

INTERACTION BETWEEN THE SOIL MICROBIAL ACTIVITY AND PHOSPHORUS AVAILABILITY OF NATURAL PHOSPHATE ROCKS

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ABSTRACT

With that study, the effect of biodegradation of various organic substrates, concerning the availability of phosphorus, contained in natural phosphate rocks from Epirus area (Greece), was investigated. The experiment was performed in a laboratory incubation period, using two soil types, a calcareous soil and a soil sample with acid reaction, under controlled conditions. To these soils, glucose or corn straw were added; in according to results, soil biological activity stimulation, was followed by a parallel intensification of amounts of available -P forms, released from natural phosphate rocks.

INTRODUCTION

The soil organic matter mineralization, is dependent on the facility of soil organic material decomposition, by soil microorganisms, so, that effect is manifested by the emission of CO₂ in the atmosphere. Since that induces a loss of organic carbon, relevant researches conclude that evolution, may be a criterion to assess changes affecting soil organic substances, dominating humification (4.5) and its decisive effect on the soil fertility (9).

The biodegradation occurs under a balanced relationship between carbon, nitrogen and phosphorus (10), affected also by the physicochemical reactions between the components of soil and the added amounts of natural rock phosphates.

In a previous work (7), the ability of soil micro flora to release amounts of P from phosphate rocks, has been already demonstrated; still, with the relevant work it was brought to light, that the activity of soil microflora, is intensified with the addition of phosphate rocks. Conversely, factors that intensify that microbial activity, increase simultaneously the biochemical solubilisation of rock phosphates.

Then, in the present study, the interaction between forms of added organic material and the release of available phosphorus for plants, from grinded natural phosphate rocks, was investigated.

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MATERIALS AND METHODS

The effect of two kinds of organic materials addition in two soil types, was investigated; the experiment included 4 repetitions for each experimental unit, and a correspondent statistical analysis was applied, to assess the obtained data, (13). As phosphate rock material, grinded natural rocks, from Pogoni area of Ioannina, containing 14.43% of P_2O_5 , was used.. The chemical analysis of the mineral used, was realized at minerals' laboratory of Nancy university (FRANCE), and given results, are cited in Table 1.

TABLE 1
Chemical composition of rock phosphate

Oxides	Content (%)
SiO ₂	3.83
Al ₂ O ₃	0.28
Fe ₂ O ₃ , total	0.22
TiO ₂	0.02
CaO	51.23
MgO	0.68
MnO	0.04
K ₂ O	0.05
Na ₂ O	0.59
P ₂ O ₅ ,	14.43
SO ₃	1.21
Losses during combustion (at H ₂ O, CO ₂ + Cl)	27.24
Total	99.64

The solubility of phosphate rock, and rock evaluation (3.12), were estimated in according to AFNOR methods (1,2) and data given are cited in Table 2. Even, according to Olsen method, (14), a small proportion of P contained in the rock (2.14%), was able to be dissolved (7).

Two types of soils were used: an with acid reaction (Alfisols, subgroup Typic Hapludalf), corresponding to “Sols Lessivés” (Sol Brun Lessivé, in according to French system) and a calcareous soil (Mollisol subgroup Typic Rendoll) corresponding to “Sols Calcimagnésiques” (Rendzine in according to French system). The physico-chemical characteristics of the soils are given in Table 3.

The added organic matter, corresponds at 5% of the initial organic matter contained in soil, and it was applied in two forms: one as glucose, characterized by rapid biodegradation and as corn straw, largely adopted in agricultural practice.

TABLE 2
Solubility of rock phosphate.

Used material	% Solubility of total-P	% Solubility of rock mineral
Citric acid 2%	10.8	0.68
Formic acid 2%	46.5	2.96

The content of soil organic carbon, was determined directly by carmographe method (H. Wosthoff o. H.G). The total organic matter was determined indirectly (organic matter = organic carbon x 1.75).

The phosphate rock was added in an amount of 100 mg to 50 g soil. The samples were incubated (28° C) for a period of 3 weeks, and in the meanwhile moisture was maintained at 80% of field capacity.

The released CO₂, was trapped with NaOH N/2, (4, 8) and it was assayed daily. The available phosphorus was determined by Olsen method, as proposed by Dabin (6) in three stages: at zero time, after a period of exacerbation of biodegradation of soil organic matter, (8 days), and at the end of experimentation (3 weeks).

RESULTS

A. Effect of phosphate rock addition to soil organic matter biodegradation

In according to data cited in Table 4 and in Fig. 1, the phosphate rock addition activated significantly soil microflora for both Soil types. The statistical analysis of the results, demonstrated the important increase in organic matter mineralization either by adding phosphate rock, or by adding organic material to soils (significance of statistical level: 0.05).

The micro flora activation by adding phosphate rock, was already confirmed by a previous work (7), studying acid soils (group of Xerorthents). Soil organic matter mineralization, also occurs in calcareous soils; nevertheless, percentage mineralization of organic matter, compared to the total present organic substance, it indicated lower percentage rates of mineralization in calcareous soils.

