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# Influence of phosphorus level cured with FYM and application of PSB, VAM on nodulation and yield of soybean (*Glycin max* L.) and soil properties

**Geetha GP, Radder BM and Patil PL**

**Abstract**
A field experiment was conducted during Kharif season 2013-14 in dharwad. The experiment consist of nine treatments Viz., $T_1$= Absolute control (No P), $T_2$ = Absolute control with biofertilizer, $T_3$ = RPP, $T_4$= 40kg $P_2O_5$ /ha + PSB + VAM, $T_5$= 40 kg $P_2O_5$/ha curing with FYM + PSB +VAM, $T_6$= 60kg $P_2O_5$ /ha + PSB + VAM, $T_7$= 60 kg $P_2O_5$/ha curing with FYM + PSB + VAM, $T_8$= 80 kg $P_2O_5$/ha + PSB + VAM, $T_9$= 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM. The experiment was replicated thrice in randomized block design. The results revealed that integration of 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_9$) produced significant higher plant height, dry matter, number of nodules/plant, dry weight of nodule/plant, pods/plant than the other treatments. Similarly, significant higher grain and stover yield were obtained from the treatment $T_9$. The protein content of seeds and available N, P, K and S and micronutrients of soil after the harvest of soybean were improved significantly due to the integration of inorganic fertilizers with organic manures. Thus, it shows the positive impact of biological and organic manure application on reduction of chemical fertilizer use.

**Keywords:** P levels, FYM, biofertilizers, available nutrients and micronutrients, nodule

## Introduction

Phosphorus is known to play an important role in growth and development of the crop and have direct relation with root proliferation, straw strength, grain formation, crop maturation and crop quality. The requirement of P, which is essential for root growth and nodulation, has to be largely fulfilled through inorganic fertilizers. Enhancing P availability to crop through phosphate-solubilizing bacteria (PSB) holds promise in the present scenario of escalating prices of phosphatic fertilizers in the country and a general deficiency of P in Indian soils (Alagawadi and Gaur, 1988) [1]. Bio-fertilizers are known to play an important role in increasing availability of nitrogen and phosphorus besides improving biological fixation of atmospheric nitrogen and enhance phosphorus availability to crop. Therefore, introduction of efficient strains of *Rhizobium* in soil, which is poor in nitrogen, may help in boosting up production and consequently more nitrogen fixation (Gill *et al*., 1987) [2].

Soybean being the "Golden Bean" of the 20th Century is a species of legume, native to East Asia, widely grown for its edible bean which has numerous uses. The plant is classed as an oilseed rather than a pulse by the Food and Agricultural Organization (FAO). Though, cultivated primarily under warm and hot climates, soybean was originally used as nitrogen fixer in early systems of crop rotation due to very poor cooking ability on account of inherent presence of trypsin inhibitor. It is now the largest oilseed crops in India after groundnut. It grows in varied agro-climatic conditions. It has emerged as one of the important commercial crops in many countries. Due to its worldwide popularity, the international trade of soybean is spread globally. Several countries such as Japan, China, Indonesia, Philippines, and European countries are importing soybean to supplement their domestic requirement for human consumption and cattle feed.

## Materials and Methods

Field experiment was conducted during kharif season 2013-14 at MARS, Dharwad. The experimental site is located at $15^0$ 26′N latitude and $75^0$ 07′ E longitude and at an altitude of 678 m above mean sea level.

The soil of the experimental area was clay with alkaline pH (7.7), available nitrogen is medium (350 kg/ha), medium in available phosphorus (32 kg/ha), medium in potassium (380 kg/ha) and medium in sulphur (19 kg/ha). The initial micronutrients status is Fe-3.6 mg/kg, Zn-0.58 mg/kg, Cu-0.48 mg/kg, Mn-5.71mg/kg. The experiment was laid out in RCBD design comprising of 9 treatments in three replications. Soybean seeds were treated with PSB and rhizobium. VAM is applied just below the seeds at the time of sowing. The inoculated seeds were dried under shade and sown immediately after drying. All the agronomic practices were carried out uniformly to raise the crop. The available micronutrients were analysed by DTPA extraction method (Lindsay and Norvell 1978) [8].

