In India, this parasitoid was first reported from Maharashtra[2] and then from Gujarat[3]. Other parasitoids recorded from other parts of India, viz. *Pristomerus testaceus*[4], *Phanerotoma* sp.[5,6], *Campyloneura* sp.[5] and *Pseudoperichaeta* sp.[5,6], have not been encountered in Bihar. Further, cumulative parasitization by *Phanerotoma* sp. and *Campyloneura* sp. was of low level, 1–2%, whereas our studies on *T. flavo-orbitalis* revealed that parasitization varied between 3.57% in February and 9.06% in November. Studies are in progress to asses the usefulness of the parasitoid as a biological control agent against *L. orbonalis*.

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1. Lall, B. S., *Vegetable Pests*, 182–211; *Entomology in India*, Pub. The Entomology Society of India, 1964.
2. Cameron, P., *J. Bombay Nat. Hist. Soc.*, 1907, **17**, 587.
3. Patel, H. K., Patel, V. C. and Patel, J. R., *Pl. Protec. Bull.*, 1967, **19**, 36.
4. Thompson, W. R., *A Catalogue of Parasites and Predators of Insect Pests*, 1946, Sec. 1 (Part 7 G to M), 339.
5. Tewari, G. C. and Krishnamurthy, P. N., *Entomon*, 1984, **9**, 63.
6. Patel, R. C., Patel, J. C. and Patel, J. K., *Indian J. Entomol.*, 1971, **33**, 358.

BIOCOENOTIC ASSOCIATION BETWEEN NITROGEN-FIXING AND PHOSPHATE-SOLUBILIZING MICROORGANISMS

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INTRODUCED microorganisms can grow in a soil environment such as the rhizosphere provided the nutritional status there suits the microorganisms and the inoculum is large enough to give them an initial competitive advantage over the normal rhizosphere population. In such conditions the introduced microorganisms can affect the development of the plant. These microorganisms may disturb the soil equilibrium; but a continuous interaction exists among these organisms, and they may revert to a stabilized equilibrium. Interaction among the microorganisms is governed by several factors, viz. competition for nutrition, inhibition or acceleration of growth by other organisms, utilization or exchange of metabolites, and, sometimes, symbiotic existence. An understanding of these factors will help in better appreciation of the plant–soil–microbes coenosis and its agricultural implications, and in the development of mixed inoculants. The present study was conducted to see the biocoenotic association between nitrogen-fixing and phosphate-solubilizing microorganisms under *in vitro* conditions.

The cultures used were *Azotobacter chroococcum* (strain 2) and *Pseudomonas striata* (strain 27), obtained from the Culture Collection Centre, Division of Microbiology, IARI, New Delhi. These two organisms were first tested for antagonistic action, if any, by the 'cross streaking' method. No antagonistic effect was observed, and this was further confirmed by the 'filter paper disc' method. Solubilization of tricalcium phosphate (TCP) in Pikovskaya's broth with single and mixed culture was studied. In each case a one-ml thick suspension of bacteria (OD 1.0) was inoculated. In the treatment where both cultures were added, the total quantity of the inoculum was kept constant (1.0 ml) and the two organisms were added in equal proportions. The flasks were incubated at 30±2°C in a BOD incubator and observations were made at regular intervals. Nitrogen fixation by pure and mixed cultures of the test organisms was studied by growing the organisms in Jensen's nitrogen-free medium. Nitrogen fixed was estimated at regular intervals by the standard method[1].