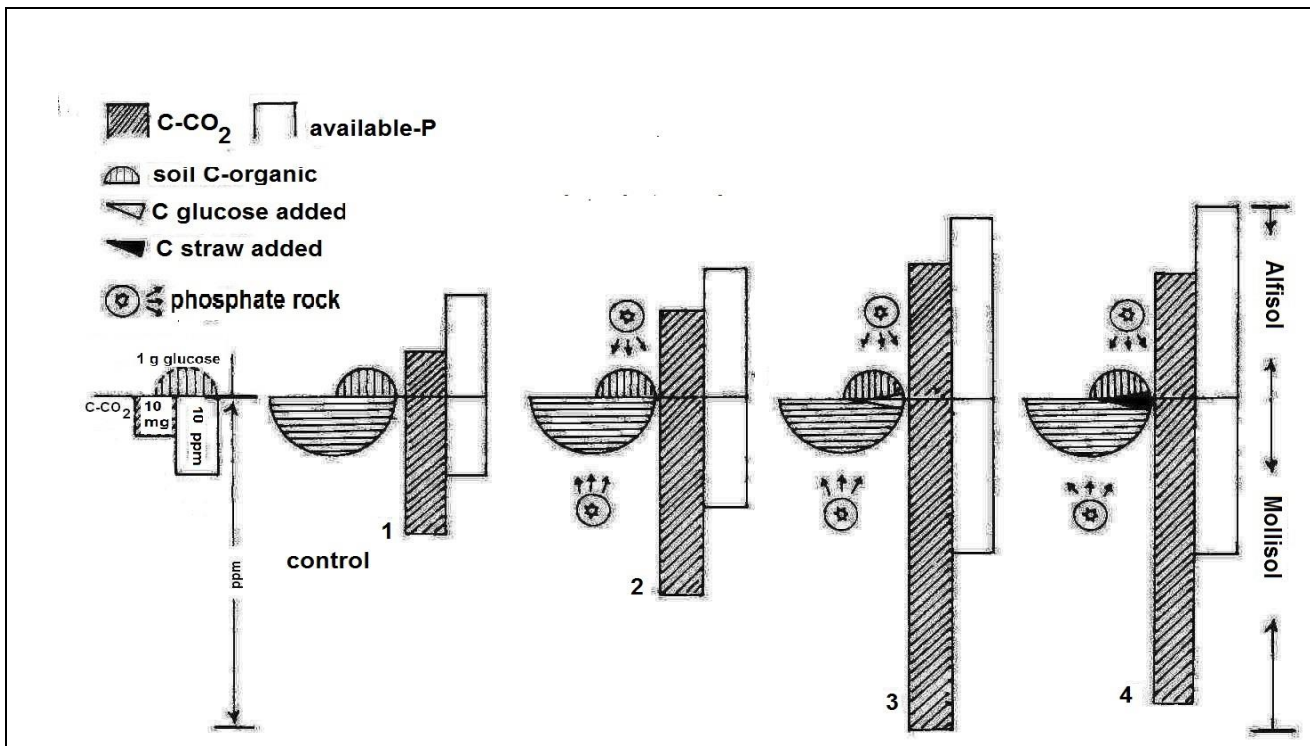


Fig. 1. Interaction between additions of phosphate rock and soil organic matter.

The effect of CaCO_3 , to the slowdown of soil organic matter mineralization, has been confirmed (5, 11); intensive investigations of the last 15 years have shown that the increased presence of active carbonate contents, firstly creates favorable conditions for the development of the soil microflora and consequently affects the decomposition of organic matter; secondarily, calcium bicarbonate characterized with active chemical behavior reacts with radicals produced during biochemical activities (carboxyl groups, phenolic groups); groups by acidic behavior are firstly neutralized and gradually or secondary coatings with CaCO_3 are created, protecting organic matter and causing a reduction to the availability of these products to soil microflora; so the biological activity is significantly reduced and the organic matter remains preserved in less advanced forms, concerning the humification process (5,11).

TABLE: 3
Characteristics of Used Soils

Soil *	Depth cm	Texture %			C- Orga- nic %	pH	CaCO ₃ %	CaCO ₃ active %	Exchangeable cations me/100 g S=Ca+Mg+K+Na				Field capa- city %
		clay	silt	sand					Ca	Mg	K	S/Tx 100	
Alfisol	0-30	26	39	35	1,01	5,3	0	0	6,5	1,1	0,3	57,2	22,25
Molli- sol	0-30	17	27	55	4,19	8,0	37	7	Satu- rated	9,4	0,45	Satur- ated	18,10

*soil samples were taken from Lorraine (France).

