Research Article

Effect of Biofertilizers in Conjunction with Chemical Fertilizers on Growth Behavior and Profitability of Field Pea (*Pisum Sativum* L.) Grown In Western Plains of Haryana

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Abstract

A field experiment was conducted during winter (*rabi*) season of 2013-14 at Research Area, CCS Haryana Agricultural University, Hisar, Haryana (latitude 29° 10' N and longitude 75° 36' E) to study the effect of biofertilizers in conjunction with chemical fertilizers on growth parameters, productivity and profitability of field pea. The experiment was conducted in randomized block design with nine treatments *viz.*, Control, seed inoculation with *Rhizobium*, *Rhizobium* + PSB, *Rhizobium* + PSB + PGPR, Recommended dose of fertilizers (RDF), RDF + *Rhizobium*, RDF + *Rhizobium* + PSB, RDF + *Rhizobium* + PSB + PGPR, RDF + $ZnSO_4$ @ 25 kg ha^{-1}. Results revealed that the growth parameters *viz.*, dry matter accumulation, LAI etc. and yield attributing character *viz.*, number of pods $plant^{-1}$, number of grains pod^{-1}, yield (kg ha^{-1}) were significantly superior in treatment receiving RDF + *Rhizobium* + PSB + PGPR application over control treatment. Similarly, highest gross returns, net returns and B: C ratio was obtained in the same treatment among all the treatments.

Keywords: *Biofertilizers*, Plant Growth Promoting Rhizobacteria (PGPR), Phosphate solubilizing bacteria (PSB), Productivity, Field Pea

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Introduction

Field pea (*Pisum sativum* L.) is a high yielding, input responsive and relatively stable pulse crop of *rabi* season. In India, area under field pea is 0.76 million hectare and production is 0.71 million tonnes with the productivity of 966 kg ha^{-1} [1].Though India is the world's largest producer of pulses and second largest producer of field pea in the world yet it imports a large amount of pulses (3.8 million tonnes) to meet the growing domestic need. The scope of increasing the area under pulses is very limited due to their low productivity in comparison to high yielding dwarf varieties of cereal and millet crops. One of the possible ways is to increase the productivity per unit area by integrating the use of chemical fertilizers with bio-fertilizers [2]. Seed inoculation with *Rhizobium*, PSB and PGPR prior to sowing is the cheapest means to improve the productivity of grain legumes, as it influences the nodulation, biological nitrogen fixation, produced growth hormones and ultimately increases grain yield. Use of efficient strains of *Rhizobium*, PSB and PGPR not only increase the nutrient use efficiency and yield but also reduce the cost of cultivation [3]. Keeping in view, the beneficial effect of integrating chemical fertilizers with organic sources of nutrient on soil and crop, a field experiment was carried out to find out the effect of biofertilizers in conjunction with chemical fertilizers on productivity and profitability in field pea.

Materials and Methods

The field experiment was conducted during *Rabi* season of 2013-14 at Research Area, CCS Haryana Agricultural University, Hisar, Haryana. The soil of the experimental field was sandy loam, slightly alkaline in pH (7.9), low in nitrogen (140 kg/ha), medium in phosphorous (30.2 kg/ha) and high in potassium content (311 kg/ha). The experiment was conducted in randomized block design [4] with nine treatments *viz.*, Control, seed inoculation with *Rhizobium*, *Rhizobium* + PSB, *Rhizobium* + PSB + PGPR, Recommended dose of fertilizers (RDF), RDF + *Rhizobium*, RDF + *Rhizobium* + PSB, RDF + *Rhizobium* + PSB + PGPR, RDF + $ZnSO_4$ @ 25 kg ha^{-1}.The seed of variety *uttera* was drilled at spacing of 30 cm X 15 cm. Weeds were managed manually by two hand hoeing at 25 and

45 days after sowing. Seed was treated with biofertilizers @ 10 g/kg seed as per treatments. Leaf area index (LAI) was worked out at 30, 60 and 90 days after sowing (DAS). Similarly, periodical changes in dry matter accumulation (DMA) per plant were recorded by taking three plants randomly and then sun drying followed by oven drying for 24 hours or more at 70°C until constant weight was obtained at 30, 60, 90 days after sowing and at maturity. Data on pods per plant, seeds per pod, 100 grain weight, grain and biological yield were recorded at maturity. Net returns as well as benefit: cost was also worked out. The net return from individual crop calculated by deducting the cost of cultivation from gross return and expressed as Rs/ha on the basis of cost of inputs and prices of outputs in experimentation year.

