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OCCURRENCE OF SILICATE SOLUBILIZING BACTERIA IN RICE ECOSYSTEM

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ABSTRACT

Silicate and phosphate solubilizing bacteria were enumerated from soils, tank sediments, water, agroinputs like super and rock phosphates and commodities of anthropogenic activities. Silicate solubilizers were lesser than the phosphate solubilizing bacteria in these materials. Three out of 17 promising isolates were authenticated by Gram and Spore staining and biochemical characteristics. All of them were *Bacillus* spp. The isolate of *Bacillus* sp. from granite crusher yard exhibited marked silicate solubilization under *in vitro* both in medium and in liquid culture. The presence of silicate solubilizing bacteria in rice ecosystem might contribute to the silicate requirement of rice.

KEY WORDS : Silicate solubilizing bacteria, distribution, rice

Rice like other members of the graminae, accumulate silica in its culms, leaf blades and husks, which confer rigidity and resistance against pest and diseases. It also plays a role in transport of oxygen to roots (Ponnamperuma, 1964). Silicon nutrition to rice is essential as it acts similar to phosphate and also as a substitute for sulphate, besides its interrelationship with several other nutrients. Further with application of higher and higher levels of nitrogen to boost the yield plant requires more of silicon to prop itself.

Silicon although abundantly available in earth's crust is in an unavailable polymerized form and occurs in the form of silicates (salts of SiO_3) and silicon dioxide (SiO_2). Polymerized silicon is almost insoluble. However dissolved silicon is observed in water in rice fields. Webley *et al.* (1960) reported that certain bacteria can depolymerize crystalline silica to soluble form. The present study was undertaken to assess the occurrence of silicate solubilizing bacteria (SSB) in rice ecosystem.

MATERIALS AND METHODS

The silicate solubilizing bacteria (SSB) present in soils, tank sediments, water and agro-inputs and commodites of anthropogenic activity like cement were enumerated in medium containing insoluble magnesium trisilicate (0.25 %). Simultaneously phosphate solubilizing bacteria (PSB) were also enumerated in Sperber's hydroxy apatitic agar. The samples were serially diluted in sterile water and appropriate dilutions were plated in th respective media. The total bacterial population was enumerated in soil extract agar and the proportion of SSB and PSB to total bacteria was calculated.

The extent of silicate and phosphate solubilization by the isolates were assessed both qualitatively by the clearing zones in plate assay and quantitatively by determining the soluble silicon released during the growth of bacteria. The available phosphorus was estimated by routine method. The pH of the liquid broth after filtration was also recorded. The efficient elite isolates solubilizing silicate alone, phosphate alone and both silicate and phosphate were screened and maintained in nutrient agar slants.

RESULTS AND DISCUSSION

Silicate solubilizing bacteria (SSB) and phosphate solubilizing bacteria (PSB) were present in different soils water sources, sewage, agro-inputs like super and rock phosphates, materials like cement and limestone (Table 1). However, their population varied with the material and ranged from a minimum of 1.8 x 10^3 g^{-1} in rock phosphate to 24.0 x 10^3 g^{-1} in soil collected from the rocky mountain top where water stagnated. River sand and coastal sand from Vedaranyam used as silicate mineral for silicate extraction also exhibited SSB. Cement, limestone and soil collected near granite crusher showed 12.1, 8.9 and 19.0 x 10^3 g^{-1} respectively. The sewage water showed the highest population among the water samples. The tank water contained a higher SSB population than bore well water.

Similarly PSB population also varied. However their population in the samples studied were higher than SSB. It was the highest in black cotton soil and lowest in the scrappings of mountain rock. Rock phosphate exhibited a higher PSB population than super phosphate. PSB were present in cement, limestone and soil collected from granite crusher yard. A few PSB were observed in water samples. Though SSB and PSB were observed in the samples the proportion of SSB to total bacteria was meagre 0.005 - 0.29 per cent and 0.04 - 1.6 per cent respectively for SSB

Table 1. Total silicate and phosphate solubilizing bacterial population in soil, water, agro-inputs and materials adjoining rice ecosystem

