SOLUBILIZATION OF ROCK PHOSPHATES BY PHOSPHATE SOLUBILIZERS IN BROTH

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PHOSPHORUS is one of the essential plant nutrients and in soil it is not easily available because of its low solubility and its fixation in soil. Rockphosphate is a cheap source of P but it is least soluble in neutral and alkaline soils. In recent years attempts have been made to increase the availability of naturally occurring cheap sources of plant nutrients, such as rockphosphate in soil. Rockphosphates have been reported to be solubilized by microorganisms[1,2]. The present study was taken up to evaluate the phosphate-solubilizing capacity of phosphate dissolving microorganisms using different sources of rockphosphate in broth.

Three different phosphate-solubilizing microorganisms, namely, *Pseudomonas striata* (S_1), *Bacillus polymyxa* (S_2) and *Aspergillus awamorii* (S_3) were obtained from Microbiology Division, I.A.R.I., New Delhi through Dr Kundu (H.A.U. Hissar) and were maintained on modified Louw and Webley[3] medium. The purity of the cultures was examined by growing them first in broth and then streaking on solid Pikovskaya's[4] medium containing Mussoorie rockphosphate as the sole source of phosphorus. Colonies forming clear zone of solubilization were picked up and were transferred to culture slants.

Microbiological vulnerability of different rockphosphates in broth at room temperature in the laboratory was examined in Pikovskaya's medium using *Pseudomonas striata*. About 50 ml broth was dispensed in 130 ml conical flasks. In place of tricalcium phosphate, different rockphosphates having 1000 ppm P were added to different flasks and the contents were sterilized at 15 lb psi for 30 min. Different rockphosphates used were: Mussoorie rockphosphate (RP_1, 7.81% total P), Jhabua rockphosphate (RP_2, 12.76% total P), Udaipur rockphosphate (RP_3, 17.73% total P) and Jordan rockphosphate (RP_4, 15.06% total P). However, the P-solubilizing capacity of a single or combination of different microorganisms with only Mussoorie rockphosphate in Pikovskaya's medium was examined. Uninoculated and no rockphosphate controls were also included in the study. Each treatment was triplicated. The flasks were shaken on a rotary shaker for 10 hr daily for 14 days at 30 ± 2°C. Phosphorus thus solubilized was determined using the

Table 1 *Effect of phosphate solubilizers on the solubility of rockphosphates in liquid culture after 14 days of inoculation (average of 3 replications).*

Treatment	pH of the broth		P solubilised (μg P/50 ml)	No. of P solubiliser ($\times 10^5$)/ml broth		
	Initial	Final		*Pseudomonas striata* (S_1)	*Bacillus polymyxa* (S_2)	*Aspergillus awamori* (S_3)
Control	6.8	6.8	0	0	0	0
Mussoorie rockphosphate (RP_1)	8.0	7.2	0	0	0	0
Jhabua rockphosphate (RP_2)	6 8	6.7	7.5	0	0	0
Udaipur rockphosphate (RP_3)	6.6	6.5	0	0	0	0
Jordan rockphosphate (RP_4)	7.6	7.3	0	0	0	0
P striata (S_1) + RP_1	7.9	6.5	28.0	23.7	0	0
$S_1 + RP_2$	6.8	4.6	59.0	39.0	0	0
$S_1 + RP_3$	6.7	4.7	17.0	7.3	0	0
$S_1 + RP_4$	7.6	4.0	171.0	53.3	0	0
B polymyxa (S_2) + RP_1	8.0	7.0	76.5	10.0	11.3	0
A awamori (S_3) + RP_1	8.0	6.9	180.0	0	0	86.3
$S_1 + S_2 + RP_1$	7.9	7.0	98.5	0	14.7	0
$S_1 + S_3 + RP_1$	7.9	6.7	123.5	3.3	0	0.4
$S_2 + S_3 + RP_1$	8.0	7.0	101.5	0	6.7	3.0
$S_1 + S_2 + S_3 + RP_1$	7.9	6.9	100.0	0.7	7.0	1.0
SEm ±	—	—	7.4			
CD(5%)	—	—	22.4			

method followed by Sundara Rao and Sinha[2].

Only shaking brought into solution about 7.5 μg P per 50 ml broth in control with Jhabua rockphosphate (without microorganisms). Phosphorus of all the rockphosphates included in the study was vulnerable to microbial solubilization (table 1). Gaur *et al*[1] also reported that due to the production of organic acids, these microbes can solubilize the insoluble phosphates. Solubilization was maximum in Jordan rockphosphate which could be attributed to its greater reactivity[5] and better support to the growth of inoculated rockphosphate bacteria found in the study.