Growth parameters

Data pertaining to LAI at various crop growth stages of field pea have been shown in **Table 1**. In general LAI increased with advancement of crop growth. The application of bio-fertilizers and their combination resulted in significantly higher LAI over control at all the stages of crop growth. At 30 DAS, maximum LAI was recorded with RDF + *Rhizobium* + PSB + PGPR treatment, which did not differ significantly from RDF + *Rhizobium*, RDF + *Rhizobium* + PSB. At 60 and 90 DAS, maximum LAI was recorded in RDF + *Rhizobium* + PSB + PGPR treatment, which differ significantly from rest of the treatments. The values of LAI in the treatments RDF and *Rhizobium* + PSB + PGPR were statistically at par at all the growth stages, showing the significant contribution in LAI by combine application of bio-fertilizers.

Table 1 Influence of combined application of chemical and bio fertilizers on periodical changes in leaf area index (LAI) of field pea

Treatments	30 DAS	60 DAS	90 DAS
Control	0.012	0.061	0.135
Rhizobium	0.014	0.071	0.150
Rhizobium + PSB	0.014	0.075	0.155
Rhizobium + PSB + PGPR	0.014	0.080	0.162
RDF (20 N + 40 P_2O_5 kg ha^{-1})	0.014	0.084	0.164
RDF + *Rhizobium*	0.015	0.091	0.178
RDF + *Rhizobium* + PSB	0.016	0.096	0.181
RDF+ *Rhizobium* + PSB + PGPR	0.016	0.103	0.194
RDF + $ZnSO_4$ @ 25 kg ha^{-1}	0.014	0.090	0.172
CD (P=0.05)	**0.001**	**0.004**	**0.006**

Data presented in **Table 2** showing gradual increase in DMA with advancement of crop growth stages. The rate of DMA was slow in the 30 to 60 DAS, 91 DAS to maturity stages and observed highest during 61-90 period. Maximum value was recorded in RDF + *Rhizobium* + PSB + PGPR treatment at all the growth stages, which was found significantly superior than rest of treatments except RDF + *Rhizobium* and RDF + *Rhizobium* + PSB treatment at 30 DAS. The higher DMA $plant^{-1}$ might be due to higher availability of nutrient which resulted in higher growth and development of the plant. The results are in conformity with the findings of Pandey *et al.* (2002) [5], Khandewal *et al.* (2012) [6] and Shabir *et al.* (2010) [7].

Yield parameters and yield

The perusal of the data in **Table 3** indicated that the combined application of RDF + *Rhizobium* + PSB + PGPR produced significantly higher number of pods $plant^{-1}$, being statistically at par with RDF, RDF + *Rhizobium*, RDF + *Rhizobium* + PSB and RDF + $ZnSO_4$ treatments. The application of alone as well as combined bio inoculants (*Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR) did not result in significant improvement in this trait over the control. The combined application of biofertilizers (*Rhizobium* + PSB + PGPR) and RDF treatments were statistically at par with each other in terms of number of pods $plant^{1}$. Similar trend was observed in number of grains pod^{-1} trait except for treatments RDF and *Rhizobium* + PSB + PGPR, which differ significantly with each other for the number of grains pod^{-1}. Different treatments did not bring out any significant gain in 100 grain weight but numerically 100 grain weight was observed maximum with treatment RDF + *Rhizobium* + PSB + PGPR. The improvement in yield attributing characters under combination of chemical and biofertilizers was probably due to adequate supply of nutrients, particularly nitrogen and phosphorus, which helped in the process of photosynthesis and partioning of

