Phosphate Dissolving Microorganisms in the Cuban Red Ferralitic and Reddish Brown Fersialitic Soils

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While the total phosphorus content of Red Ferralitic and Reddish Brown Fersialitic Cuban soils is high /1000-1500 kg/ha/, their available phosphorus content is only 18-30 kg/ha under natural conditions /BAISRE and PEREZ JIMENEZ, 1979/. Most of this phosphorus is present in inorganic form as ferric-, calcium- and aluminium phosphate, although organic phosphates can also be found. The occurrence of a large-number of phosphate dissolving microorganisms in soil was reported by many workers /LOUW and WEBLEY, 1959; PABLOVA and MUROMZEV, 1980; PAUL and SUNDARA RAO, 1971/. However, there is no information on the occurrence of such microorganisms in Cuban soils and of their biological role in the phosphorus cycle.

Authors studied the phosphorus solubilizing microorganisms in these soils and compared their efficiency of dissolving phosphate in liquid medium.

Materials and methods

Representative soil samples from San Nicolas de Bari of Havana, were collected from the 0-20 cm depth twice during 1987. The soils were cultivated with sugar cane and soil and rhizosphere samples were taken. Some characteristics of the soils are given in Table 1. Microorganisms capable of solubilizing tricalcium phosphate /Ca-PSM/ were estimated by the dilution plate technique using PIKOVSKAYA's medium /1949/, while those capable of dissolving ferric and aluminium phosphate /Fe-PSM and Al-PSM/ were determined in PABLOVA and MUROMZEV's medium /1980/. The plate was incubated at 30 °C for 3 days, colonies with a clear zone around them were picked up and further purified by replating.

Isolates were tested for their efficiency of phosphate solubilization by inoculating them in a liquid medium containing 0.5% of P as tricalcium phosphate, ferric phosphate or aluminium phosphate. 50 ml of liquid medium /PABLOVA and MUROMZEV, 1980; PIKOVSKAYA, 1948/ with pH 7, was taken in 250 ml Erlenmeyer flasks in quadruplicate and sterilised for half an hour daily on 3 consecutive days. After sterilization 0.5 ml of an 36 hour-old heavy suspension of the respective cultures were inoculated and incubated at 30 °C for 14 days. A set of uninoculated flasks in quadruplicate, too, was incubated at the same time as each inoculated medium.

Table 1
Some characteristics and phosphorus fractions of the investigated soils /0-20 cm depth/

Soil type	pH	Organic matter %	Available P ppm	Available K ppm	P-Fe %	P-Ca %	P-Al %
Typical red ferralitic	6.2	3.03	37.2	155.4	61.3	35.4	3.3
Reddish brown fersialitic	7.1	3.60	18.4	112.0	36.0	34.0	30.0

The volume was made up to 50 ml and the fungal suspension was filtered, while the bacterial suspension was centrifuged. The pH and the P_2O_5 content in the clear liquid were determined, the latter being determined colorimetrically by Backton's reagent.

Isolates were tested for their lecitin solubilization capacity by inoculation in 10 ml of yolk medium in 100 ml Erlenmeyer flasks according to RAMOS and CALLAO /1967/. After 5 days incubation at 30 °C they were centrifuged.

Results and discussion

The population of phosphate solubilizing microorganisms varies greatly in the soils studied, though their number was highest in the rhizosphere of sugar cane, as shown by the R/S values /Table 2/.

The largest number of phosphate dissolving microorganisms was represented by FePSM, followed by Ca-PSM in the Red Ferralitic soil, while in the case of the Reddish Brown Fersialitic soil the three groups /Fe-PSM, Ca-PSM, and Al-PSM/ were similar /Table 2/ according to the relationships between ferric phosphate, calcium phosphate and aluminium phosphate in both soil types. Bacteria and actinomycetes were dominant groups of Ca-PSM, while fungi was dominant of Al-PSM. None of these groups were dominant in the solubilization of ferric phosphate.

Table 2
Population of P-solubilizing microorganisms, and relation between different groups of P-solubilizing microorganisms /%/ in the investigated soils /0-20 cm depth/

Soil type	Rhizosphere of sugar cane /R/	Soil /S/	R/S	Fe-PSM			Ca-PSM			Al-PSM		
				R	S	X	R	S	X	R	S	X
Typical red ferralitic	1296.3	206	6.29	50	34	42	41	31	36	24	18	21
Reddish brown fersialitic	756.6	104.3	7.25	44	35	39	32	30	31	24	33	29

Bacillus and Pseudomonas were the main bacteria isolated, whereas Penicillium and Aspergillus followed by Fusarium, Trichoderma, Spicaria, Curvularia, Alternaria and Psecelomyces were the principal fungi. Streptomyces was the only genus of actinomycetes isolated.

The efficiency of bacterial and fungal strains in phosphate solubilization varied greatly with the type of inorganic phosphate, but bacteria were the most efficient in all cases.

Ferric phosphate solubilization by bacteria was high /between 45 and 50%/ whilst aluminium phosphate solubilization was very low. Calcium phosphate dissolving bacteria were moderately efficient /between 3.58 and 12.58%/. Their efficiency was similar to the bacterial rhizosphere of different cultivated legumes of some Indian soils reported by PAUL and SUNDARA RAO /1971/. Fungi showed similar behaviour as bacteria.

It was interesting that two fungal strains, both Aspergillus niger /A. niger white lineage and A. niger yellow lineage/ were capable of solubilizing the three kinds of inorganic phosphate, but A. niger white lineage showed higher efficiency than the latter strain.

Solubilization of phosphate showed a significant inverse correlation /r=-0.57/ with the acidity produced by the microorganisms in the medium. Thus, bacterial and fungal strains with higher solubilization of phosphate /50%/ lowered the pH of cultural medium to 3.1. A. niger white lineage with 91% of ferric phosphate dissolved dropped pH of medium to 2.4. General workers have reported a decline in pH of the cultural medium together with phosphorus release /BORIE and BARES, 1981; PAUL and SUNDARA RAO, 1971; SINHA, 1961; VENKATOSWARLU et al., 1984/.

Numerous isolated bacteria as well as fungi showed elevated organic phosphate solubilizing efficiency.

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