Among all the P-solubilizers studied, *Aspergillus awamorii* was the most efficient solubilizer and gave 180 μg P per 50 ml broth while *P. striata* was the least efficient giving only 28 μg P per 50 ml broth. Sundara Rao and Sinha[2] and Gaur *et al*[1] also found that P-solubilizing capacity of fungus is more than bacteria in broth under laboratory conditions. Interestingly, a combination of $S_1 + S_2$ solubilized more P than individually but when these bacteria were mixed with fungus, phosphorus released was always less than that solubilized by the fungus alone, though it was more than the capacity of the bacteria alone. Bacterial culture, when grown with fungus, reduced its P solubilizing capacity probably by producing antifungal substances (figure 1). Kundu and Gaur[6] also reported that *Pseudomonas striata* when grown with *Aspergillus awamori* or *Bacillus polymyxa* inhibited their growth and this effect was more pronounced on *A. awamori*. Critical examination of the results revealed no correlation between the degree of solubilization and change in pH. Results reported elsewhere[7–10] also corroborate the above findings. However, results showing increased solubilization with increased acidity have also been reported in the literature[2,11].

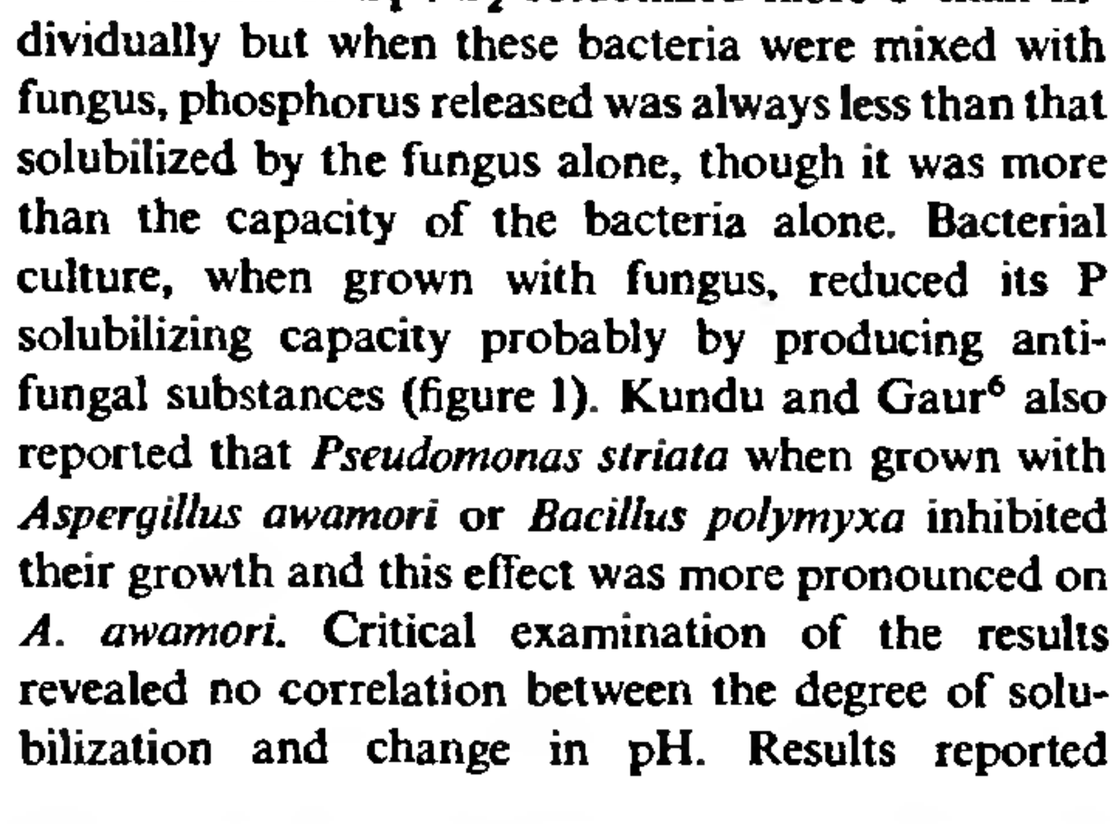

Figure 1. Inhibitory action of *Bacillus polymyxa* (S_2) on *Aspergillus awamori* (S_3)

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CYTOLOGICAL STUDIES ON DIPLOID, AUTOTETRAPLOID AND AUTOTRIPLOID *SOLANUM SISYMBRIFOLIUM*

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CYTOLOGICAL studies on induced autopolyploids form an important aspect of chromosome behaviour and such studies are rare in spinous solanums, which are of importance in medicines as well as vegetables[1]. With a view to obtaining such information autotetraploids were produced in some of the species, and our observations on diploid ($2n = 24$), autotriploid ($2n = 36$) and autotetraploid ($2n = 48$) *Solanum sisymbrifolium* Lam. are reported here. The triploid