photosynthates (sink filling process) [8]. Similarly the combined application of bioinoculants (*Rhizobium* + PSB and *Rhizobium* + PSB + PGPR) along with RDF resulted in significantly higher grain yield than RDF and control, however sole application of *Rhizobium* with RDF did not bring out any significant improvement. Lowest grain yield was recorded in control which remained statistically at par with sole application of *Rhizobium*. The additional use of $ZnSO_4$ with RDF did not result in significant improvement in the grain yield over the RDF alone. The combined application of only bioinoculants (*Rhizobium* + PSB + PGPR) produced significantly lower yield than RDF. The higher seed yield under the INM as compared to alone application, might be due to improvement in physio-chemical and biological properties of soil and constant and optimum supply of nutrients by the soil enhanced the growth and yield attributing characters. The combined application of bioinoculants (*Rhizobium* + PSB + PGPR) resulted in significantly higher biological yield over control, *Rhizobium* and *Rhizobium* + PSB treatments. The significantly higher biological yield was observed in RDF + *Rhizobium* + PSB + PGPR treatment compared to all other treatments except RDF + *Rhizobium* + PSB. Improvement in yield was due to profound influence of nitrogen and phosphorus nutrients on vegetative and reproductive growth of the crop owing to nutrient accumulation and their translocation towards sink (yield forming attributes *viz*., pods plant^{-1}, grains pod^{-1} and test weight). An overall increase in yield attributes and yield of field pea crop due to combined application of chemical fertilizers with biofertilizers have also been reported by Mishra *et al*. (2010) [9], Rajput and Kushwah (2005) [10], Bhat *et al*. (2013) [11], Erman *et al*. (2009) [12], Negi *et al*. (2006) [13], Dass *et al*. (2005) [14] and Kumari et al (2012) [15].

Table 2 Periodical changes in dry matter accumulation per plant as affected by combined application of chemical and bio-fertilizers in field pea

Treatments	30 DAS	60 DAS	90 DAS	At maturity
Control	0.42	0.96	3.36	8.19
Rhizobium	0.45	1.09	4.06	10.17
Rhizobium + PSB	0.46	1.16	4.45	10.90
Rhizobium + PSB + PGPR	0.49	1.33	5.27	13.41
RDF (20 N + 40 P_2O_5 kg ha^{-1})	0.56	1.65	6.97	18.40
RDF + *Rhizobium*	0.58	1.76	7.84	21.22
RDF + *Rhizobium* + PSB	0.61	1.89	8.87	24.17
RDF+ *Rhizobium* + PSB + PGPR	0.68	2.21	11.03	30.41
RDF + $ZnSO_4$ @ 25 kg ha^{-1}	0.57	1.69	7.36	20.07
CD (P=0.05)	**0.10**	**0.06**	**0.23**	**2.29**

Table 3 Effect of bio-fertilizers and their combination with chemical fertilizers on yield attributes and yields of field pea

Treatments	**No. of Pods plant^{-1}**	**No. of grains pod^{-1}**	**100 grain wt. (g)**	**Grain Yield (kg ha^{-1})**	**Straw Yield (kg ha^{-1})**	**Biological Yield (kg ha^{-1})**	**Harvest Index (%)**
Control	12.0	4.20	13.3	1595	2798	4393	36.4
Rhizobium	13.3	4.26	15.1	1727	3012	4740	36.5
Rhizobium + PSB	14.5	4.26	15.3	1802	2873	4675	38.6
Rhizobium + PSB + PGPR	16.1	4.50	15.5	2116	3136	5252	40.2
RDF (20 N + 40 P_2O_5 kg ha^{-1})	19.9	5.23	16.3	2499	2925	5424	46.2
RDF + *Rhizobium*	21.2	5.40	16.6	2577	3019	5596	46.1
RDF + *Rhizobium* + PSB	22.2	5.50	16.7	2731	3025	5756	47.6
RDF+ *Rhizobium* + PSB + PGPR	23.3	5.70	16.9	2931	3095	6026	48.7
RDF + $ZnSO_4$ @ 25 kg ha^{-1}	20.3	5.30	16.5	2549	3058	5607	45.2
CD (P=0.05)	**4.3**	**0.51**	**NS**	**137**	**NS**	**409**	**3.6**

A linear equation was fitted between yield (grain and biological) and treatment (biofertilizers and their combination with chemical fertilizers) and coefficient of determination was found to be 0.85 showing that a good fit is between them (**Figure 1**).

