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Research Application Summary

Phosphate sorption by andisols and ultisols, and its implication on phosphorus bioavailability in the wet tropics of Tanzania

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Abstract

Phosphorus (P) sorption and desorption behaviour of Andisols of Siha - Kilimajaro and Ultisols of Magadu -Morogoro, Tanzania was studied in pot experiments. This was to facilitate development of P management strategies for enhanced maize productivity as these areas have high P sorption capacities and require high amounts of this nutrient for it to be available to crops. Six P rates (0, 0.1, 0.2, 0.4, 0.8, and 1.0 mg P L^{-1}) were studied. There was a significant increase in maize dry matter yield with addition of P at all rates. It is therefore recommended that soils in the study areas be supplemented with P to improve its availability to maize and thereby increase crop yield.

Key words: Andisols, dry matter yield, maize, mineral availability, P-sorption, Ultisols

Résumé

Le comportement d'absorption et de dégagement de Phosphore (P) des Andisols de Siha - Kilimandjaro et des Ultisols de Magadu-Morogoro, en Tanzanie a été étudié dans des expériences en pot. Ce fut pour faciliter le développement de stratégies de gestion du phosphore P pour la productivité du maïs amélioré, car ces régions ont une grande capacité d'absorption de phosphore P et nécessitent une grande quantité de ce nutriment pour qu'il soit disponible pour les cultures. Six taux de P (0, 0,1, 0,2, 0,4, 0,8 et 1,0 mg P L^{-1}) ont été étudiés. Il y a eu une augmentation significative du rendement en matière sèche du maïs avec addition de P à tous les taux. Il est donc recommandé que les sols dans les zones d'étude soient supplées en phosphore P pour améliorer sa disponibilité pour le maïs et d'augmenter ainsi le rendement des cultures.

Mots clés: Andisols, rendement en matière sèche, maïs, disponibilité des minéraux, absorption-P, Ultisols

Background

Unavailability of phosphorus (P) to plants is a fertility constraint in subtropical and tropical soils resulting from high immobilization of both native and P added to such soils. This increases essentiality of phosphorus inputs if high levels of maize

production are to be achieved on these soils, other soil fertility and plant growth attributes being optimal. In Tanzania, phosphorus nutrient is a limitation to plant productivity in most soils. Changes in various soil properties tend to produce rhizosphere effects that influence P sorption and desorption mechanisms and its plant uptake. It is important to establish P sorption and desorption mechanisms and trends, the soil processes and properties involved, and the consequent P availability and maize crop response to the native and P added to soils as a fertilizer material.

This study was set up to assess P sorption and desorption behaviours of the Andisols of Siha- Kilimanjaro and Ultisols of Magadu- Morogoro, Tanzania. Results of the study will assist in the development of long-term P management strategies for enhanced and sustainable maize growth in the respective regions to check the prevalent food insecurity across the country.

Literature Summary

In Tanzania, phosphorus deficiency is a widespread soil fertility constraint in most acid (Ultisols) and young (Andisols) soils dominated by the 1:1 layer silicate clays like kaolinite and free hydrous oxides of Al and Fe, and the amorphous aluminosilicates (Msanya *et al.*, 2003). In uncultivated soils, the availability of P to plants is a function of the amount and form of soil P present and the rate at which it can be mobilized and transported to plant roots. The nature and stability of native P is related to the soil parent material and the extent of pedogenesis. The rate of transport to plant roots is controlled mostly by the soil moisture regime and the soil P sorption power (or capacity) (Nye and Tinker, 1977).

The low food production in Tanzania is contributed largely by poor agricultural technical packages including inadequate research and lack of information on different agro-ecological zones (Kileo, 2000), poor land use planning (Msanya *et al*., 2001), poor crop husbandry and management and growing of crops in marginal areas. Unreliable rainfall, poor soil fertility and different forms of land degradation are other factors responsible for low food production (Kileo, 2000).

Andisols and Ultisols have high P sorption capacity and may require over 200 kg P ha^{-1} to raise the soil solution concentration of the plough layer to 0.2 mg L^{-1}, a level where P limitation of crop yield is alleviated (Sanchez and Uehara, 1980).

Study Description

Soils were collected from Matadi and Magadini villages in Siha district- Kilimanjaro region for the Andisols and Magadu-Morogoro region for the Ultisols. The P bioavailability was determined in a 35-day glasshouse pot experiment with maize as the test crop and KH_2PO_4 as the source of P. The P rates applied were derived from the linear form of Langmuir and the modified Freundlich isotherms. The critical P level was taken as 0.2 mg P L^{-1} in the equilibrium solution at the end of equilibration period and from the P sorption isotherms.

Soil samples were initially characterized before being subjected to KH_2PO_4 for sorption, desorption and pot experiment studies. The P rates applied were based on the sorbed P in the equilibrium with 0, 0.1, 0.2, 0.4, 0.8 and 1.0 mg P L^{-1}. The corresponding P amounts were thoroughly mixed with 4 kg of 2 mm sieved soil sample portions in 5 L capacity plastic pots and each incubated at field capacity moisture status for one week. Thereafter, four maize seeds were planted in each pot and thinned to two plants per pot two weeks after germination. All pots received an application of urea $CO(NH_2)_2$ fertilizer at a rate of 100 kg N ha^{-1} applied in three splits, at thinning, seven and 14 days after thinning. Based on the initial soil characterization results, the limiting nutrients were applied, but not to significantly influence the P-sorption capacities of the soils. The treatments were replicated three times in a completely randomized block design.