B. Interaction between organic matter addition and release of available amounts of phosphorus for plants

The statistically significant increase in the release of available-P amounts, proves the positive effect of organic matter addition and biodegradation, on bioavailability of rock phosphates. Comparing Table 4 and 5 data, it is found that enrichment of soil with available -P forms, grows with increasing production of CO₂, liberated by soil micro flora aerobic activity; it must be due also, to the phosphorus contained in the cells of microorganisms, extractable by Olsen reagent. Furthermore, between total production of available -P amounts, and the total released amounts of CO₂, a high positive linear coefficient correlation (r=0.99), statistically significant, was observed (acceptable level of significance 0.05).

It is also worth to note that in most cases, the maximum releasable available-P forms, occur in eight days, but that effect in the presence of corn straw it happens after a certain delay, (table-5). Similar effects were observed with the release of CO₂, (Table-6), confirming equally the relationship between biological activity and the decomposition of phosphate rock; that delay observed, can be easily explained by the more difficultly bio decomposed plant material, riche in lignin, such as corn straw. On the contrary, the presence of easily available to soil microorganisms, such carbohydrates (glucose), provides very available nutrients for heterotrophic microorganisms.

Finally, despite the too low biological activity, in acidic middle, the chemical degradation of the rock phosphate, caused an important release of available forms of phosphorus; certainly, available amounts of P solubilised in soil, are also produced from soil physicochemical process, promoted by reactions between soil components and rock phosphate (7).

TABLE 4
C released during the incubation period as CO₂.

Soil type	Treatment	C released during the incubation period as CO ₂ , mg (Average of repetitions n = 4)	coefficient of variance % CV	C released during the incubation period (in% of initial organic C)
Alfisol	(1) Control	12.50	12.8	2.48
	(2) Soil + phosphate rock	22.32	9.4	4.21
	(3) Soil + Phosphate rock+glucose	34.91	2.6	6.58
	(4) Soil + Phosphate rock+corn straw	32.40	1.6	6.10
Mollisol	(1) Control	34,90	3.2	1.66
	(2) Soil + phosphate rock	50.80	3.2	2.42
	(3) Soil + Phosphate rock+glucose	85,78	2.0	3.89
	(4) Soil + Phosphate rock+corn straw	78.44	1.7	3.56

TABLE 5
Available phosphorus released

Soil type	Amounts of Available-P released during incubation				coefficient of variance % CV (at the end of incubation)
	Treatment	Available-P (ppm)			
		Time: 0 day	Day: 8th	End incubation	
Alfisol	(1) Control	12, 15	14.00	13.50	4.4
	(2) Soil + phosphate rock	12.50	18,50	17,00	4.7
	(3) Soil + Phosphate rock+glucose	12.50	24,50	23,50	3.0
	(4) Soil + Phosphate rock+corn straw	12.50	19.75	24,75	2.4
Mollisol	(1) Control	10,50	12,80	10,00	6.0
	(2) Soil + phosphate rock	11, 25	15.50	14.00	9.3
	(3) Soil + Phosphate rock+glucose	11.80	20.00	19,80	5.6
	(4) Soil + Phosphate rock+corn straw	11,00	17,00	20.25	2.0

Repetitions n=4

TABLE 6
C organic mineralization (%) of initial contents

Dosage/ time	Alfisol				Mollisol			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
from 0-8th Day	1.17	2.99	4.74	3.71	0.97	1,42	2.77	2.25
from 8th day - to end	1.31	1.22	1,84	2,39	0.69	1.00	1.12	1, 31

(1): Control, (2) : Soil+ phosphate rock, (3) = Soil+ phosphate rock + glucose,
(4): Soil+ phosphate rock + corn straw

CONCLUSIONS

With the present experimentation, two forms of organic material such as glucose (readily bio degradable material by soil microorganisms) and corn straw, were added to two soil types, to an acid soil and to a calcareous soil. After a period in a laboratory incubation, conditions promoting biodegradation of organic matter, and phosphate rock dissolution, were studied. In according to obtained data, the promotion of soil organic matter mineralization is positively correlated with available phosphorus amounts produced in soil solution, by natural phosphate rock. From the results of that experiment, a practical conclusion can be formulated as, "soil conditions favorable to soil biological activity in relation with soil chemical properties (ie slightly acidic soil) could allow the solubilisation of natural phosphate rocks" efficiently for crops.

It would be interesting to be explored in the future: a) the types of microorganisms that intensify the dissolution of phosphate rocks, and b) the botanical species of root crops, that could favorably affect these process.

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RESUME

INTERFERENCE ENTRE L' ACTIVITE BIOLOGIQUE ET L'ASSIMILABILITE DES PHOSPHATES NATURELS

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Dans cette étude nous avons déterminé sous conditions d'incubation artificiel, l'activité biologique dans les sols en corrélation avec la libération de P assimilable par les phosphates bruts (provenance de Ioannina-Grèce). L'expérience est effectuée sur deux sols qualifiés par leur valeur pH et leur teneur en matière organique (Alfisol et Mollisol). L'adjonction dans ces sols du glucose et de paille, entraîne à une stimulation de l'activité biologique, qui va dans le même sens avec la libération de P-assimilable.