Economics

The range of net returns was between Rs. 7826 to 36,875 among the different treatments. Net returns and B C ratio were highest in RDF + *Rhizobium* + PSB + PGPR treatment. This treatment realized Rs. 34,949 and Rs. 12,720 higher net returns over control and RDF. Similar trend was observed for B C ratio (**Figure 2**). Treatments are represented by using symbol *viz.*, Control (T1), seed inoculation with *Rhizobium* (T2), *Rhizobium* + PSB (T3), *Rhizobium* + PSB + PGPR (T4), Recommended dose of fertilizers (RDF) (T5), RDF + *Rhizobium* (T6), RDF + *Rhizobium* + PSB (T7), RDF + *Rhizobium* + PSB + PGPR (T8) and RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T9).

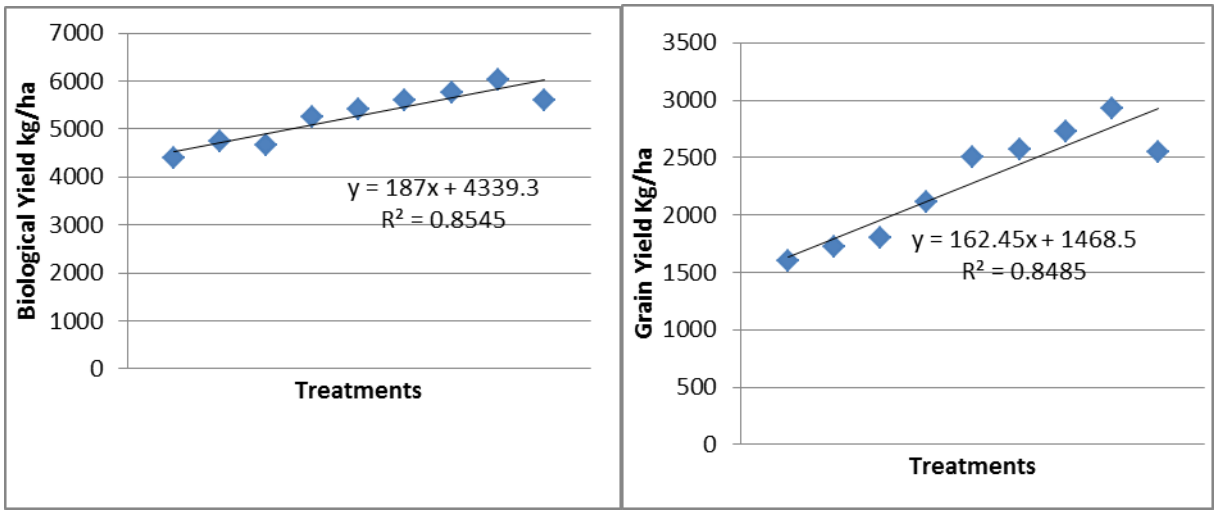

Figure 1 Relationship between treatment and yield (grain and biological yield)

