

## EFFECT OF BIO-FERTILIZER AND FERTILIZERS ON PRODUCTIVITY OF SOYBEAN

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### ABSTRACT

A field experiment was conducted at farmer's field at village Nandupura (Vidisha) during kharif season of 2012 and 2013 to study the effect of bio-fertilizers and fertilizers on yield and quality of soybean [*Glycine max* (L.) Merr.]. The experiment was laid out in randomized block design with seven treatments and four replications. Results revealed that use of 75% NPK with VAM, PSB and rhizobium recorded significantly higher nodules per plant (73.7) nodules weight (481 mg/nodule) plant height (76.2 cm) pods per plant (31.6), seeds per pod (3.45), seed yield (26.8 q ha<sup>-1</sup>) leaf area index (14.2) and harvest index (49.4%). However, lowest yield of 12.6 q ha<sup>-1</sup> was obtained in control. Dual inoculation of rhizobium and PSB improved the quality of soybean in presence of chemical fertilizers. The uptake of N P and K, protein and oil content was significantly higher with 75% NPK + PSB+ VAM + Rhizobium compared to the other treatments and saves approximately 25% inorganic fertilizers. The use of PSB + VAM and Rhizobium + VAM gave at par results but statistically superior to control. The co-inoculation of VAM, PSB and Rhizobium with 75% NPK gave maximum values of chlorophyll (2.81 mg g<sup>-1</sup>) carbohydrates (5.46 mg g<sup>-1</sup>) and reducing sugar (1.97 mg g<sup>-1</sup>) Net returns (₹ 52739) and B: C ratio(2.91) were recorded highest with 75% NPK +VAM + Rhizobium + PSB.

**Key words:** Biofertilizers, soil fertility, soybean, profitability, yield

### INTRODUCTION

Soybean is known as the golden bean of the 21<sup>st</sup> century. It has great potential as a *kharif* oilseed and has emerged as an important commercial oilseed crop in Madhya Pradesh. Imbalanced nutrition is one of the important constraints of low soybean productivity in north plains. Application of bio-fertilizers along with inorganic fertilizers into the soil leads to increase in productivity of the crop and sustain the soil health for longer period (Manna *et al*, 2007). *Rhizobia* is one of the dominant symbiotic nitrogen fixing bacteria with legumes but a number of factors leads to poor nodulation and nitrogen fixation in legumes. Legumes with *Rhizobium* symbiosis contribute at least 90 X10<sup>6</sup> metric tonnes of N year<sup>-1</sup> all over the world (Subba Rao, 1982). As most of our soils are poor in organic matter, response to fertilizers has not been high due to rapid fixation of nutrients. Under such conditions inoculation with microorganism like VAM and PSB could be advantageous. To overcome these adverse effects, the VAM and other beneficial microbes need to be established to a high level of effectiveness. It was recommended that the VAM fungi are the universal compensators needed to accomplish the mission of sustainable agriculture. The concept of active management of rhizosphere population of legume has advanced towards dual or triple microbial inoculation of *rhizobium*, VAM and PSB strains with plant growth promoting rhizobacteria. It is an effort to shift

microbiological equilibrium in favour of increased plant growth promotion, nutrient uptake, crop yield, quality and protection from pest and diseases. Hence, the study was undertaken to evaluate the co-inoculation of VAM, PSB and *Rhizobium*, fungi with NPK fertilizers on growth parameters, yield, nutrient uptake and economics of soybean.

