CAN MAIZE INFLUENCE THE DISSOLUTION OF LOW WATER SOLUBLE PHOSPHORUS FERTILIZERS?

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ABSTRACT

The objectives of this study were to evaluate the respective importance of maize (*Zea mays*) and soil properties on the dissolution of two sparingly soluble P fertilizers. The surface horizon of an acidic and a calcareous soils were amended with Thomas' slag or phosphate rock and were either incubated or cultivated with maize. Maize cultivation increased the rate of dissolution of both fertilizers in both soils. Its influence remained limited compared to fertilizer dissolution in the incubated acidic soil. In the calcareous soil, however, the presence of maize increased significantly the rate of fertilizer dissolution compared to that observed in the incubated soil. Processes by which maize could have affected the dissolution of both fertilizers were discussed.

KEY WORDS

Phosphate rock, Thomas slag, incubation, pot experiment, ^{32}P, resin extractable P

INTRODUCTION

A lot of forage and crop species receive phosphate rocks or Thomas slags. However, these fertilizers contain sparingly soluble forms of calcium phosphates (P) which have to be dissolved before becoming plant available. The most important soil properties in determining the dissolution of these phosphates are soil pH and the sorption capacity of the soil for P and Ca (Hammond *et al*., 1986). Besides, P deficient plants can develop specific P acquisition strategies either through enhanced H^+ or organic acids root exudation and enhanced Ca uptake which in turn could increase the rate of solubilization of sparingly soluble forms of P (Marschner, 1995). The objectives of this study were to evaluate the respective importance of maize (*Zea mays*) and soil properties on the dissolution of two sparingly soluble P fertilizers (rock phosphate and Thomas' slag).

MATERIALS AND METHODS

The surface horizons of two soils low in available P, a calcareous loamy fluvisol (Lushnja, pH_{H2O} 8.2; clay 309 g kg^{-1}) and an acidic clayey chromic cambiosol (Burrel, pH_{H2O} 6.2; clay 402 g kg^{-1}) (FAO classification), were amended with 1300 mg P kg^{-1} either in the form of rock phosphate or in the form of slag. Both fertilizers were added as particles larger than 20 mm and homogeneously mixed in the soils. Amended samples were wetted to 80% of their water holding capacity and divided in two batches. One was cultivated with maize (var DEA) and the other was incubated without plants. Both experiments were conducted for a month. In each experiment a control treatment without P addition was also considered. Plants were grown in the presence of 70 mg N kg $soil^{-1}$ added as NH_4NO_3 and 40 mg K kg $soil^{-1}$ added as KCl. The temperature was set up at 25° C during the day and 23½C during the night, the photoperiod was 15 hours. Cultivated soils were labeled with 0.55 Bq $^{32}PO_4$ kg $soil^{-1}$ in order to quantify the amount of P taken up by maize derived from the fertilizer (Pdff) after one month of plant growth. Soil samples were taken just after one month of incubation or plant growth, air dried, totally dispersed with a Na^+ resin, and extracted for P with a Cl^- resin for 48 hours. The proportion of P dissolved after one month of incubation (Ðincub %) was calculated as follows:

Ðincub = [Pres.fertil.incub.soil - Pres.fert. - Pres.incub.cont.]*100/ added P

where: **Pres.fertil.incub.soil, Pres.fert.** and **Pres.incub.cont.** were respectively the P resin content (mg P kg $soil^{-1}$) of the incubated fertilized soil, of the added fertilizer and of the soil incubated without P. The same approach conducted on cultivated soil allowed the evaluation of the dissolution of P in the presence of maize (**Ðmaize**). Finally the difference between **Ðmaize** and **Ðincub** was used to evaluate the contribution of maize to fertilizer dissolution.

RESULTS

The addition of both sparingly soluble fertilizers significantly increased resin extractable P in both soil samples (Sinaj, 1993) showing that the phosphate rock and the slags had been partially dissolved. However, soil properties, the type of fertilizer and the presence of maize affected the rate of dissolution of the added fertilizers differently. Their dissolution rate was much higher in the acidic soil of Burrel than in the alkaline soil of Lushnja (Table 1). Slags were always more rapidly dissolved than phosphate rock, and dissolution was more intense in cultivated soils compared to incubated soils. Finally, the amount of P derived from the fertilizer and taken up by maize was also much higher in Burrel than in Lushjna and was higher for slags than for the phosphate rock (Table 2).

DISCUSSION AND CONCLUSIONS

Maize cultivation increased the rate of dissolution of both fertilizers in the studied soils. However, its influence remained limited compared to fertilizer dissolution in the incubated acidic soil (Burrel). In this sample, dissolution was driven by soil acidity together with the high P fixing capacity and low Ca saturation rate of the soil (Sinaj, 1993). In the alkaline soil (Lushnja) on the other hand, maize cultivation significantly increased the rate of fertilizer dissolution compared to that observed in the incubated soil.

The increased dissolution rate observed in both soils may be related to several processes. Maize acting as a sink for P and Ca displaced the soil/solution equilibrium, increasing P transfer from the solid phase to the solution. Furthermore, maize may have adapted itself to these soils low in available P by exudating compounds such as organic acids which may have contributed to the dissolution of the studied fertilizers (Marschner, 1995). Finally, the higher rate of dissolution observed with the slag compared to the phosphate rock was related to their mineralogical composition, the first being dominated by silicato-calcium phosphates where phosphate was highly substituted by other ions, and the second by francolite, calcite and quartz (Sinaj, 1993). In conclusion, although maize may significantly increase the dissolution of sparingly soluble phosphate in calcareous soils, this might remain too limited to properly sustain maize P nutrition. Therefore such fertilizers should be used only in acidic soils.

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Table 1

Dissolution rate (%) of a phosphate rock and Thomas slag after one month of incubation or maize growth in two soils

Soils	Fertilizers	Cultivated soils	Incubated soils	Maize effect
Burrel	Slag	27.2^{y}	24.4^{x}	2.8
	Phosphate rock	9.8^{y}	9.4^{x}	0.4
Lushnja	Slag	5.3^{y}	4.0^{x}	1.3
	Phosphate rock	3.5^{y}	2.7^{x}	0.8

^{x,y}Values on the same line with different superscripts are different, $P < 0.05$

Table 2

Production of dry matter, total P exportation and exportation of P derived from the fertilizer (Pdff) by maize grown in two soils in the presenceof two sparingly soluble P fertilizers.

Soils	Fertilizers	Dry matter g	Exported P mg kg soil^{-1}	Pdff %
Burrel	Control	2.71^{x}	2.29^{x}	
	Slag	3.53^{z}	5.77^{z}	92.8
	Phosphate rock	3.11^{y}	5.54^{y}	90.6
Lushnja	Control	2.83^{y}	2.91^{x}	
	Slag	2.53^{x}	4.23^{y}	31.6
	Phosphate rock	2.37^{x}	4.10^{y}	30.4

^{x,y,z}Values for a given soil in the same column with different superscripts are different, $P < 0.05$