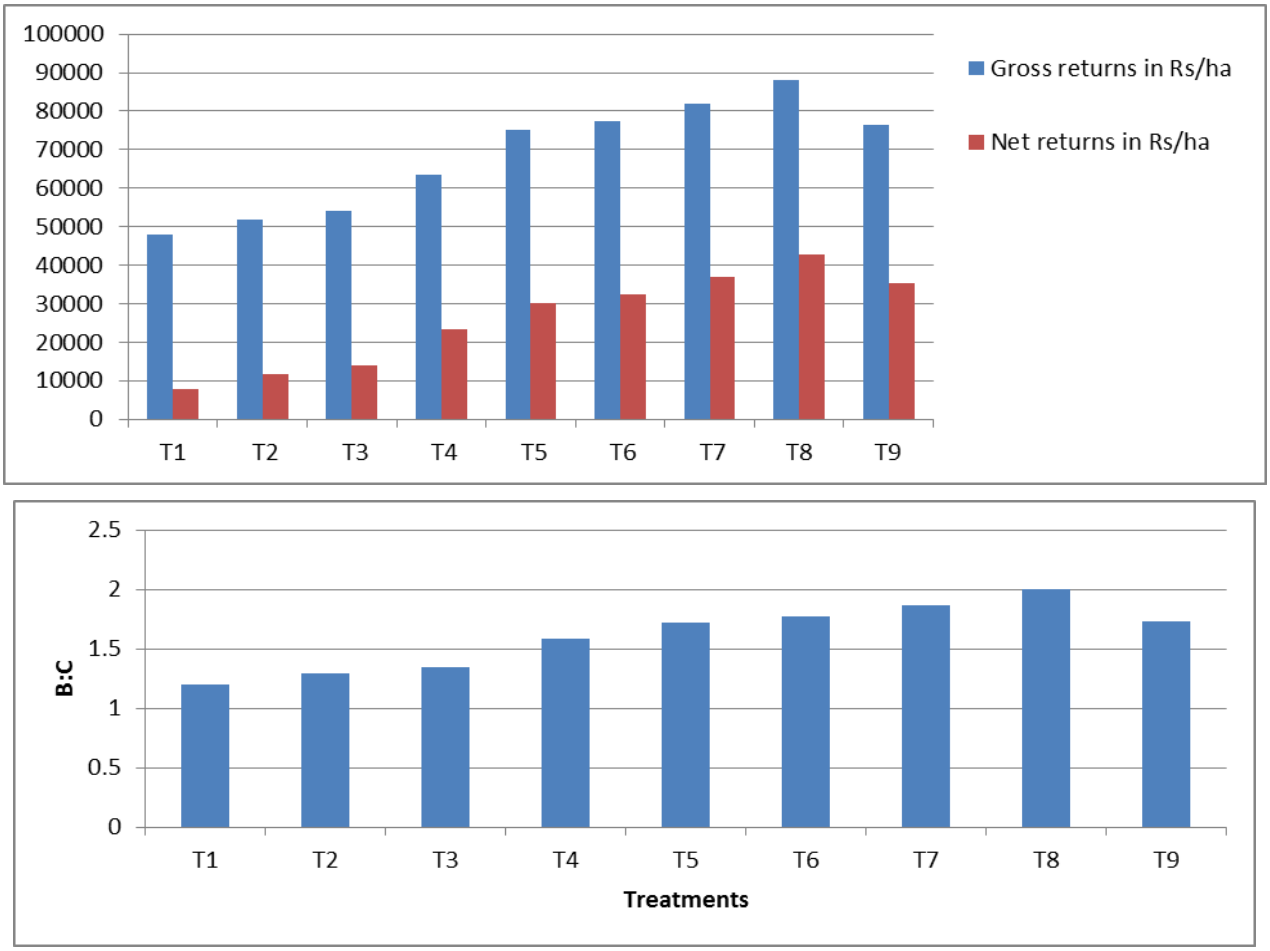

Figure 2 Economics of field pea as influenced by biofertilizers in conjunction with chemical fertilizers

Conclusion

The yield attributing traits were also observed higher in the RDF + *Rhizobium* + PSB + PGPR treatment. The grain and straw yield were improved by 17% and 6 %, respectively in this treatment over RDF alone. Net returns were realized Rs. 12,720 and Rs. 34,949 ha^{-1} more in the combined application of RDF with bio-fertilizers (*Rhizobium* + PSB + PGPR) treatment than RDF and control, respectively. The B:C was also observed highest (2.00) in this treatment than the values of 1.72 and 1.20 in RDF and control treatments

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