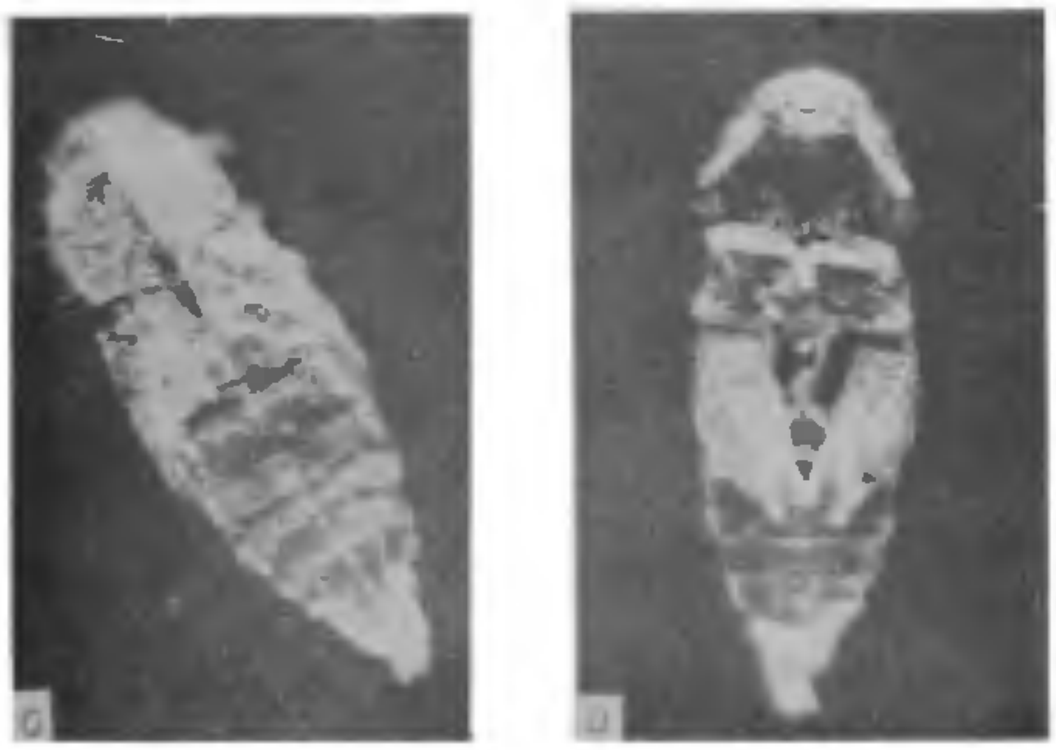
FIGS. A and B. Dorsal and ventral view of normal adults of *T. castaneum.*



FIGS. C and D. Dorsal and ventral view of pupal–adult intermediates f *T. castaneum.*

time bearing pupal characters like thorax bearing immobile legs, pupal-like abdomen bearing elytra pointed latero-ventrally (Figs. C and D). The intermediates died in 3–7 days. There was no record of any deformed adults after treating with A13–63392 as have been reported earlier[2,3].

The above results indicate that the compound A13-63392 is well suited for the control of *T. castaneum* in view of the fact that there is no increase in the duration of larval life and number of larval moults. Also low concentration is found sufficient to check the development of larvae and further all the larval stadia are also found equally susceptible to the compound. The laboratory studies made have thus revealed that 1 ppm of the compound can be used with greater profit and less risk for the control of *T. castaneum* although its practical utility calls for further research under large scale storage conditions.

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EFFECT OF *RHIZOBIUM* AND PHOSPHOMICROORGANISMS ON YIELD AND NUTRIENT UPTAKE IN CHICKPEA

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THE usefulness of biofertilizers such as *Rhizobium*, *Azotobacter* and phosphate solubilising microorganisms (phosphomicroorganisms) has often been questioned. Experiments, where no plant growth stimulation occurs, are often accounted to the failure of the microbial inocula to establish in the plant rhizosphere. Seed bacterization temporarily changes the balance of the rhizosphere population and such changes may sometimes influence the plant growth, yield and nutrient uptake depending upon the establishment of the inoculated culture. Microbial fertilizers prepared using *Rhizobium*, *Azotobacter* and phosphomicroorganisms separately have been tested extensively on several crops for their effect on yield and nutrient uptake[1–6].

It has been shown that seed bacterization can improve plant growth if the bacteria can establish and grow well in the rhizosphere[7]. Benefit from using bacterial inoculants can be obtained particularly in soils having less competitions, with high organic matter status and a pH close to neutral[8].

Reports are scanty on the use of mixed culture of nitrogen fixing and phosphate solubilising microorganisms for cereal crops and pulses in particular. Therefore, the present study is aimed at the use of both nitrogen fixing and phosphate solubilising microorganisms for their effect on the yield and nutrient uptake of chickpea crop under field conditions.