Sample	Moisture (%)	pH	SSB ($10^3 g^{-1}$ or ml^{-1})	PSB ($10^4 g^{-1}$ or ml^{-1})	Total bacteria ($10^6 g^{-1}$ or ml^{-1})	SSB* (%)	PSB* (%)
Clayey soil (Farm of AC & RI, Madurai)	21.5	7.2	15.3	5.7	27.4	0.06	0.20
Red soil (Narasingh-ampatti, Madurai)	4.0	6.5	4.8	5.1	33.1	0.02	0.16
Black cotton soil (Aruppukkottai)	5.0	7.8	14.7	18.7	28.3	0.05	0.66
River sand (Paramakudi)	17.9	7.5	7.9	4.5	13.2	0.06	0.34
Silica mineral (Vedaranyam)	3.3	8.2	12.7	3.2	19.3	0.07	0.17
Rock scrapping (Y. Anamalai, Madurai)	28.4	8.8	10.8	1.7	38.8	0.03	0.04
Soil (Mountain top)	45.5	7.8	24.0	3.0	40.8	0.06	0.07
Soil (Quaries, Narasinghampatti)	16.4	8.2	19.0	7.3	39.0	0.05	0.19
Limestone (Local kiln)	2.5	8.1	8.9	14.6	8.9	0.10	1.60
Cement (Construction material)	1.9	8.4	12.1	8.1	4.1	0.29	1.98
Tank water (Chittangulam tank)	-	7.2	8.3		8.7	0.10	-
Irrigation water (Farm of AC & RI Madurai)	-	7.5	2.1		44.5	0.005	-
Sewage (AC & RI, Madurai)	-	8.0	9.0		25.0	0.04	-
Tank silt (Chittangulam tank)	48.7	7.8	12.3	4.2	24.6	0.05	0.17
Rock phosphate	1.4	7.5	1.8	6.4	2.5	0.07	2.56
Super phosphate	12.1	2.2	1.9	4.4	3.3	0.06	1.33

* per cent of total bacteria

and PSB. The pH of the samples tested varied from 2.2 to 8.8 and the moisture content from 2 to 49 per cent indicating that the SSB and PSB survive under varying soil reaction and moisture. Among the 132 isolates obtained, 17 showed prominent clearing zones of either silicate or phosphate or both and were selected for further study. Four isolates (4, 27, 61 and 84) exhibited marked silicate solubilizing potential under *in vitro* but with only a trace of phosphate solubilization whereas certain of the isolates (51, 52, 84 and 97) showed greater phosphate solubilizing property with negligible silicate solubilizing ability. The isolates (27 and 52) showed greater abilities to solubilize both silicate and phosphate (Table 2).

The isolate 61 obtained from soil near granite crusher yard solubilized silicate to a greater degree (160 mg SiO_2 l^{-1}), while isolate 51 obtained from clay soil solubilized phosphorus (17 mg l^{-1}) markedly. The isolate 27 from tank silt solubilized both silicate (90 mg SiO_2 l^{-1}) and phosphorus (15 mg l^{-1}) to a greater extent. The solubilization of silicate increased with incubation period in most of cultures although a decline was observed on 15th day in certain isolates. Similarly the phosphate solubilization increased with incubation period but the activity decreased on 15th day. All the above three cultures were identified as *Bacillus* sp. The pH of the medium changed slightly with the bacterial growth. Certain isolates shifted the pH to further acidic while a few others increased the pH slightly higher than the initial (6.9). The isolates 27, 34, 43, 51, 58, 61, 65, 105, 123 and 132 shifted the medium to acidic pH while others raised the pH to varying degree in the silicate medium.

Silicon is an important constituent of rice which is accumulated in almost every part of the plant and hence it is certain, rice and silica are inseparable (Yoshida, 1975). The present investigation had clealy shown the natural occurrence and distribution of silicate solubilizing bacteria (SSB) and phosphate solubilizing bacteria (PSB) in rice soils, rocky mountains and water reservoirs. The agro-inputs and articles of anthropogenic activity were also not devoid of them. Among the cultivated soil, the clay soil where low land rice cultivation is traditionally practised, showed a higher population than a red soil (lateritic) that resulted due to continuous leaching of silicates.

