EFFECT OF ACIDIFICATION ON RECOVERY OF FERTILIZER PHOSPHORUS WITH THREE WATER EXTRACTION METHODS

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Abstract

The replenishment of phosphorus (P) in the soil solution is of considerable importance from the standpoint of plant nutrition, since the quantity of inorganic P in the solution phase at any time, is usually insufficient to meet the crops' requirements during the whole growing season. Acidification is a natural process in the environment; however, human activity often increases this tendency. Through this study we are concerned in the P recovery from soil solid phase that have received different levels of P-additions and of acidification applying three different water extraction methods.

A calcareous loamy soil, pH_{H2O}=7.9 was incubated with 0, 80 and 320 $mgPkg^{-1}$ soil for one month. Four different levels of P-acidification (pH 7.9, 7.3, 6.0 and 4.5) were adjusted by adding calculated volumes of HCl and incubating the soil samples for further one month, then equilibrated with different rates of phosphorus as 0, 80, 160 and 240 $\mu gP10cm^{-3}$. The desorbed quantity of phosphorus was determined applying EUF, HWP and multistep desorption methods.

Some part of the added phosphorus can be recovered by all methods, depending on the dose and time of P addition (previous or recent), on acidity of the soil and on the method used. The desorbable phosphorus amounts are in average 19 % of sum of P-loading at 0 $mgPkg^{-1}$ level, and 31 and 64 % at 80 and 320 $mgPkg^{-1}$ levels, respectively. Phosphorus recovery is generally more in acidified soil then in non acidified one but at high fertilizer dose it is somewhat less.

Introduction

The effect of change of pH on phosphate desorption depend on the soil properties. There are reports that phosphate concentration is increased by raising the pH (Barrow, 1984 and Grinsted, 1982) which would be expected because of the effect of OH^- ions as a displacing ligand, but there are also reports that it is decreased, possibly because raising the pH to about 6 increases the hydrolysis and polymerization of aluminium onto which phosphate ions are adsorbed (Haynes, 1982)

Németh (1976) developed an electro-ultra-filtration (EUF) method and an instrument suitable for serial analysis. The EUF method is a water extraction method regulated by an electric field and accelerated through the use of vacuum. The EUF method is also suitable for determining the kinetics of the release of nutrients into solution (Füleky, 1987). Körschens et al. (1984) used hot water to measure the available C and N contents of soil in a Soxhlet extraction process technically similar to the measurement of lipids. The majority of elements can be extracted in detectable amounts by the method of Hot Water Percolation provided that, they are present in the soil in an available, readily soluble from (Füleky and Czinkota, 1993).

In this project, our objective was to study the phosphorus recovery from the soil applying three different methods of water extraction: multiple desorption, EUF and HWP techniques.

Material and methods

The phosphorus experiment was carried out on a calcareous loamy soil from Keszthely, Hungary. The soil samples were incubated for one month at room temperature, at field water capacity moisture level, with different rates of phosphorus (0, 80 and 320 $mgPkg^{-1}$). Four acidity levels (pH 7.9, 7.3, 6.0 and 4.5) were adjusted by adding HCl. The soil samples were incubated for a further month.

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The multi-step phosphorus desorption study was applied to the soils with different previous P-additions under two levels of acidity (pH 7.9 and 4.5). For this purpose, phosphorus adsorption was determined with different P-levels: 0, 80, 160 and 240 μgP10cm^{-3} (recently additions) as 1 g soil and 10 cm^3 of aqueous Phosphate solution for 24 hours, and after that phosphorus desorption was measured by extraction with distilled water through 12 step.
The EUF procedure was applied to the incubated soil samples under two levels of acidification pH (7.9 and 4.5) after adsorption experiments with phosphorus solutions (0, 80, 160 and 240 μgP10cm^{-3}) (recently additions) as described in multi-step water extraction technique. The residual solid phase was transferred quantitatively into the container of the EUF apparatus. The desorption has been conducted under a constant field strength of 400 V 5 cm^3 and temperature of 20 °C. Ten-minute fractions were collected for 400 minutes (Németh, 1976).
Hot Water Percolation (HWP) was carried out on the soils that have only received previous P-additions (0, 80 and 320 mgPkg^{-1}soil) with a wide range of pH (7.9, 7.3, 6 and 4.5) in an instrument resembling a coffee percolator. The replaceable sample holder was filled with 40 g sample as mixture of 30 g soil with 10 g washed sand. Water was preheated to 102-105 °C in the container and passed through the sample at a pressure of 120-150 kPa and collected in 100 cm^3 aliquots. The experiments and determinations were carried out on 5 percolations per soil (Füleky and Czinkota, 1993).