The study was undertaken to assess the effect of interaction between these two organisms on their growth pattern. The results indicated that *A. chroococcum* and *P. striata* could grow together and no antagonistic behaviour of one organism towards another was noticed, stressing the feasibility of using these two together as microbial inoculants. Table 1 shows the rate of phosphate solubilization by individual and mixed cultures. Both bacteria were able to solubilize TCP to varying degrees. Maximum solubilization was observed with the mixed culture. The co-existence of the two species could be explained by the fact that nitrogenous compounds and growth-promoting substances synthesized by *Azotobacter* could be utilized by *Pseudomonas*, and

Table 1 *Phosphate solubilization by pure and mixed cultures in Pikovskaya's medium*

	Period of incubation (days)							
	7		14		21		28	
	pH of medium	Soluble P (mg/100 ml)	pH of medium	Soluble P (mg/100 ml)	pH of medium	Soluble P (mg/100 ml)	pH of medium	Soluble P (mg/100 ml)
A. chroococcum	5.82	5.7	5.96	8.0	6.00	8.7	5.86	9 6
P. striata	4 90	25.0	5.20	17.2	5.56	12.1	5.91	10.8
A. chroococcum + *P. striata*	4.81	28.9 (15.6)*	5.08	19.1 (11.0)	5.63	13.0 (7.4)	5.80	11.6 (7.4)

*Per cent increase over *P. striata* alone.

Table 2 *Nitrogen fixation by pure and mixed cultures in Jensen's medium*

	mg N fixed/g sucrose oxidized			
	Period of incubation (days)			
	15	30	45	60
A. chroococcum	20.0	19.5	16.1	12.5
P. striata	1.3	6.2	4.3	4.5
A. chroococcum + *P. striata*	17.8	17.3	15.3	11.1

Azotobacter growth was stimulated owing to the presence of available phosphorus in the culture medium. The results also indicate an inverse correlation between phosphate solubilization and pH of the medium. With the increase in pH with time of incubation, there was a decrease in phosphate solubilization[2].

Estimates of nitrogen fixation by pure and mixed cultures (table 2) revealed that *A. chroococcum* alone, fixed a fairly high amount of nitrogen in Jensen's liquid medium, ranging from 20.0 mg/g of sucrose oxidized at 15 days to 12.5 mg at 60 days. Surprisingly, association of *A. chroococcum* with *P. striata* did not improve the nitrogen-fixing capacity of *Azotobacter* and the quantity of nitrogen fixed was less than that by *A. chroococcum* alone. This is in conformity with an earlier finding[3] and could probably be due to assimilation of the fixed nitrogen by *Pseudomonas.*

Thus, synergistic interaction of *P. striata* and *A. chroococcum* in increasing phosphate solubilization may prove beneficial for developing a mixed inoculant for increasing crop productivity.

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1. Jackson, M. L., *Soil Chemical Analysis*, Prentice Hall of India Pvt Ltd., New Delhi, 1967.
2. Arora, D. and Gaur, A. C., *Indian J. Exp. Biol.* 1979, **17**, 1258.
3. Shende, S. T., Arora, C. K. and Sen, A., *Zbl. Bakt. Abt. 11. Bd.*, 1973, **128**, 668.

LEVELS OF SERUM ANTIOXIDANTS IN DOXORUBICIN-TREATED RATS—INFLUENCE OF VITAMINS E AND C

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DOXORUBICIN (also known as adriamycin) is a broad-spectrum chemotherapeutic agent effective against human malignancies such as leukaemias, lymphomas and many solid tumours[1]. Formation of free radicals as well as accumulation of lipid peroxides have been well documented in heart[2] and serum[3] of patients and experimental animals under doxorubicin therapy. The increased peroxidation of polyunsaturated fatty acids is recognized as one of the possible biochemical mechanisms of genesis of membrane injury in the myocardium[4]. Generally, iron in its free form is believed to accelerate lipid peroxidation induced by free radicals[5]. A major part of extracellular antioxidant defence is to keep this ionic iron largely sequestered in proteins[6]. Albumin, haemopexin and haptoglobin have been shown to inhibit various radical reactions probably by sequestering metals[6].

Since the deleterious effects produced by free radicals depend upon the balance between oxidant and antioxidant capacity of the system, we investigated the levels of the extracellular antioxidants uric acid, ceruloplasmin and albumin, and total iron-binding capacity. Serum iron and lipid peroxides