### MATERIALS AND METHODS

Field experiments were carried out during *kharif* season of 2012 and 2013 at farmers' field MPWSRP project GanjBasoda, Vidisha (Madhya Pradesh). The experimental soil belongs to the order of Vertisol, slightly alkaline (7.8) in nature, medium in available N (297 kg ha<sup>-1</sup>), available P (18.5 kg ha<sup>-1</sup>) and high in available K (380 kg ha<sup>-1</sup>). The organic C content in soil was 6.4 g kg<sup>-1</sup>. The experiment consisted of seven treatments namely T<sub>1</sub>-control, T<sub>2</sub>-VAM fungi (5.0 kg ha<sup>-1</sup>), T<sub>3</sub>- Rhizobium (4.0 kg ha<sup>-1</sup>), T<sub>4</sub>- PSB (500 g ha<sup>-1</sup>), T<sub>5</sub>-VAM + Rhizobium, T<sub>6</sub>-VAM + PSB, T<sub>7</sub>- 75% NPK +VAM + *Rhizobium* + PSB. Recommended dose of NPK for soybean was (20 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O ha<sup>-1</sup>). Nitrogen, P and K were applied at the time of sowing in the form of urea, single super phosphate and muriate of potash, respectively. Treatments were tested in RBD with four replications. The recommended dose of *Rhizobium* and PSB as per treatments was first mixed in clean water to make thick slurry. This slurry was mixed with required quantity of seeds before sowing. 75% NPK + VAM+ Rhizobium+ PSB treatments

above process was repeated for the second time. VAM culture after mixing with air dried soil was applied into the field at the time of sowing at the seeding depth. The pre-inoculated seeds were sown as per the treatment. The seed was inoculated with *Rhizobium* and PSB by slurry method, whereas the soil was inoculated with VAM inoculums. PSB and VAM were applied @500 g carrier ha<sup>-1</sup> and 5.0 kg carrier (soil) ha<sup>-1</sup>, respectively. Soybean cv. JS 93 05 was sown at a spacing of 30 cm X 10 cm. The plant growth characters were recorded at 30, 45 and 60 DAS. The biochemical constituents like total chlorophyll, total carbohydrates and total reducing sugar were determined by adopting standard procedures. Nitrogen, P and K concentration in grain and straw were determined by adopting standard procedures (Jackson 1973). The nutrient uptake was computed by multiplying yield data with nutrient content. The economics was calculated on the basis of prevailing market prices of inputs and produce.

## RESULTS AND DISCUSSION

### Yield attributing characters and yield

The co-inoculation of *Rhizobium* PSB and VAM along with 75% NPK enhanced the growth significantly than the control. Application of 75% NPK + VAM+ *Rhizobium*+ PSB produced tallest plant at different growth stages (38.0, 66.0 and 76.2 cm, respectively.) The lowest plant height (29.0, 43.0 and 57.70 cm, respectively) was recorded in control. The increase in plant height might be due to the increased metabolic activities, stimulation of root growth resulting in enhanced uptake of nutrients. The findings are in accordance with Cirak *et al.* (2006). The leaf area index (LAI) was recorded higher (14.20) with 75% NPK + VAM+ *Rhizobium*+ PSB and lowest LAI (8.17) in control. The LAI per plant

probably increased due to more activities of meristematic tissues of the plant producing more number of trifoliolate, correlated with increase in total photosynthetic surface and increased LAI of the plant during the growth period. These results are in agreement with those of Saxena *et al.* (2013) and Basavararaja *et al.* (2014) who observed such increased LAI in soybean when the crop was dual or triple incubated with *Bradyrhizobium* and VAM and PSB. The number of seeds/pod was not influenced significantly due to various treatments. However, 75% NPK + VAM+ *Rhizobium*+ PSB produced higher pods/plant (94.8), seed yield (26.8qha<sup>-1</sup>) and test weight (17.99) compared to control. Number of nodules per plant (43.7) was significantly higher under 75% NPK + VAM+ *Rhizobium*+ PSB at 60 DAS which may be due to availability of abundant organic matter and effective microbial activities because of sufficient supply of feeding material for *Rhizobium* bacteria in the form of humus (Prakash *et al.*, 2001). It also ensured healthy soil environment and better aeration for higher nodulation (Mishra *et al.*, 2005). Dual inoculation of VAM+ *Rhizobium* and VAM+ PSB gave highest number of nodules (37.3, 37.5) which was 76.0 % higher over control. Increased nodules by the PSB could be due to the greater availability of nutrients in the soil and better nodulation under the influence of inoculation resulted better growth and development which might be attributed to better mobilization of phosphorus and might be increased allocation of photosynthates towards the economic parts and also hormonal balance on the plant system. The grain yield is the manifestation of various yield and yield attributing character.

