CHAPTER-II
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Phosphorus plays an important role in the growth and metabolism of plants. Plants absorb only the watersoluble phosphates in the soil. But the water soluble form of phosphates in the soil is in extremely small quantities. Though the water soluble phosphates are applied to the soil they are converted into insoluble form due to interaction between added soluble phosphates and soil constituents. Soil phosphates are rendered available to the plants by soil micro-organisms, these are called as Phosphate Solubilizing Micro-organisms (PSM). Many workers have used PSM as inoculants in various pot cultureexpeiments and field trials and have got encouraging results. In this chapter an attempt has been made to review the literature on effect of PSM on growth and yield of crops, and also the literature on effect of phosphorus nutrition on nitrogen metabolism of the leguminous crops.

2.1 Phosphate solubilizing micro-organisms as inoculants.

Solubilization of phosphates by micro-organisms was known as early as 1903 by Stalstrom.

Sackett et al.,(1908) showed the solvent action of soil bacteria on the insoluble phosphates of raw bone meal and natural rock phosphates. However, a systematic approach in this regard was made by Pikovskaya (1948) who showed dissolution of tricalcium phosphate by pure culture of bacterium P. Since then

there have been several reports on the solubilization of insoluble phosphates by micro-organisms in liquid medium [Bardiya and Gaur, (1972) Gaind, (1983) Singh et al, (1984)] and in soil [Bajpai and Sunder Rao, (1971) Wani et al (1978)]. The earliest report of increased P-uptake and dry weight of plants through inoculation of phosphate solubilizing bacteria was made by Gerresten (1948). He found that oats, mustard, sunflower and rape innoculated with pure cultures of rhizosphere bacteria in pots containing sterilized soil ammended with difficultly soluble phosphate, resulted in increased dry wt. of plants as well as P-uptake varying from 16 to 54 percent.

Bajpai (1965) observed increased P-uptake by cowpea and wheat crop inoculated with phosphobacteria and *Bacillus circulans*.

Lehri and Mehrotra (1968) reported that the phosphobacterium inoculated wheat crop initially failed to show any effect. However when a legume crop was selected for these studies a marked increase in yield was obtained from its inoculation.

Taha et al., (1969) reported an increase in the dry matter yield and phosphate uptake by barley due to inoculation with *Bacillus megaterium*, *Pseudomonas striata* and *Streptomyces*.

In pot experiments with cowpea, Bajpai and Sundar Rao (1971) observed increased yield and total P_2O_5 uptake by the plants due to inoculation with

Bacillus megaterium and *Bacillus circulans*.

Sunder Rao and Venkatraman (1971) reported the results of several field trials in different types of soils on the response of berseem, wheat, maize, pigeonpea and paddy crops to phosphobacterin inoculation. Except in trials conducted in acidic and calcarious soils, 9 out of 27 trials showed significant increase in dry matter yield and P-uptake of maize due to seed inoculation with *Pseudomonas sps*. Sharma and Singh,(1971) reported higher grain yield in case of rice inoculated with phosphobacterin and bone meal application to sandy loam soil showed increase in the N-and P-uptake of rice crop

Gaur and Ostwal (1972) reported that in the presence of rock phosphate *Bacillus polymyxa* significantly increased the grain and straw yields of wheat and P-uptake by grains as well.

Vidyashekharan et al (1973) observed five times increase in P-uptake in groundnut plant due to inoculation of *A. awamori*.

Ahamad and Jha (1977) studied the effect of seed inoculation with two strains of 'P' solubilizing organisms on yield and P-uptake of gram and observed that the seed inoculation increased the yield and P-uptake and this effect was pronounced when FYM was mixed in the soil.

Increase in available soil phosphorus, phosphate uptake, grain yield and dry

matter yeild of gram due to seed inoculation with *Aspergillus awamori* and *Bacillus polymyxae* was noted by Wani et al. (1978).

Gaur et al.,(1980) recorded a significant increase in the grain yield of wheat under field conditions, when rock phosphate was applied to soil and seeds were inoculated with *Pseudomonas striata*. Response of the crop to bacterial inoculation was equivalent to 50 Kg $P_2 C_5$/ha as superphosphate.

