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EFFECT OF PSB, *RHIZOBIUM* AND PHOSPHORUS LEVELS ON GROWTH PARAMETERS AND BENEFIT COST RATIO OF SOYBEAN (*GLYCINE MAX* (L.) MERR.)

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ABSTRACT

The experiment was conducted at CSKHPKV, Palampur during *Kharif* 2011 to study the effect of phosphorus solubilizing bacteria on the growth attributes and benefit cost ratio in soybean. esults revealed that growth attributes of soybean increased with the application of 60 kg P_2O_5 ha^{-1} along with *Rhizobium* and phosphorus solubilizing bacteria but found to be at par with the treatment getting 45 kg P_2O_5 ha^{-1} along with *Rhizobium* and phosphorus solubilizing bacteria. Application of 45 kg P_2O_5 ha^{-1} , *Rhizobium* and phosphorus solubilizing bacteria recorded the highest B: C ratio (1.39) followed by the crop sown with 60 kg P_2O_5 ha^{-1} along with *Rhizobium* and phosphorus solubilizing bacteria (1.14). While highest gross and net returns (67328 and 35326 ha^{-1}, respectively) were recorded under the treatment applied with 60 kg P_2O_5 ha^{-1} along with Rhizobium and phosphorus solubilizing bacteria followed by treatment getting 45 kg P_2O_5 ha^{-1} along with Rhizobium and phosphorus solubilizing bacteria (62219 and 3380 ha^{-1}, respectively). Therefore, study concluded that net benefits can be obtained with the treatment receiving the application of 45 kg P_2O_5+*Rhizobium*+PSB over the recommended dose of phosphorus which results in net saving of 15 kg P_2O_5 ha^{-1} .

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.), a leguminous crop, is one of the most important and extensively grown crop. Soybean protein is rich in valuable amino acid lycine (5%) in which most of the cereals are deficient. It builds up the soil fertility by fixing large amounts of atmospheric nitrogen through the root nodules and also through leaf fall on the ground at maturity. Soybean being the richest, cheapest and easiest source of best quality proteins and fats and also having a vast multiplicity of uses as food and industrial products is sometimes called as wonder crop. In the country, soybean is cultivated over an area of 9.79 m hectares, with annual production of 10.05 million tones (Anonymous 2011).

Though, the fertilizers have played a prominent role in increasing the productivity of crops in the country. But continuous and imbalance use of fertilizers cause deterioration of soil health. Integrated nutrient

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management is in fact most important components of the production technology to sustain soil fertility and crop productivity in the future. The combined use of bioferilizers and phosphorus fertilizers not only push the production and profitability of soybean but also help in maintaining the fertility status of the soil.

Phosphorus is a structural part of the membrane system of the cell, the chloroplast and mitochondria. Being a constituent of adenosine phosphate and ribulose phosphate, it plays an important role in energy transformation and various metabolic activities of plant. Plant height, leaf area index, seed yield, no. of pods per plant, 1000 seed weight and nitrogen fixation generally increased with increasing P application (Mohan and Rao 1997). Application of phosphorus along with PSB, improved phosphorus uptake by plants and yields indicating that the PSB are able to solubilize phosphates and to mobilize phosphorus in crop plants. Soils of mid hills of Himachal Pradesh are acidic in reaction. The soil below neutrality restrict the availability of phosphorus to the plants as phosphorus is locked up/ fixed up with the ions of Fe and Al whose activities are tremendously increased at low pH. This affects the growth and development of the plants and thus the final yield. Micro- organisms play a key role in soil phosphorus and subsequent availability of phosphate to plants (Richardson, 2001). The role of PSB is very important, as it helps in de-phosphorylation of phosphorus bearing organic compounds. Release of phosphorus by PSB from insoluble and fixed/adsorbed forms is an important aspect regarding P availability in soils. Similarly, Rhizobium inoculation can take care of N requirement of plant through symbiotic N fixation. Dual inoculation with efficient strain of Rhizobium and PSB have increased nodulation, nitrogen fixation in nodule, dry matter accumulation and grain yield through better availability and uptake of nutrients by plants (Singh and Pareek 2003).

MATERIAL AND METHODS

The experimental soil was silty clay loam in texture, having high organic C content (0.77%) with low in available N (280 kg/ha), medium in available P (21 kg/ha) and low in available K (160 kg/ha). Soil was acidic in reaction (pH 5.36). The experiment consisted of 16 treatment having combinations of two *Rhizobium* (with and without), two phosphorus solubilizing bacteria (with and without) and four phosphorus levels (0, 30, 45 and 60 kg P_2O_5/ha). These treatments were evaluated in a randomized block design with three replications. The plots were uniformly basal dressed with 20 kg N and 40 kg K_2O/ha and full quantity of phosphorus as per treatment at the time of sowing. Phosphorus solubilizing bacteria (PSB) cultures were mixed with FYM thoroughly and applied as per treatments. The seeds were treated with *Rhizobium* before two hours of sowing and sown in the evening. The soybean variety VLS-47 was sown using seed rate of 100 kg/ha and inter and intra-row spacing was kept at 30 x 10 cm. During crop season, 2039.6 mm rainfall was received. The estimation of oil content was determined by Soxhlet extraction method (A.O.A.C 1970).

RESULTS AND DISCUSSION

Plant height, dry matter accumulation and Number of nodules

There was a significant increase in the plant height, dry matter accumulation and number of nodules per plant (Table 1). Inoculation of the soybean seeds with *rhizobium* and PSB resulted in a significant increase in the growth parameters (plant height, dry matter production and number of nodules) and B: C ratio.