Table 1: Treatment influence on the yield attributing characters and yield of soybean (mean of 2 year)

Treatments	Plant height (cm)			No of Nodules			Dry wt. of Nodules (mg nodules <sup>-1</sup> )			pods plants <sup>-1</sup>	Seeds plants <sup>-1</sup>	Test wt. (g)	Harvest Index (%)	Grain yield (qha <sup>-1</sup> )	Straw Yield (qha <sup>-1</sup> )
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS						
Control	29.0	43.0	57.7	15.3	19.3	21.3	93	131	133	23.5	2.10	15.55	45.5	12.6	20.79
VAM(5kg)	33.5	57.0	73.3	26.0	31.3	33.8	175	230	240	25.3	2.45	17.12	51.3	23.7	39.11
Rhizobium (4 kg)	33.6	56.8	73.5	27.0	33.9	34.7	181	241	245	25.6	2.88	17.22	50.3	23.6	38.94
PSB(500 gm)	33.5	55.2	72.0	28.0	34.0	34.8	180	240	245	26.1	2.92	17.33	50.8	22.5	37.13
VAM+RZB	35.0	62.3	74.3	29.0	36.3	37.5	247	370	403	29.8	3.23	17.89	55.6	25.9	42.74
VAM+PSB	34.7	55.5	72.2	28.5	36.2	37.3	245	370	400	29.5	3.12	17.88	54.1	25.4	40.26
NPK75%+VAM+PSB+RZB	38.0	66.0	76.2	35.4	38.2	43.7	252	400	481	31.6	3.45	17.99	57.1	26.8	44.22
SEM±	0.37	0.39	0.31	0.30	0.32	0.31	0.34	0.66	0.82	0.3	0.23	0.29	1.1	0.60	0.41
CD at 5%	1.12	1.18	0.95	0.92	0.97	0.96	1.04	2.01	2.50	0.93	0.70	0.88	3.4	1.84	0.12

The higher yield (26.8 q ha<sup>-1</sup>) was obtained under 75% NPK+VAM+ *Rhizobium* + PSB treatments (Table 1). The increase in seed yield by

112.7% was recorded with 75% NPK+VAM+ *Rhizobium* + PSB treatments over the control. The increase in seed yield by 105.5% and 101.5% per cent

was recorded with VAM +RZB, and VAM + PSB, respectively over control. Increase in yield by dual or triple inoculation of VAM, RZB and PSB might be due to increased number of leaves and leaf area which determines the photosynthetic efficiency of plants, dry matter production and ultimately yield. Similar results were also reported by Ghosh and Joseph (2008). Harvest Index (HI) was recorded significantly maximum (57.1%) with 75% NPK+VAM+*Rhizobium*+ PSB and least (45.5%) in control. It might be due to comparatively highest increase of grain yield than that of respective straw yield of crop.

#### Nutrient Uptake

The higher N uptake was recorded in all the treatments compared to control. Treatment 75% NPK+VAM+*Rhizobium*+ PSB recorded highest N uptake (140.8 kg ha<sup>-1</sup>) and the least in control (83.5 kg ha<sup>-1</sup>). The co-inoculation of VAM with *Rhizobium* showed significant increase in N uptake (138.4 kg ha<sup>-1</sup>). Increase in N uptake might be due to higher availability of nitrogen from soil reservoir and additional quantity of N supplied by adding fertilizers. These findings corroborate with those of Shubhangi *et al.* (2008) in soybean and Bhat *et al.* (2013) in field pea. Phosphorous uptake (14.1 kg ha<sup>-1</sup>) was maximum with the application of treatment receiving 75% NPK+VAM+ *Rhizobium*+PSB and lowest (8.39 kg ha<sup>-1</sup>) with control and the extent of increase was 68.6 % as compared to control. Increased P uptake might be due to solubilization of

insoluble phosphorus and additional quantity of P supplied by adding fertilizers. The results obtained in this study revealed that the single inoculation of VAM fungus is better than the other single inoculation in soybean. These findings are in agreement with those of Reddy and Swamy (2000). Potassium uptake (91.7 kg ha<sup>-1</sup>) was highest in 75%NPK+VAM+*Rhizobium*+PSB and lowest (53.3 kg ha<sup>-1</sup>) in control. The K uptake of soybean was significantly higher in both inoculation either *Rhizobium* or PSB (80.9 and 81.0 kgha<sup>-1</sup>) over control. This might be due to greater availability of these nutrients with extended root system and increased cation exchange capacity of roots (Mahajan *et al.* 2002).