Rice cultivation is done not far away from human habitation and the presence of SSB in water, sewage, building materials like cement which is

Table 2. *In vitro* solubilization of silica and phosphorus by the bacterial isolates

Isolate	Source	Silica (mg l^{-1})*			Phosphorus (mg l^{-1})*		
		5 DAI	10 DAI	15 DAI	5 DAI	10 DAI	15 DAI
4	Tank silt	293	297	303	34.6	46.5	40.5
27**	Tank silt	303	344	394	28.5	38.0	43.5
34	Clay soil	271	277	282	33.0	37.5	34.5
43	River sand	271	282	287	28.5	32.5	42.0
51**	Clay soil	239	250	277	28.0	42.0	45.0
52	Black cotton soil	271	293	282	37.5	40.0	44.0
55	Sewage	250	250	255	34.0	44.0	33.5
58	Rock phosphate	277	287	287	23.5	28.5	31.0
61**	Soil (quaries)	287	353	393	26.0	39.5	31.0
65	Irrigation water	271	282	239	23.0	28.0	33.5
79	Cement	255	261	218	22.5	41.0	33.2
84	Silica mineral	266	282	293	31.0	36.5	44.5
90	Rock scrappings	245	239	229	13.0	34.0	36.0
97	Soil (Mountain top)	261	266	255	32.0	37.5	44.0
105	Soil (Mountain top)	261	239	239	31.0	26.0	40.0
123	Tank water	266	266	255	25.5	32.5	32.0
132	Tank water	266	271	250	26.0	32.5	40.0
Control		239	239	239	28.5	28.5	28.5

* Expressed as SiO_2 and P respectively
Initial : 147 mg l^{-1} SiO_2 and 17.5 mg l^{-1} P
DAI · Days after inoculation
** Bacillus spp.; rest unidentified cultures

primarily calcium silicate, limestone, soils in a granite crusher yard can serve as an additional inoculum due to contamination by these bacteria. The soil from mountain top and dry scrappings from discoloured bands on the slopes of rocky mountain surface caused by continuous oozing of water during monsoon rains showed the presence of SSB. Webley *et al.* (1963) reported that highest bacterial population was observed in crevices in rocks where organic matter content was high. Purushothaman *et al.*, (1974) observed SSB in river sediments and reported that clayey sediments always harboured more than sandy ones. The presence of high SSB population in tank sediment observed in present study is in agreement with their observation. It is of interest to observe both SSB and PSB in super phosphates which is highly acidic and rock phosphate that is slightly above neutral pH. It is likely that all these materials can contribute more potent organisms to rice besides giving available nutrients. The shifting of the medium towards acidic or alkaline pH by the growth suggest that under both conditions silicate can be solubilized. It was reported that acidity, alkalinity and polysaccharide production solubilize silicate (Ehrlich, 1981) similar to phosphate solubilization.

Therefore, isolation of SSB from rice ecosystem screening efficient culture. testing their potential for solubilization, mass multiplication and use as bioinoculant to not only rice but also to rice based crops will boost crop yield. This will also help in solubilization of phosphate as available silica in solution reverses the phosphorus fixation in soil (Silva, 1971).

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RESEARCH NOTES

EFFECT OF WEED CONTROL METHODS ON YIELD AND ECONOMICS OF RAINFED AND RICE FALLOW SUMMER COWPEA

Nearly 75 per cent of the area under pulses in Kerala is occupied by cowpea. The main cowpea growing seasons are *Kharif* and summer. In *kharif*, it is grown in uplands as rainfed crop, while in summer, as rice fallows. Heavy weed infestation during the early stages is a major constraint limiting the productivity of cowpea. The problem becomes more critical when farmers do no tget their field weeded at appropriate time due to manpower shortage and high cost of labour. The situation necessitates the formulation of an effective and economic weed management strategy for cowpea and hence the present invetigation.

The experiment was conducted at the Regional Agricultural Research Station, Pattambi during the *Kharif* and summer seasons of 1994-95. The experiment laid out in randomised block design comprised of seven weed control treatments (Table 1). The test variety was Kanakamony and the crop was raised as per the package of practices. Fluchloralin was incorporated in the soil prior to sowing. During both the seasons, there was sufficient moisture in the soil at the time of sowing. Other herbicide treatments were given as pre-emergene sprays one day after sowing. The spray volume was 400 l/ha. Handweeding and hoeing were done 20 days after sowing. In handweeding, the weeds were pulled out manually and in hoeing, the inerspaces were worked with handhoe. During both the seasons, the same set of treatments were evaluated. The economics of different treatments in terms of net income and benefit cost ratio also was worked out.