Results and discussion

The multi-step extractable phosphorus amounts applying the model solved from the two simultaneous equations (stepwise and Freundlich one third exponent) detected by Tolner et al. (1995) show that, where the lower doses of P-fertilization is presented, the lower desorption of phosphorus is observed, thus, with the increasing of phosphorus fertilization (both previous and recent) increase the desorbable amount of phosphorus. The same conclusion was drowning with the increasing of acidity, where the desorbable-P amount also increased (Table 1).

Table 1. Phosphorus recovery percentage as a function of (previous + recent) P-additions and of acidification, using multi-step water extraction technique

Previously added-P (mg P kg^{-1})	Non acidified soil, pH 7.86				Acidified soil, pH 4.51			
	Recently added phosphorus (mg P kg^{-1})							
	0	80	160	240	0	80	160	240
0	-	11	23		16	27	36	
80	15	23	31	41	24	34	40	48
320	50	60	65		54	55	62	

The recovery of phosphorus has been calculated using the amounts of desorbed phosphorus at different levels of P loading and of acidification and taking into consideration that the reference point for our calculation is the desorbed-P from the control treatment. This results states that phosphorus recovery percentage increases with the increasing of phosphorus loading, are in agreement with Obigbesan and Mengel (1981) and Judel et al. (1985).
The comparative prediction was fulfilled by calculating the average values extracted from multi-step and EUF techniques in both cases, non-acidified and acidified soils, and shows that, the desorbable phosphorus amounts are approximately 19 % of the sum of P-loading at 0 mgPkg^{-1} level, and rise to about 31 and 64 % at 80 and 320 mgPkg^{-1} levels, respectively. In case of acidification, the corresponding values are 22, 37 and 61 % of the sum of added phosphorus, respectively. Thus, the recovery percentages are somewhat higher than those of non-acidified soils depending on the P loading. With general conclusion, in acidified cases,

the phosphorus recoveries are higher than in non-acidified soils especially at lower phosphorus doses (recent 0 level) while with the increasing of P-loading the opposite is true (Table 2).

Table 2. Phosphorus recovery percentage as a function of (previous + recent) P-additions and of acidification using EUF technique

Previously added-P (mg P kg^{-1})	Non acidified soil, pH 7.86				Acidified soil, pH 4.51			
	Recently added phosphorus (mg P kg^{-1})							
	0	80	160	240	0	80	160	240
0	-	14	28		8	17	22	
80	13	28	42	67	27	22	37	46
320	67	77	82		47	59	65	

The results that the recovery increases with the increasing of acidification are in agreement with earlier findings of Haynes (1982), who found increased desorption as the soil pH was lowered from 6,2 to 4,5.

Table 3. Phosphorus recovery percentage as a function of (previous + recent) P-additions and of acidification, using HWP method

Previously added-P (mg P kg^{-1})	Acidification pH			
	7.86	7.25	5.99	7,51
0	-	0	2	6
80	4	4	7	14
320	21	230	27	34

The observations concluded from HWP technique (Table 3) showed that, the phosphorus recovery increases also with the P-loading and acidification, and the values are lower than those calculated from the earlier two methods, indicating that the phosphorus released by this technique is less compared to the multi-step and EUF methods (Figure 1).

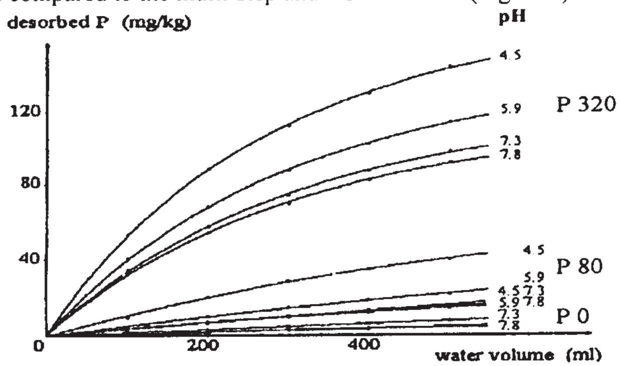

Figure 1. Desorbed phosphorus quantities from soils as a function of previously added-P and acidification, using HWP technique

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