#### Quality Parameters

Application of 75% NPK + VAM+ *Rhizobium*+ PSB recorded maximum total chlorophyll content (2.8 mg g<sup>-1</sup>) carbohydrates, (5.46 mg g<sup>-1</sup>) reducing sugars (1.97 mg g<sup>-1</sup>), protein (37.7 %) and oil content (19.5%) and least in control. These results might be due to physiological influence of *Rhizobium*, VAM and PSB on the activity of number of enzymes along with the inorganic nutrients. The dual inoculated plots showed significant increase in quality parameters than the single inoculants. However, VAM treated plot had significant increase in the protein content over the plot treated with either PSB or *Rhizobium*, but less than the dual inoculums. These findings are in agreement with Subhangi and Kachhave (2008).

Table 2: Treatments influence on nutrient uptake and quality of soybean (mean of 2 year)

Treatments	Nutrient uptake (kg ha <sup>-1</sup> )			Protein content (%)	Oil content (%)	Total chlorophyll (mg g <sup>-1</sup> )	Total carbohydrate (mg g <sup>-1</sup> )	Total Reducing Sugar (mg g <sup>-1</sup> )	LAI	Net return (₹.ha <sup>-1</sup> )	BCR
	N	P	K								
Control	83.5	8.39	53.3	34.0	15.7	1.08	2.12	1.01	8.17	9892	1.35
VAM(5kg)	113.4	10.8	70.4	35.4	17.5	1.61	2.48	1.12	11.20	39592	2.42
<i>Rhizobium</i> (4kg)	135.5	10.9	70.8	35.4	17.8	1.63	2.45	1.43	12.01	42892	2.54
PSB(500 gm)	133.2	11.0	70.9	35.5	17.9	1.65	2.49	1.62	11.57	43112	2.54
VAM+RZB	139.4	12.6	81.0	36.5	18.5	2.51	3.83	1.80	13.77	45212	2.78
VAM+PSB	138.4	12.4	80.9	36.1	18.3	2.49	3.82	1.77	13.43	49712	2.62
NPK75%+VAM+PSB+RZB	140.8	14.1	91.7	37.7	19.5	2.81	5.46	1.97	14.20	52739	2.91
SEM±	0.31	0.83	0.30	0.23	0.51	0.85	0.23	0.14	0.46	-	-
CD at 5%	0.96	0.25	0.92	0.72	0.15	0.25	0.71	0.43	1.60	-	-

#### Economics

The highest net return of ₹52739 was obtained from treatment with 75% NPK + VAM+ *Rhizobium* + PSB. In the light of this, it can be argued that more seed yield with these treatments may be the reason for the resultant profits. Sarawgi *et al.* (2012) also reported highest net return with the application of

chemical fertilizers along with PSB, *Rhizobium* and VAM. The income per rupee spent (B:C ratio) was highest (₹2.91) with 75% NPK + VAM + *Rhizobium* + PSB . It may be due to more net return (Rs ha<sup>-1</sup>) than the cost of cultivation involved with these treatment. Thus, it may be concluded that application of 75% NPK+ VAM+ *Rhizobium* + PSB

was found beneficial for enhancing soybean productivity in Vertisol under Vindhya plateau of Madhya Pradesh. Recommended dose of 75% NPK and VAM + *Rhizobium*, and PSB resulted in higher growth, yield and benefit cost ratio. Therefore, integrated use of chemical fertilizer and co-

inoculation of VAM, *Rhizobium*, and PSB can be used to boost up the production of soybean crop and saves approximately 25% inorganic fertilizers.

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