The chickpea (*Cicer arietinum* L.) var. H 208 was the test crop for this stdy. The *Cicer–Rhizobium* strain

TABLE I

Effect of single and mixed inoculants on nodulation and nitrogenase activity in chickpea

Treatment	Nodules/plant		Nodule dry weight (mg/plant)		Nitrogenase activity (nm C_2H_2 reduced/ h/plant)	
	40 days	80 days	40 days	80 days	40 days	80 days
Control (uninoculated)	28	14	609·7	628·0	352	39
Pseudomonas striata	32	14	833·0	829·0	360	46
Aspergillus awamorii	31	14	632·7	782·0	398	43
Rhizobium sp.	39	19	972·7	870·4	442	84
P. striata + *R.* sp.	35	17	661·7	837·3	454	69
A. awamorii + *R.* sp.	30	18	677·0	832·0	442	70
P. striata + *A. awamorii*	37	14	892·0	854·0	437	84
P. striata + *A. awamorii* + *R.* sp.	44	18	1100·7	910·1	457	100
S.E. (m)	4·12	3·04	11·52	13·95	0·05	0·017
C.D. (5%)	9·45	N.S.	34·9	N.S.	N.S.	N.S.

Ca 181 was obtained from the Department of Microbiology, H.A.U., Hissar. *Aspergillus awamorii* and *Pseudomonas striata* phosphate solubilizers were from the Culture Collection of the Division of Microbiology, I.A.R.I., New Delhi. Seeds were inoculated with *Rhizobium* and phosphate solubilizers in all the possible combinations using cell suspensions grown in yeast extract mannitol broth and Pikovskaya's tricalcium broth, respectively, for 7 days at 28 ± 2°C on a rotary shaker. The viable count on seed was determined on yeast extract mannitol agar and Pikovskaya's agar media by dilution plate count and was found to be about 10^4 cells or propagules/seed. Sowing was done after drying the seed in the shade in randomised block design keeping three replications for each treatment. The plot size was 7·2 sq m and the spacing between row to row and plant to plant was 30 cm and 10 cm, respectively. Seed rate was 40 kg/ha. Mussorie rock phosphate was applied as a basal dressing @ 40 kg P_2O_5/ha. The experiment was conducted on the HAU, Farm, Hissar during *rabi* 1979–80. The farm soil was sandy loam in texture with pH 7·3, electrical conductvity 0·28 m mhos/cm and the organic carbon content of 0·49%. The levels of nitrogen, phosphorus and potash were 364, 41 and 534 lb/acre, respectively. The field was irrigated at flowering stage (68 days).

Plants were uprooted randomly after 40 and 80 days of plant growth for nodulation and nodule nitrogenase activity. The nitrogenase activity was determined by using porapak R column of Nucon-5500 gas chromatograph. The intact root nodules of five plants were taken in airtight glass bottles of 300 ml capacity fitted with subaseals and then the air was replaced with 10% of C_2H_2. The samples were incubated for 2 hr at 28 ± 2°C and the extent of C_2H_2 reduction was determined. Total nitrogen and phosphorus content of dried plant tops at 80 days of plant growth were determined by micro-Kjeldahl method[9] and by the procedures described by Jackson[10], respectively. The crop was harvested after 149 days and the yield/plot was recorded.

Table I shows the nodulation status and nodule nitrogenase activity after 40 and 80 days of plant growth. No appreciable difference was observed in different treatments in nodule number and nodule dry weight, except, where all the three cultures were used simultaneouly at both the stages of plant growth. The nodule number decreased at 80 days of plant growth due to degeneration of nodules compared to 40 days. Among the phosphate solubilizers *P. striata* inoculation gave more nodule number and nodule dry weight than *A. awamorrii* and it was further

TABLE II

Effect of single and mixed inoculants on nutrients uptake and grain yield of chickpea

Treatment	Phosphorus uptake (kg/ha)	Nitrogen uptake (kg/ha)	Grain yield (q/ha)	Per cent increase over control
Control (uninoculated)	30·66	362·38	24·09	..
Pseudomonas striata	42·67	390·88	27·34	13·5
Aspergillus awamorii	42·97	482·26	26·30	9·2
Rhizobium sp.	47·96	504·93	27·95	16·0
P. striata + *R.* sp.	51·83	535·18	28·79	19·3
A. awamorii + *R.* sp.	59·47	585·60	28·65	18·9
P. striata + *A. awamorii*	56·34	489·85	27·65	14·8
P. striata + *A. awamorii* + *R.* sp.	60·82	628·61	32·55	35·1
S.E. (m)	0·49	4·89	1·81	..
C.D. (5%)	N.S.	N.S.	N.S.	..

improved with *Rhizobium*. Similar trend was noticed at 80 days of plant growth. The nodule nitrogenase activity was found to be higher in inoculated treatment as compared to uninoculated control. However, the nitrogenase activity was non-significant at both stages of growth. No correlation between nitrogenase activity and nodule dry weight was found.

The use of biofertilizers improved N and P uptake of chickpea (Table II). The maximum N and P uptake was with all the three cultures, to the extent of 260 and 20 kg/ha, respectively. The grain yield with inoculation was increased from 9 to 35% over control and mixed culture was found to be most effective (Table II). Similar results have been reported by Ocampto *et al.*[7], using *Azotobacter* and phosphorus organisms with lavender plants and by Kundu and Gaur[11] with cotton. The highest grain yield was found with the use of all the three cultures together (3,260 kg/ha). Slight increase in grain yield was observed with the mixed culture of *Cicer rhizobium* either with *P. striata* or *A. awamorii*, however, the increase was non-significant. The increase in grain yield is perhaps due to the supply of more available phosphorus to plants by phosphomicroorganisms and supply of nitrogen by *Rhizobium* influencing the synthesis, and secretions of organic compounds by the plant which benefit these microorganisms. On the basis of these observations the use of mixed culture may be encouraged in chickpea as this has helped the plant to receive more nutrients without any adverse effect on each other. However, more work has to be done to confirm these findings.

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