The P- uptake and growth of soybean has been increased by seed inoculation with P-decomposing micro-organisms in pot tests carried out by Li (1981).

Similar observations were made by Shinde and Patil (1985) in wheat inoculated with *P.striata* and *B.polymyxa*.

Seed bacterization with *Bacillus polymyxa* and *Pseudomonas striata* increased the yield and phosphate uptake of potato crop, when used as single and mixed inoculant. The effect was better with the composite culture than with single culture. (Kundu and Gaur, 1980)

Banik and Dey (1981) noticed a significant increase in P-uptake and dry weight of rice due to soil inoculation with inoculant containing three Bacillus sp.

Gaur and Sing (1982) obtained a significant increase in yield of rice by just inoculation with *Bacillus polymyxa*.

In one of the trials at Dholi on alluvial soil, rice yield with rock phosphate (100 kg. P2O5/ ha plus P-solubilizing culture was as good as superphosphate applied at the same rate.

Datta et al.(1982) also found significant increase in the yield and phosphate uptake of rice due to inoculation with *Bacillus firmus*.

Increased plant dry matter and P-uptake by barley plants were recorded by El-Din and Baber (1983) in a salt affected calcareous soil inoculated with phosphate dissolving bacterium, *Bacillus megaterium* var. phosphaticum.

Increase in yield and nutrient uptake of rice due to inoculation of phosphate solubilizer viz. *Pseudomonas striata*, *Aspergillus awamori* with or without chemical fertilizer was observed by Kundu and Gaur (1984).

From several multilocation trials Gaur (1985) reported that the inoculation with phosphate solubilizing bacteria increased the yield of wheat by 10-40 percent. Bengal gram by 10-30 percent and potato by 30-50 percent.

Phosphate solubilizing *Bacillus firmus* capable of producing (IAA) indol acetic acid, was found to increase the available phosphorus in soil and vegetative growth of soybean, but did not increase the grain yield of soybean. (Banik and Datta, 1988).

Asea et al.(1988) using ^{32}P isotope dilution method found that green house

grown wheat inoculated with *Penicillum bilaji* was able to obtain 18% of its 'P' from sources unavailable to uninoculated plants and the organisms was also able to solubilize added rock phosphate.

Kucey (1988) observed increased dry matter production and P-uptake in wheat in response to *Penicillium bilaji* inoculation both under green house and field conditions. Field inoculation of *P.bilaji* also increased the dry matter production and P-uptake of Wester canola (*Brassica napus* L.) was reported by Kucey and Legget (1981).

Salih et al.(1989) found that inoculation of calcareous soil treated with triple superphosphate or rock phosphate with *Penicillium* and *Aspergillus* isolates increased dry matter and P-uptake of sorghum.

Tiwari et al.(1989) studied the effect of inoculation of phosphomicrobes on rice, wheat and chikpea and found that seed inoculation with *Bacillus polymyxa*. markedly increased the yield of rice and chick pea, where as *Pseudomonas striata* caused a greater impact on wheat when used with rock phosphate or super phosphate.

Increase in P_2O_5 percentage in grains due to inoculation with *A. awamori* was observed by Sattar and Gaur (1989).

Mohod et al.(1989) found increased root CEC and a significant increase in the P-uptake of rice inoculated with phosphate solubilizing culture consisting of

Pseudomonas striata and *Bacillus polymyxa* mixed in 1:1 ratio. They observed greater beneficial effects with rock phosphate than single super phosphate.

Increased grain and straw yield and N-uptake of rice was also noticed due to inoculation with *P.striata* and *B. polymyxa* by Mohod et al. (1991).

Inoculation of P.solubilizing bacteria along with the application of 17.5 kg.P/ha as Mussorie rock phosphate resulted in increased dry matter accumulation in chick pea and was as effective as the application of single super phosphate (Prabhakar and Saraf, 1990).