## Results and Discussion

**Plant height and dry matter:-** Plant height and dry matter were significantly influenced by the application of different levels of phosphorus and application of biofertilizers (Table 1). The plant height produced by $T_9$= 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM is 66.27 cm followed by $T_3$=RPP, $T_7$= 60 kg $P_2O_5$/ha curing with FYM + PSB + VAM (64.53 cm) and (62.53 cm). Similarly treatment $T_9$ produced highest dry matter of 27.49 g/plant and treatment next in the order is $T_3$ (24.85 g/plant) and $T_7$ (22.56 g/plant). Sharma *et al*. (2002) [18], reported that positive improvement in growth parameters under increased phosphorus application might be due to increased metabolic process in plants resulting into greater meristematic activities and apical growth there by improving plant height and ultimately resulted in improved dry matter accumulation. These results were similar with Hernandez and Cuevas (2003) [4] and Menaria, *et al*. (2003) [9], Tomar *et al*. (2004) [22], Qasim shahid, *et al.* (2009) [12], Nandini devi, *et al*. (2012) [11].

### Nodulation

In the present study, nodule count was also significantly influenced by P levels and biofertilizers. Among different treatments, the $T_3$ treatment which received RPP recorded the highest number of effective nodules per plant of 34.33 at 65 DAS and there were on par with the treatment receiving, 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_9$) with 32 nodules at 65 DAS and 60 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_7$) with 30.67 at 65 DAS, respectively. The increase in nodule number with phosphorus may have diluting effect, as phosphorus is known to stimulate nodulation (Sarkar and Mukherjee, 1991, Nandini devi, 2012) [13, 11]. It has been known that Rhizobium culture has played a direct role in nodule number (Sharma and Namdeo, 1999, Nagendra kumar 2005) [16, 10]. The treatment $T_3$ (RPP) recorded highest dry weight of nodule per plant of 0.33 g/plant at 65 DAS. It might be due to more number of nodules per plant during this period (Nandini devi, 2012) [11]. Further phosphorus has specific role in nodule initiation, growth and function in addition to its role in host plant growth.

The increase in nodule number and dry weight also increased with P levels and rhizobium seed inoculation. This might be ascribed to congenial soil condition developed due to FYM application leading to profuse root growth for higher infection sites and energy sources for better growth of nodules. The results are in close agreement with finding of Gopalkrishnan and Palaniappam (1992) [3].

**Table 1:** Effect of different levels of phosphorus with or with out cured, PSB, VAM on plant height (cm), dry matter (g/plant), nodulation in soybean crop.

| Treatments | Plant height (cm) | Dry matter (g/plant) | No of effective nodule /plant | Dry weight of nodule (g/plant) |
|---|---|---|---|---|
| $T_1$= Absolute control (No P) | 48.33 | 12.58 | 16.00 | 0.14 |
| $T_2$ = Absolute control with biofertilizer | 50.60 | 13.57 | 18.00 | 0.18 |
| $T_3$ = RPP | 64.53 | 24.85 | 34.33 | 0.33 |
| $T_4$= 40 kg $P_2O_5$ /ha + PSB + VAM | 54.10 | 15.33 | 20.00 | 0.21 |
| $T_5$= 40 kg $P_2O_5$/ha cured with FYM + PSB +VAM | 56.40 | 16.40 | 24.00 | 0.23 |
| $T_6$= 60 kg $P_2O_5$ /ha + PSB + VAM | 57.53 | 18.27 | 26.00 | 0.24 |
| $T_7$= 60 kg $P_2O_5$/ha cured with FYM+ PSB + VAM | 62.53 | 22.56 | 30.67 | 0.28 |
| $T_8$= 80 kg $P_2O_5$/ha + PSB + VAM | 59.13 | 20.21 | 28.00 | 0.26 |
| $T_9$= 80 kg $P_2O_5$/ha cured with FYM + PSB + VAM | 66.27 | 27.49 | 32.00 | 0.30 |
| SE m± | 0.99 | 0.86 | 1.14 | 0.01 |
| CD @ 5% | 2.98 | 2.59 | 3.42 | 0.03 |

### Yield and quality parameters

Number of pods/plant, grain and stover yield of soybean was also increased with increasing levels of phosphorus fertilizer. Application of 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_9$) produced maximum number of pods/plant (87.00). However, it was on par with RPP ($T_3$) and 60 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_7$) but significantly superior over rest of the treatments. It might be due to better growth and development of crop due to supply of phosphorus. The maximum grain yield (30 q/ha) produced by the application of 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_9$) was found to be on par with RPP ($T_3$) (29.17 q/ha) and 60kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_7$) (28.27 q/ha). The increase in seed yield might be due to better yield parameters *viz*, number of pods per plant, seeds per pod and hundred seed weight. The low yield of soybean grain at lower levels of P and no P application was probably due to lesser magnitude of P response. (Stefanescu and Palanciuc, 2000, Landge *et al*., 2002, Umale *et al.*, 2002, Jain and Trivedi 2005, Tomar, 2011) [20, 6, 23, 5, 22]. In another study, Nandini devi, *et al*. (2013) also reported that seed yield of soybean increased with inoculation and applying higher levels of phosphorus. Maximum stover yield (45.40 q/ha) was obtained from the application of 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_9$) and it was found to be on par with RPP ($T_3$) (43.30 q/ha) and 60kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_7$) (41.97 q/ha). The higher value of stover yield at higher levels of P is owing to significantly higher value of dry matter per plant. These findings are in conformity with the results of Sarkar *et al*. (1997) [14] and Nandini Devi *et al*. (2012) [11] in Soybean, Tauseef *et al.* (2013) [21] in Field pea.

