

Ameliorating acid soil infertility by application of basalt, ground magnesium limestone and gypsum

Shamshuddin Jusop^A and Che Fauziah Ishak^B

Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, ^AEmail samsudin@agri.upm.edu.my; ^BEmail fauziah@agri.upm.edu.my

Abstract

Ultisols and Oxisols are often acid, having high Al, but are deficient in Ca, Mg, K and P. Studies were conducted to determine the effects of basalt, ground magnesium limestone (GML) and gypsum applications on the soils and crop growth. Results showed that basalt application increased soil pH with concomitant decrease in pHo, which in turn increased cation exchange capacity (CEC). Dissolution of basalt had released Ca, Mg, K and P into the soil making them available for crop consumption. In the soils treated with GML, Ca remained in the zone of incorporation. When GML was applied together with gypsum, Ca moved deeper into the soil profile. SO₄ adsorption onto the surfaces of oxides resulted in an increase in pH and negative charge. The increase in pH was due to the replacement of OH by SO₄.

Key Words

Basalt, ground magnesium limestone, gypsum, maize, Ultisol, Oxisol.

Introduction

Malaysia grows oil palm, rubber and cocoa on Ultisols and Oxisols, which are dominated by kaolinite, gibbsite, goethite and hematite (Shamshuddin and Ismail 1995; Anda *et al.* 2008). The charges on the mineral surfaces change with changing pH. The soils are sometimes used for field crops, but their yields are limited by low pH, high Al and Ca and/or Mg deficiencies (Shamshuddin *et al.* 1991). This paper describes the effects of basalt, GML and gypsum applications on the soils and maize growth.

Material and Methods

Two Ultisols and one Oxisol were used for this study. The ameliorants tested in this study were basalt, GML and gypsum. The soils were treated with these amendments in pot and field experiments for specified periods.

Results and Discussion

Effects of basalt application

Basalt application had increased pH slightly. The increase in pH resulted in reduction of exchangeable Al. The increase in pH resulted in the increase of CEC (by NH₄Cl). The CEC increase may also be due to the lowering of pHo. The dissolution of basalt had released Ca, Mg, K and P into the soil. Hence, exchangeable Ca, Mg and K and available P had increased.

Movement of Ca

Calcium remained in the zone where the lime was originally incorporated. Highly weathered soils of Malaysia are dominated by kaolinite and sesquioxides (Anda *et al.* 2008) and the charge on the exchange complex of these minerals increases with increasing pH. When the GML was applied, pH increased, followed by an increase in CEC. Hence, Ca was held by the negatively-charged surfaces. When GML was applied together with gypsum, some Ca moved deeper into the soil profile, ameliorating the subsoil.

Adsorption of SO₄

SO₄ from the gypsum was adsorbed specifically on the surface of oxides. As a consequence, the pH and negative charge on the oxides increased. However, the resultant increase in pH was only observed in the Oxisol. In the Ultisol, the pH tended to decrease. Obviously, there was another opposing reaction that took place simultaneously as SO₄ adsorption when gypsum was applied. This second reaction was the replacement of Al on the exchange complex by Ca. Al went into the solution and pH was lowered accordingly. Both SO₄ adsorption and Al replacement by Ca occurred in the Oxisol and Ultisol, but the former was more dominant in the Oxisol as the soil contained higher amount of oxides. On the other hand, exchangeable Al was high in the Ultisol and, therefore, Al replacement was more dominant.

Amelioration of acid soil infertility

Our study indicated that Al toxicity can be overcome by GML application at the rate of 2 t/ha or to a limited extent by gypsum application (Shamshuddin *et al.* 1991). It seems that a good agronomic option is to apply GML together with gypsum in the topsoil.

Ca itself is able to detoxify Al. When GML and/or gypsum were applied onto the soils, Ca was made available in large quantities, and consequently reduced Al toxicity. A 10% drop in relative top maize weight corresponds to a Ca/Al concentration ratio of 79. It shows that Ca needs to be considerably high in the soil solution of Ultisols and Oxisols in order to alleviate Al toxicity.

Long-term effect of GML application

The field experiment was started in 1986. It was monitored till 1993. At high rate of GML application, the exchangeable Ca in July 1991 remained reasonably high. After 1991 the exchangeable Ca began to decrease. In the case where 2 t GML/ha were applied, the exchangeable Ca was reduced to the level of the untreated soil. In 1993, at the GML rate of 4 and 8 t/ha, the exchangeable Ca was considered to be within the range suitable for maize growth. This means that the ameliorative effect of GML at the rate 4 t/ha or higher can last up to 8 years. Data on exchangeable Al show consistent results with those of the exchangeable Ca.

Conclusion

Basalt and GML are good soil ameliorants. GML application is only able to alleviate topsoil acidity. In order to alleviate subsoil Ca deficiency of Ultisols and Oxisols GML has to be applied together with gypsum. Gypsum can be used to ameliorate Oxisols having high oxides content, but not to be applied single handedly onto Ultisols having high exchangeable Al. SO_4 adsorption by oxides increased pH and negative charge via replacement of OH by SO_4 . Liming at the rate of 4 t/ha or higher is effective for about 8 years.

References

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