Rachewad et al., (1991) reported that seed inoculation of maize with *Bacillus polymyxa* and or 75 kg P_2O_5/ha applied as single super phosphate and Mussorie rock phosphate increased biomass production, P-content and uptake in plants compared with the uninoculated control. They also found that inoculation along with the application of P was more effective than inoculation alone.

Rachewad et al.,(1992) found that use of phosphate solubilizing biofertilizer produced from *Bacillus megaterium* var phosphaticum in association with single super phosphate increased the phosphorus content from 5.8 to 9.8 percent and P-uptake from 23.7 to 24.5 percent in sunflower.

2.2 Phosphorus nutrition and nirtogen metabolism in legumes.

Legumes have a high phosphate requirement for growth, nodulation and nitrogen fixation. Phosphorus deficiency in soils is therefore a major factor

contributing poor nitrogen fixation and yield of legumes. Several experiments have proved that P fertilization results in improved growth and nitrogen fixation in legumes.

De Mooy and Reseek (1966) demonstrated increased nodulation in soybeans due to application of phosphorus.

Gates and Wilson (1974) studied the interaction of nitrogen and phosphorus on growth, nutrient status and nodulation of *Stylosanthes humilis* (a tree) and observed improved symbiotic nitrogen fixation due to application of phophatic fertilizer. Similar results were observed by De Mooy et al (1975) in case of soybean.

Andrew C.S. (1977), stated that phosphorus fertilization improved the growth and nitrogen fixation in legumes.

Akhtar et al (1982) studied relation between phosphorus fertilization and nitrogen fixation, in summer moon (*Vigna radiata var.* T- 44) and found that P-uptake enhances nodulation and also nitrogen uptake of the plant.

Sprent and Minchin (1983) studied the environmental effects on physiology of nodulation and nitrogen fixation in temperature legumes. They stated that phosphorus influences the formation and function of symbiosis.

High phosphorus requirement was also found in *Vigna aureus* and Gill et al

(1985) observed increased yield with phosphorus and potash application.

Jackobson (1985) also observed improved nitrogen fixation in case of young pea plants. (*Pisum sativum*).

Olofintoy (1986) observed positive response to different levels of phosphorus and nitrogen on growth, yield and nodulatin of cowpea (*Vigna unguiculata* L.Walp). Israel (1987observed increased specific nodulation or specific nitrogenase activity was associated with phosphorus nutrition.

Reinsvold and Pope(1987), observed similar effect of phosphorus in a tree species,*Robinia pseudoacacia*.

Pereira and Bliss (1989), studied the effects of phosphorus nutrition on early growth, nodule activity and yield of common bean (*Phaseolus Vulgaris* L.)

O'Hara et al., (1988), found improved symbiosis due to phosphorus nutrition.

Dhingra et al., (1988) observed increase in number of nodules, nitrogenase activity and nitrogen uptake due to phosphorus application.

Similar results were obtained by Ogata et al. (1988) in case of pigeon pea. (*Cajanus Cajan* .Mollsp).

Hart (1989) observed effect of phosphorus application on early growth.

nodulation and nitrogenase activity in white clover.

Sanginga et al.,(1989), observed effect of phosphorus fertilization on nodulation and growth of two tree species, *Allocasuarina* and *Casuarina*.

Thind et al.,(1990), studied the effect of applied phosphorus on green gram, bengal gram and cow pea and recorded increased nodulation and nitrogen fixation.

Wan Othman et al., (1991), observed reduced nodulation and N_2 fixation due to low level of phosphorus supply in case of cow pea (*Vigna unguiculata* L.Walp).

Sun et al.,(1992), observed improvement in nitrogenase activity in two genotypes of *Acasia mangism* due to application of phosphorus.

Gunavardena et al.,(1992), studied phosphorus requirement and nitrogen accumulation by three mungbean cultivators and observed positive results with respect to growth and nitrogen metabolism.

Gunavardena et al.,(1993), recorded similar results in three soyabean cultivators.

Khan et al.,(1993), observed increased yield and nodules per plant in groundnut due to application of 70 Kg P_2O_5/ha.