Theme 1
Status and trends of global soil nutrient budget

Assessing phosphorus availability on Malagasy soils with functional and mechanistic method

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INTRODUCTION

Ensure food security relies on ensure productivity. Knowing process governing availability of elements means having a part of controls of food productivity, especially for phosphorus, which is a limited factor for tropical soil like Malagasy soils. Study of the processes governing mobility and availability of soil elements shows that the diffusion process is the major process that fixes the availability of phosphorus (P) to plants. It has been shown experimentally that the part of P in soil that is available for plants can be predicted by the amount of dissolved and transferable orthophosphate ions (P-ions) at the solid-solution interface. This amount is assessed by isotopically dilutable or exchangeable phosphorus (Fardeau et al., 1996). Diffusion at the solid-solution interface controls the transfer of P-ions from the soil to the root, following a difference in P-ions concentration. Indeed, after root absorption, the concentration of P-ions around the root decreases, inducing the move of P-ions on the surface of the solid constituents of the soil towards the soil solution around the root (Morel et al., 2000). To evaluate the quantity of P-ions available to plants, the use of an assessment based on this diffusion process would give reliable results.

METHODOLOGY

A study was conducted in several type of Malagasy soils to assess availability of phosphorus for plants in a functional and mechanistic method. The functional and mechanistic method is a result of a long-term research on phosphorus in various sites spreading in the world. This method was tested several times in temperate soil. Our study completes its usefulness on tropical soil, tested in several type of soil representing type of soils which do exist in Madagascar. This method couples' sorption-desorption experiments with isotopic dilution kinetics of P-ions in steady-state soil suspensions, conducted in laboratory. After having experimental values of the amount of phosphorus susceptible to be available to plant, it allows describing dynamic of phosphorus in soil-solution interface by P-ions concentration in solution (Cp) and time, by using the Freundlich kinetic function Pr=v.Cpw.tp. 116 samples of soils type were tested.

RESULTS

Results describes the evolution of P-ions concentration in solution (Cp) and the amount of P-ions diffusible (transferable) on solid-solution interface (Pr). Fig.1 shows dissolved P-ions concentration and quantity of diffusible P-ions at the solid-solution interface for 6 samples selected to cover all the variability observed from the 116 samples. The other 110 samples have a response curve intermediate. The experimental values of Pr are presented according to the dose of P and the 3 isotopic dilution times (usually 3, 30, and 300 minutes). These values are fitted with the kinetic function of Freundlich Pr = v.Cpw.tp (lines). Our results shows that samples of soil have varied characteristics between them. Some reacts intensively with P-ions, thus for some, transfer of phosphorus in soil-solid interface is gradual. Soils is stated as 'reacts' if the known amount of phosphorus introduced in solution disappear after the experiments, only a few amounts remain in solution. In this case Pr values increase quickly than Cp values like sample no.20,26,60 for instance (fig.1). That means phosphorus was passes through solution to solid phase. If the transfer is stated 'gradual', that means a major quantity of phosphorus introduced remain in solution. In this case Cp values increase with dose of P-ions introduced in solution, Pr doesn't change significantly, like sample no.15 for instance (fig.1). This is paired with saturation of solid phase.

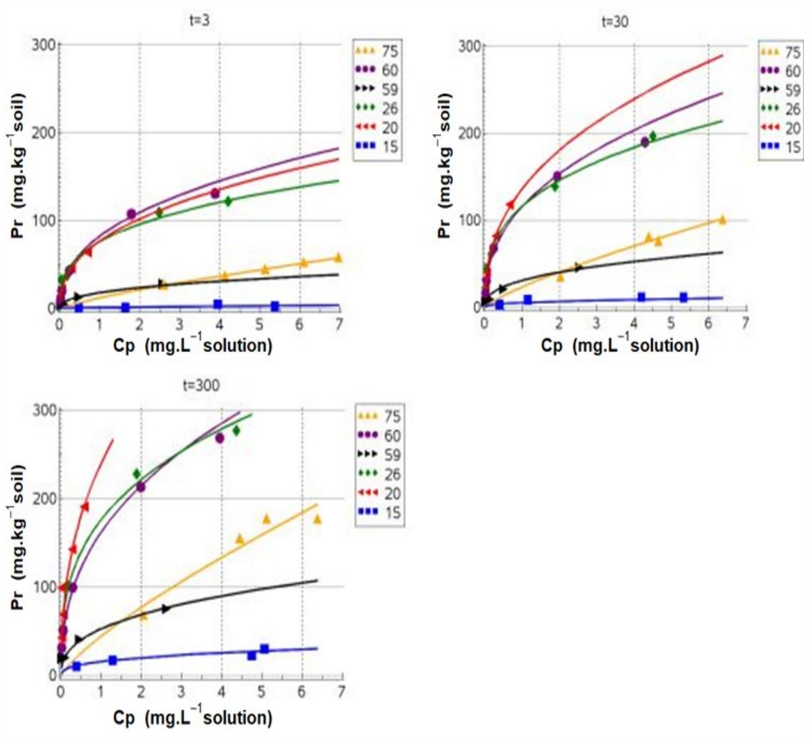

Fig.1. the amount of P-ions diffusible on solid-solution interface function of P-ions concentration in solution after 3, 30, 300 minutes of isotopic dilution

Handle experimental values of orthophosphate ions diffusible and its values obtained in the Freundlich kinetic function in a regression shows r^2 equal to 0.997 with 79 experimental observations (fig.2).

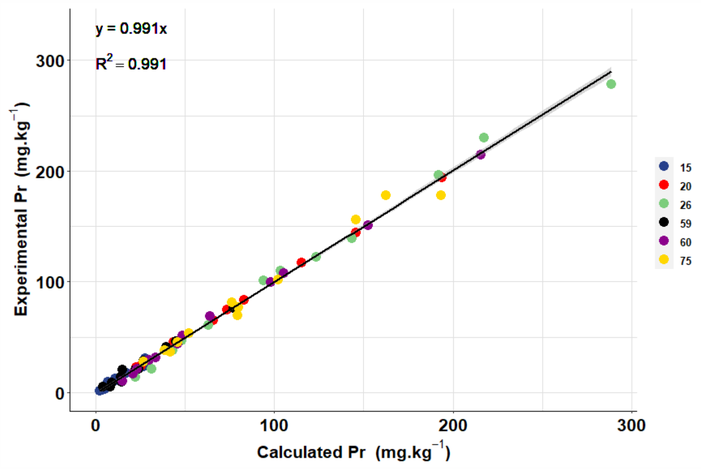

Fig.2. relationship between experimental values and calculated values of P-ions diffusible on solid-solution interface

CONCLUSIONS

Functional and mechanistic evaluation of dynamic of phosphorus proved its steadfastness, even in tropical soil like Malagasy soils. This method allows to identify both concentration of orthophosphate ions in solution, quantity of P-ions sorbed or desorbed and above all, to quantify the diffusible P-ions at the solid-solution interface as a function of dissolved P-ion concentration and time. The use of the Freundlich kinetic function makes possible knowing the amount of phosphorus available for plants by having concentration of ions in solution and time. From the kinetic equation of Freundlich, parameters (v, w, p) which could characterize the behavior of soils with respect to P-ions are obtained.

We are convinced that knowing phosphorus availability improve success on productivity, that can contribute to reach food security.

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