phosphorus across all the soils

Key words: Biomass, exchangeable aluminium, lime requirement, soil pH

Résumé

Une expérience dans la serre a été menée pour évaluer les effets de l'application de la chaux (à des taux différents) sur le pH du sol, de l'aluminium échangeable (Al^{3+}) et la réponse de la plante à l'application de la chaux sur quatre séries des sols fortement acides du Lesotho. L'objectif de cette étude était d'élaborer des recommandations d'utilisation de la chaux pour la gestion des sols acides au Lesotho, en déterminant les besoins en chaux des sols choisis, en déterminant l'effet de la chaux sur la biomasse et la hauteur des haricots (*Phaseolus Vulgaris*) et l'effet du chaulage sur le phosphore disponible. Cette expérience a été une conception aléatoire complète des blocks

4 x 6 avec trois répétitions et a été une expérience à deux facteurs comportant seulement des sols et de la chaux. Les résultats de cette étude ont indiqué que le pH du sol dans tous les sols a augmenté avec addition croissante de la chaux. Toutefois, les Al^{3+} ont diminué avec plus d'addition de la chaux sur tous les sols. Les deux paramètres des plantes (hauteur et biomasse) ont augmenté avec l'augmentation des taux de la chaux, mais la réponse a été négative plus la chaux était ajoutée, c'est à dire, il n'y avait pas de relation linéaire entre les taux de la chaux et la réponse de deux paramètres de la plante ($P > 0,05$). Il n'y avait pas d'effet significatif de la chaux sur le phosphore dans tous les sols.

Mots clés: Biomasse, aluminium échangeable, besoins en chaux, pH du sol

Background

Crop production is one of the most important components of all the farming systems in Lesotho. Nevertheless, agricultural productivity in Lesotho is on the decline due to a number of factors including inadequate rainfall, soil erosion, poverty, unemployment and low soil fertility resulting from low pH, low base saturation and phosphorus deficiency. Schmitz and Rooyani (1987) reported that seven out of eleven benchmark soils of Lesotho had an acidic soil reaction and most of them occurred in the lowlands and lower foothills. However, as indicated further by Marake (1999) the seriousness of soil acidity in Lesotho is often obscured by the fact that maize (a dominant cereal crop in Lesotho) is relatively tolerant of low pH conditions while yield of other cereals such as beans (*Phaseolus vulgaris*) are significantly affected by low pH conditions. Therefore this research concentrated on four of the most acidic soil series of Lesotho (Sefikeng, Machache, Tumo and Leribe) with the purpose of developing recommendations for management of acid soils in Lesotho by determining the lime requirement of selected soils, determining the effect of lime on biomass of bean plants and establishing the effect of liming on available phosphorus.

Literature Summary

The main way to bring about the amelioration of acid soils is to apply lime and before lime is applied soils have to be tested for their lime requirement. Rowell (1988) indicated further that lime requirement (LR) has been considered as the amount of lime required to raise pH of a soil to a certain value often 6.5 in temperate regions. However, with rapid development of tropical regions for crop production and increased understanding of the

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importance of Al^{+3} and Mn toxicities as limitations to plant growth the term is now used as the amount required to alleviate restrictions to crop yields. Turan *et al.* (2003) studied the effect of different doses of lime material on soil properties and growth of spinach (*Spinacia oleracea*) and found that soil pH, exchangeable calcium (Ca^{+2}) and magnesium (Mg^{+2}) increased with increasing rates of lime doses but exchangeable Al^{+3} and H^+ , exchangeable K^+ and available iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) content decreased with increasing doses.

Samples from four acidic soils of Lesotho namely (Leribe, Machache, Sefikeng and Tumo) series were collected and air-dried. Six rates of lime (Dolomitic lime) were dry mixed with the potted soil (6 kg soil/pot). This lime was added with regard to the actual LR determined for each soil in the laboratory. After one week of soil-lime interaction beans seed were planted in each pot for all the four soils series. This experiment was a 4 x 6 randomized complete block design with three replications and was a two factor experiment involving only soil and lime. Data taken (after 8 weeks) included plant biomass, height, aluminium toxicity (Al^{3+}) and soil pH (in water and KCL). All data was analysed statistically using analysis of variance (ANOVA). Single degree of freedom polynomial contrasts were used for mean separations.

Table 1. ANOVA table.

Source of variation	DF	Pr > F				
		Biomass	Height	Al3+	pHw	pHk
Soil	3	0.0002	0.0001	0.5527	0.0001	0.0001
Lime	5	0.0091	0.0001	0.0018	0.0001	0.0001
Contrast						
Limelin	1	0.1388	0.1401	0.0071	0.0001	0.0001
Limequad	1	0.0035	0.0274	0.0094	0.0001	0.0001
Soil*lime	15	0.0673	0.0833	0.0858	0.0001	0.0001
Contrast						
Linearly	1	0.5216	0.8433	0.4028	0.0002	0.0001
Quadratic	1	0.4492	0.935	0.2118	0.0001	0.681

Research Application

Lime effect on soil pH. Application of lime significantly ($P < 0.05$) increased soil pH across all the soils. Soil pH increased with lime rates to a point where there was no more acidity to be neutralised by lime in the soil.

Lime effect on Al³⁺. Lime application increased soil pH (as expected) but it also decreased KCl extractable Al³⁺ and this resulted in significantly ($P < 0.05$) lowering the activity of Al³⁺ in the soils. The activity of Al³⁺ was inactivated at 100% standard recommendation, i.e., at the actual lime requirement as determined in the laboratory.

Lime effect on biomass and height. The results indicated that there was a significant ($P < 0.05$) effect of lime on biomass and height of the bean plants. Both plant parameters increased with increase in lime rates but the response became negative as more lime was added, i.e., there was no linear relationship between lime rates and both plant parameters' response. But quadratically there was a significant effect of lime on bean height ($P < 0.05$).

Lime effect on phosphorus. Lime addition on all the soils had no effect on phosphorus level, i.e., there were no significant differences in phosphorus content of all soils before and after lime application. Several laboratory and field studies have been undertaken to determine how phosphate (P) availability responds to lime addition. The results have often been inconsistent. In some case liming was reported to increase, decrease or have no effect on P availability (Hynes, 1982).

Recommendation

Based on the results of this study it is recommended that there should be demonstrations based on the effects of lime on crop yields by the Ministry of Agriculture through the extension service. It is believed that the establishment of such demonstrations would capture farmers' interest in lime application, and as a result, they will be encouraged to test their soils for lime requirement. By doing so, yield losses associated with low pH will be avoided hence farmers will be able to realise the full benefit of their fertiliser investment.

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