Apart from other factors, quality of crop depends upon the protein content of seed, which is the major constituent of seed in legumes. The maximum crude protein content (43.74.00 %)

was achieved by using RPP ($T_3$) per hectare, whereas, the lowest protein content (31.30 %) was observed in control treatment. This may be due to increased availability of phosphorus resulting in more nitrogen fixation by the bacteria which in turn helped in better absorption and utilization of the entire plant nutrients thus resulting in more uptake of N, P and K. The increased protein content with seed inoculation might be due to increased N uptake in grains. Similar results have also been reported by Shabir *et al*., (2010) [15] in field pea, Nandini devi *et al*. 2012 [11], soybean crop and Tauseef *et al.* 2013 [21] in field pea crop.

**Table 2:** Effect of levels of phosphorus with or with out curing, PSB, VAM on crude protein content and yield parameters.

| Treatments | No of pods/plant | Grain yield (q/ha) | Straw yield (q/ha) | Crude protein content (%) |
|---|---|---|---|---|
| $T_1$= Absolute control (No P) | 50.00 | 15.64 | 23.47 | 31.25 |
| $T_2$ = Absolute control with biofertilizer | 60.67 | 18.77 | 27.10 | 32.73 |
| $T_3$ = RPP | 84.00 | 29.17 | 43.30 | 43.75 |
| $T_4$= 40 kg $P_2O_5$ /ha + PSB + VAM | 66.67 | 22.77 | 34.50 | 32.50 |
| $T_5$= 40 kg $P_2O_5$/ha cured with FYM + PSB +VAM | 70.67 | 25.04 | 37.03 | 35.42 |
| $T_6$= 60 kg $P_2O_5$ /ha + PSB + VAM | 73.33 | 26.10 | 39.10 | 36.58 |
| $T_7$= 60 kg $P_2O_5$/ha cured with FYM+ PSB + VAM | 81.33 | 28.27 | 41.97 | 39.16 |
| $T_8$= 80 kg $P_2O_5$/ha + PSB + VAM | 78.67 | 26.25 | 40.10 | 38.96 |
| $T_9$= 80 kg $P_2O_5$/ha cured with FYM + PSB + VAM | 87.00 | 30.80 | 45.40 | 41.04 |
| SE m± | 8.98 | 1.00 | 1.38 | 1.23 |
| CD @ 5% | 26.93 | 3.00 | 4.14 | 3.70 |

**Available Nutrients**

A significant increase in soil available N, $P_2O_5$, $K_2O$ and S was recorded with increased application of phosphorus and seed inoculation with PSB and Rhizobium and soil application of VAM (table 3). Application of RPP ($T_3$) recorded the highest soil available nitrogen (355.67 kg/ha) followed by application of 80 kg $P_2O_5$ /ha curing with FYM + PSB + VAM ($T_9$) and 60 kg $P_2O_5$ /ha curing with FYM + PSB + VAM ($T_7$) with 352.27 and 349.13 kg/ha, respectively. The increase in soil available nitrogen could be attributed to greater biological nitrogen fixation with adequate P supply and also due to favorable effect of rhizobium. Significant increase in soil available $P_2O_5$, $K_2O$ and S was also found in the treatment which received 80 kg $P_2O_5$ curing with FYM + PSB + VAM ($T_9$) recorded 31.67, 379.47, and 18.73 kg/ha, respectively. This may be due to the status of soil phosphorus improved firstly due to application of P cured with FYM to soil and secondly through organic acids released by decomposition of legume roots capable of solubilizing soil P. Further, this is also attributed to the additional supply of P through phosphate fertilizers along with FYM where in, FYM on decomposition releases organic acids which also solubilise native P in the soil, besides minimizing fixation of applied P by soil constituents. The results are in close conformity with Latif *et al.* 1992, Dadhich *et al*., 2011, Sharma *et al*., 2011, Nandini devi *et al.* 2012, and Tauseef *et al*. 2013 [7, 19, 11, 21].