Maize plants were harvested at 35 days of growth for dry matter and percentage P contents determination at the different levels of P applied. Data were analysed using MSTATC computer package. Means were separated using the Least Significant Difference (LSD) test at 5% level of significance.

Research Application

Dry matter yield was significant ($P<0.05$) among the three soils. Matadi soil had mean dry matter production of 29g/pot whereas Magadini and Magadu soil averaged 25g/pot and 22g/pot respectively. Determination of the plant percentage P for each soil following KH_2PO_4 applied rates is in progress.

Application of KH_2PO_4 as inorganic fertilizer significantly increased ($P\leq0.05$) maize dry matter yield for each studied soil. The mean dry matter yield as a result of KH_2PO_4 increased by 1- 6%, 12 - 18% and 8- 25% for Matadi, Magadini, and Magadu, respectively (Fig. 1). Visual observations showed that maize performance was poor in Magadu soil although the dry matter yield obtained was not significantly different from other

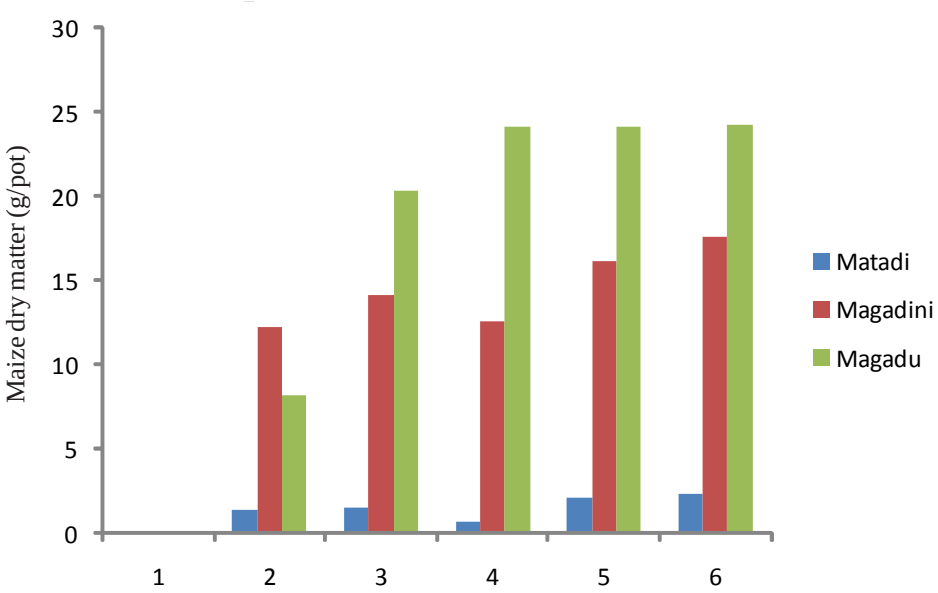

Figure 1. Effects of different rates of KH_2PO_4 on dry matter yield of maize.

soils. Application of 4.4g KH_2PO_4/pot (4-kg soil pot) gave optimum dry matter yield for all three soils.

Recommendation

It is recommended that Matadi, Magadini and Magadu soils be supplemented with KH_2PO_4 to improve maize performance. However, subsequent effects of pH on the fates of P in the soil system have to be checked with alternative sources of liming materials.

References

Kileo, E.P. 2000. Land suitability assesment of the Wami plains in Morogoro, Tanzania with respect to the production of the main food crops and extensive grazing. M.Sc. Thesis, Sokoine University of Agriculture, Morogoro, Tanzania. pp. 152.

Msanya, B.M., Kaaya, A.K., Araki, S., Otsuka, H. and Nyadzi, G.I. 2003. Pedological characteristics, general fertility and classification of some benchmark soils of Morogoro District, Tanzania. *African Journal of Science and Technology . Science and Engineering Series* 4 (2): 101- 112.

Msanya, B.M., Kimaro, D.N., Kileo, E.P., Kimbi, G.G. and Mwango, S.B. 2001. Land suitability evaluation for the production of food crops and extensive grazing: A case study of Wami plains in Morogoro rural district, Tanzania. Soils and land resources of Morogoro rural and urban districts, Volume 1. Department of Soil Science, Faculty of

Agriculture, Sokoine University of Agriculture, Morogoro, Tanzania.

Nye, P. H. and Tinker, P. B. 1977. Solute movement in the soil-root system.' Blackwell: Oxford.

Sanchez, P.A. and Uehara, G. 1980. Management considerations for acid soils with high phosphorus fixation capacity. In: F.E. Khasawneh *et al.* (Ed.). The role of phosphorus in agriculture. ASA, Madison, WI. pp. 471-514.