Significant increase in plant height was observed when seeds were inoculated with bio-fertilizers (*rhizobium* and PSB). The magnitude of increase in plant height due to rhizobium and PSB were to the extent of 3.56 and 4.93 % respectively, over the control.

The PSB might have helped in releasing P from

Table 1 Effect of *Rhizobium*, PSB and P levels on plant height, dry matter accumulation and number of nodules

Treatment	Plant height (cm)	Dry matter accumulation (g/m^2)	Number of nodules
A. Rhizobium			
No *Rhizobium* (R_1)	75.8	737	47.2
With *Rhizobium* (R_2)	78.6	805	50.6
CD(P=0.05)	1.5	21.6	1.5
B. PSB			
No PSB (PS0)	75.2	736	46.2
With PSB (PS1)	79.1	805	51.6
CD (P=0.05)	1.5	21.6	1.5
C. P levels			
0 kg P_2O_5 ha^{-1} (P_1)	72.5	731	45.2
30 kg P_2O_5 ha^{-1} (P_2)	74.6	758	49.6
45 kgP_2O_5 ha^{-1} (P_3)	80.2	791	49.7
60 kg P_2O_5 ha^{-1} (P_4)	81.0	803	51.0
CD(P=0.05)	2.1	30.6	2.1

Table 2. Effect of Rhizobium, PSB and P levels on gross returns, net returns and B: C Ratio in soybean

Treatment	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Cost of Cultivation (□ ha^{-1})	Gross Returns (□ ha^{-1})	Net Returns (□ ha^{-1})	B:C Ratio
T_1 (no *rhizo* + no PSB + no P_2O_5)	13.9	24.7	24524	42391	20208	0.96
T_2 (no *rhizo* + no PSB + 30 kg P_2O_5)	16.4	30.9	25705	50324	25116	1.00
T_3 (no *rhizo* + no PSB + 45 kg P_2O_5)	16.3	31.6	26295	50422	24473	0.95
T_4 (no *rhizo* + no PSB + 60 kg P_2O_5)	16.9	32.1	26886	52114	26004	1.01
T_5 (no *rhizo* + PSB + no P_2O_5)	16.3	32.6	24786	50765	24360	0.93
T_6 (no *rhizo* + PSB + 30 kg P_2O_5)	16.9	37.1	25967	53571	26857	1.01
T_7 (no *rhizo* + PSB + 45 kg P_2O_5)	18.0	40.1	26558	57149	27457	0.96
T_8 (no *rhizo* + PSB + 60 kg P_2O_5)	19.5	41.0	27149	61133	32108	1.22
T_9 (*rhizo* + no PSB + no P_2O_5)	16.8	32.1	24699	51773	25395	0.98
T_{10} (*rhizo* + no PSB + 30 kg P_2O_5)	18.7	32.1	25880	56448	29128	1.08
T_{11} (*rhizo* + no PSB + 45 kg P_2O_5)	19.5	36.1	26470	59663	31564	1.28
T_{12} (*rhizo* + no PSB + 60 kg P_2O_5)	20.4	40.0	27061	63174	32752	1.11
T_{13} (*rhizo* + PSB + no P_2O_5)	16.8	32.6	24961	51990	25719	0.98
T_{14} (*rhizo* + PSB + 30 kg P_2O_5)	18.9	37.0	26142	58515	31561	1.35
T_{15} (*rhizo* + PSB + 45 kg P_2O_5)	20.1	39.2	26733	62219	33830	1.39
T_{16} (*rhizo* + PSB + 60 kg P_2O_5)	21.6	44.2	27324	67328	35326	1.14

native as well as protecting fixation of added phosphate by excretion of organic acid and enzymes, some of hydroxyl acid may form chelates with cations as Ca^{++} and Fe^{++} which resulted in effective solubilisation of phosphates and rendered more available phosphorus for the plants leading to increased nutrient content of the plants which resulted in increased plant height as reported by Singh and Pareek (2003).

Among the different levels of phosphorus, significant increase in plant height (81.0) were recorded in the treatment receiving 60 kg P_2O_5/ha which was at par (80.2) with the application of 45 kg P_2O_5/ha and significantly superior over the other treatments.

Increase in dry matter accumulation were observed in soybean when seeds were treated with *rhizobium* and PSB. Application of 60 kg P_2O_5/ha results in a significant increase in the dry matter production accumulation (803 g/m^2) and was found to be at par with the application of 45 kg P_2O_5/ha Application of phosphorus improved the overall nutritional environment in the whole plant system and enhanced plant growth by promoting the meristmatic activity and dry matter accumulation.

Nodulation of soybean seeds was significantly improved with inoculation of bio-fertilizers and phosphorus application. The graded enhancement of phosphorus application recorded significant increase the root nodules Application of 60 kg P_2O_5/ha increased the root nodules by 11.3 % over the control (45.2). Increase in number of nodules with bio-fertilizers and phosphorus application might be attributed to early onset of nitrogen fixation but also to longer functioning of the nodules (Bonetti *et al*. 1984).

Benefit Cost Ratio

The order of magnitude of B: C ratio in respect of *Rhizobium*, PSB and different phosphorus levels over T5 (no *Rhizobium* + PSB + no P2O5) is as follows:

$T_{15} > T_{14} > T_{11} > T_8 > T_{16} > T_{12} > T_{10} > T_6 > T_4 > T_2 > T_9 > T_{13} > T_7 > T_1 > T_3$

Highest B :C ratio (1.39) were obtained from the crop sown with 45 kg P_2O_5 ha^{-1}, *Rhizobium* and phosphorus solubilizing bacteria (T_{15}) followed by the crop sown with 60 kg P_2O_5 ha^{-1} along with *Rhizobium* and phosphorus solubilizing bacteria (1.14) i.e., T_{14} (Table 2).

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