**Available Micronutrients**

The DTPA-extractable copper, iron, manganese and zinc status in soil was significantly increased due to application of P fertilizers and biofertilizers (Table 4). The treatment ($T_9$) receiving 80 kg $P_2O_5$/ha curing with FYM + PSB + VAM recorded higher available Fe (3.57 mg/ kg), Cu (0.47 mg/ kg), Mn (5.67 mg/ kg), Zn (0.50 mg/ kg).Which was on par with RPP ($T_3$) and 60 kg $P_2O_5$/ha curing with FYM + PSB + VAM ($T_7$) (Fig.5). This might be due to addition of FYM which releases micronutrient to soil through its chelating effect. Further, FYM also prevents loss of micronutrients from precipitation, oxidation and leaching (Sharma *et al.* 2001) [17]. The extent of build up of residual micronutrients status of soil was slightly lower at the harvest of crop was less than at 60 DAS and this might be attributed to the higher uptake of micronutrients by the crop during reproductive phase.

**Table 3**: Nutrient status of the soil after the harvest of soybean crop as influenced by levels of phosphorus cured or uncured and biofertilizers

| Treatments | Ava N (kg/ha) | Ava $P_2O_5$ (kg/ha) | Ava $K_2O$ (kg/ha) | Ava S (kg/ha) |
|---|---|---|---|---|
| $T_1$= Absolute control (No P) | 198.33 | 15.47 | 321.20 | 9.53 |
| $T_2$ = Absolute control with biofertilizer | 209.97 | 18.07 | 337.23 | 10.93 |
| $T_3$ = RPP | 355.67 | 29.47 | 377.67 | 17.67 |
| $T_4$= 40 kg $P_2O_5$ /ha + PSB + VAM | 330.13 | 21.13 | 364.13 | 11.93 |
| $T_5$= 40 kg $P_2O_5$/ha cured with FYM + PSB +VAM | 334.87 | 22.27 | 368.07 | 13.53 |
| $T_6$= 60 kg $P_2O_5$ /ha + PSB + VAM | 339.87 | 24.03 | 370.27 | 15.13 |
| $T_7$= 60 kg $P_2O_5$/ha cured with FYM+ PSB + VAM | 349.13 | 28.67 | 376.80 | 16.13 |
| $T_8$= 80 kg $P_2O_5$/ha + PSB + VAM | 343.27 | 26.10 | 373.00 | 15.90 |
| $T_9$= 80 kg $P_2O_5$/ha cured with FYM + PSB + VAM | 352.27 | 31.67 | 379.47 | 18.73 |
| SE m± | 8.11 | 0.90 | 12.35 | 0.73 |
| CD @ 5% | 24.32 | 2.70 | 37.02 | 2.20 |

**Table 4:** Micronutrient concentration (mg/kg) in soil after harvest of crop as influenced by levels of phosphorus cured or uncured and biofertilizers

| Treatments | Fe | Mn | Zn | Cu |
|---|---|---|---|---|
| $T_1$= Absolute control (No P) | 2.00 | 3.73 | 0.25 | 0.22 |
| $T_2$ = Absolute control with biofertilizer | 2.23 | 4.03 | 0.33 | 0.26 |
| $T_3$ = RPP | 3.53 | 5.43 | 0.48 | 0.43 |
| $T_4$= 40 kg $P_2O_5$ /ha + PSB + VAM | 2.40 | 4.47 | 0.35 | 0.29 |
| $T_5$= 40 kg $P_2O_5$/ha cured with FYM + PSB +VAM | 2.60 | 4.63 | 0.38 | 0.33 |

| | | | | |
|---|---|---|---|---|
| $T_6$= 60 kg $P_2O_5$ /ha + PSB + VAM | 2.80 | 4.83 | 0.40 | 0.39 |
| $T_7$= 60 kg $P_2O_5$/ha cured with FYM+ PSB + VAM | 3.37 | 5.33 | 0.47 | 0.42 |
| $T_8$= 80 kg $P_2O_5$/ha + PSB + VAM | 3.07 | 5.07 | 0.45 | 0.40 |
| $T_9$= 80 kg $P_2O_5$/ha cured with FYM + PSB + VAM | 3.57 | 5.67 | 0.50 | 0.47 |
| SE m± | 0.37 | 0.47 | 0.04 | 0.01 |
| CD @ 5% | NS | NS | NS | NS |

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