Associative Influence of Soluble Phosphate, Rock Phosphate and Arbuscular Mycorrhizal Fungus on Plant Growth and Phosphorus Uptake of Three Tropical Legumes

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Abstract

Cowpea, pigeonpea and groundnut were grown in the glasshouse in a gamma ray-sterilized Andisol (Melanudand) subsoil (Bray 1-P: 1.04 μg P g^{-1}; Bray 2-P: 1.91 μg P g^{-1}) and inoculated with or without mycorrhiza, *Glomus etunicatum* (Ge). They were fertilized with South African rock phosphate (EPL 86) and 20 mg of readily soluble phosphate (SP). KH_2PO_4 was also used as starter fertilizer and its effect on utilization of the rock phosphate-P for growth by the legumes was investigated. Shoot dry weight of cowpea was unaffected by mycorrhiza only treatment but those of groundnut and pigeonpea were increased. Rock phosphate (RP), however, failed to increase the shoot growth of the legumes irrespective of mycorrhizal treatment. Total shoot dry weight and total P content increases of pigeonpea and groundnut plants receiving the SP + Ge and tripartite (RP + SP + Ge) treatments were mainly due to the combined roles of SP and Ge since there were no significant differences between these treatments. This suggests a lack of any RP role in such responses. In cowpea, however, the tripartite application also enhanced the total shoot dry matter production and, in addition, specifically increased the dry weight and P content of its vegetative parts. The effects of the tripartite treatment on the total shoot dry weight of cowpea and the P content of its vegetative organs were synergistic, with mycorrhiza playing a strong role, mediated through the well-developed root system and the improved nodulation. The treatment also induced additive responses of sporulation on cowpea, the mycorrhizal association in cowpea greatly enhanced the extensity of root ramification into the soil thereby enabling the roots to extract P from the sparingly soluble RP. In pigeonpea and groundnut, however, no significant priming effect on growth and RP-P utilization due to the starter SP was observed. These findings suggest that in some agricultural crop plants root access to rock phosphate-P could be enhanced through simultaneous mycorrhization and application of small doses of a readily soluble phosphate fertilizer as a primer.

Introduction

An important observation on rock phosphate (RP) research, especially in the tropics, is the role of plant-available phosphorus in the very early stages of plant development (Hammond *et al.*, 1986). One of the major limitations of finely-ground RP is its inability to satisfy this early requirement because of its slow rate of dissolution. To overcome this, it is often recommended that the RP be applied several weeks or months prior to planting so that a greater portion of it is dissolved by the time of planting. This approach is effective, however, only when practised in flooded systems which can increase the availability of P in the reaction products (Kanabo & Gilkes, 1988), or when the P retention capacity of the soil is low so that the dissolved P remains available to the plant throughout the incubation period. Unfortunately, in tropical soils fertilizer P can be fixed into forms unavailable to plants by Fe and Al oxides commonly found in such soils (Sample *et al.* 1980; Abekoe &