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Economics of Fieldpea (*Pisum sativum* L.) as Influenced by Phosphorus Levels and Bio-fertilizers in Central Plains of Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the student instructional farm of CSAUA&T, Kanpur, during the Rabi season of 2021-22 and 2022-23. Sandy loam was the texture of the experimental soil. There are twelve treatment involving combinations of phosphorus and biofertilizers with three replication of factorial randomized block design (FRBD). A fieldpea variety IPFD 6-3 was planted according to recommended agronomic practices. The results of these studies indicate that fieldpea cultivation over a two-year period is consistent with T_{12} (P_{90} R_1 PSB_1), the most economically effective treatment and also recorded the highest economics parametric values i.e., maximum cost of cultivation of ₹39006 & ₹39751, gross return of ₹ 106055 & ₹118535, net return of ₹67049 & ₹ 78784 and benefit to cost ratios were 1.72 & 1.98 followed by the treatment T_{11}.

Keywords: Fieldpea; cultivation; years; treatment; return.

1. INTRODUCTION

India is a major pulse-growing country globally, accounting for roughly one-third of the total area under pulses and one-fourth of the world's production. Field pea (*Pisum sativum* L.) is a popular pulse crop of India. India is the second largest producer of pea in the world after Russia. Pea is rich in protein, carbohydrates, vitamin A, calcium and phosphorus. 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 (Erman et al., 2009). 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 & Gaur, 1988). Phosphorus is a vital nutrient for plant growth, affecting various aspects of field pea development. Its availability in soil influences root development, flowering and overall yield. Proper phosphorus management can enhance field pea growth. When it comes to keeping plant development and crop productivity going strong, phosphorus is the second most important nutrient given to the soil (Singh et al., 2023). 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. Biofertilizers are living microorganisms that are bacterial, fungal or algal in origin. As a result of biofertilizers, atmospheric nitrogen is fixed in the root nodules and made available to plants. By applying nutrients at the appropriate dose, you can achieve a profitable as well as economically and environmentally optimal result. Along with enhancing grain yield, microbes may also contribute to reducing chemical fertilizer input by lowering production costs (Singh et al., 2018). Therefore, introduction of efficient strains of Rhizobium and PSB in soil, which is poor in nitrogen, may help in boosting up production and consequently more nitrogen fixation. Being a legume crop, major portion of N requirement of the crop is met through biological nitrogen fixation. Therefore, the present study was designed to assess the influence of phosphorus and bio-fertilizers combined effect on the economics of the various treatments of field pea.

2. MATERIALS AND METHODS

The 12 treatment with three replications of factorial randomized block design (FRBD) were performed. Detailed treatment information is provided in Table 1.

2.1 Economics Characters

Seed and stover yield are based on an average in consecutive years i.e. 2021-22 and 2022-23, different treatments were analysed economically.

2.1.1 Cost of cultivation

Based on input rates at the farm, we calculated the cost of cultivation. Costs associated with treatments were calculated separately. To obtain the total cost of cultivation, all expenses incurred in cultivation were considered and treatment costs (including interest on working capital) were added.

2.1.2 Gross return (₹ ha^{-1})

Market rates were used to calculate the income from seed and straw production. Gross return per

hectare were calculated by converting fieldpea crop yield to current produce prices.

Gross return (₹ ha^{-1}) = Total income from grain and Straw yield

2.1.3 Net return (₹ ha^{-1})

To calculate profit, subtract cultivation cost from gross income (ha^{-1}). Following is the formula used to calculate the net return:

Net return (₹ ha^{-1}) = Gross return (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

2.1.4 Benefit: cost ratio

Net income of each treatment was divided by cultivation cost of respective treatment and cost benefit ratio was recorded. There was calculated with the help of following formula.

$$\text{Benefit: cost ratio} = \frac{\text{Net Return (₹ ha}^{-1})}{\text{Cost of cultivation (₹ ha}^{-1})}$$

The outcomes are given in respective tables and shown graphically in figures.

Table 1. Detail of the treatment combinations

S. No.	Treatment Details	Symbol
1.	0 kg P+ without *Rhizobium* + without PSB	P_0 R_0 PSB_0
2.	0 kg P+ without *Rhizobium* + with PSB	P_0 R_0 PSB_1
3.	0 kg P + with *Rhizobium* + without PSB	P_0 R_1 PSB_0
4.	0 kg P+ with *Rhizobium* + with PSB	P_0 R_1 PSB_1
5.	60 kg P+ without *Rhizobium*+ without PSB	P_{60} R_0 PSB_0
6.	60 kg P+ without *Rhizobium* + with PSB	P_{60} R_0 PSB_1
7.	60 kg P+ with *Rhizobium* + without PSB	P_{60} R_1 PSB_0
8.	60 kg P+ with *Rhizobium* + with PSB	P_{60} R_1 PSB_1
9.	90 kg P+ without *Rhizobium*+ without PSB	P_{90} R_0 PSB_0
10.	90 kg P+ without *Rhizobium* + with PSB	P_{90} R_0 PSB_1
11.	90 kg P+ with *Rhizobium* + without PSB	P_{90} R_1 PSB_0
12.	90 kg P+ with *Rhizobium* + with PSB	P_{90} R_1 PSB_1

Table 2. Effect of different treatment combinations on seed yield (q ha^{-1}) of fieldpea

Treatments		Seed Yield (q ha^{-1})						
		2021-22			2022-23			
		PSB_0	PSB_1	Mean	PSB_0	PSB_1	Mean	Pooled
P_0	R_0	12.01	14.52	13.27	13.57	15.16	14.37	13.82
	R_1	13.40	15.60	14.50	14.25	15.90	15.08	14.79
	Mean	12.71	15.06	13.89	13.91	15.53	14.72	14.30
P_{60}	R_0	16.25	17.00	16.63	16.65	17.61	17.13	16.88
	R_1	16.63	17.46	17.05	16.86	18.32	17.59	17.32
	Mean	16.44	17.23	16.84	16.76	17.97	17.36	17.10
P_{90}	R_0	18.20	19.10	18.65	18.78	19.94	19.36	19.00
	R_1	18.54	19.45	19.00	19.04	20.62	19.83	19.41
	Mean	18.37	19.28	18.83	18.91	20.28	19.60	19.21
Overall Mean		15.84	17.19	16.52	16.53	17.93	17.23	16.88
		S.Ed±	C.D. at 5%		S.Ed±	C.D. at 5%		C.D. at 5 %
P		0.43	0.89		0.45	0.93		0.29
R		0.35	0.73		0.36	0.76		0.24
PSB		0.35	NS		0.36	NS		0.24
P × R		0.61	NS		0.63	NS		0.42
P×PSB		0.61	NS		0.63	NS		NS
R×PSB		0.50	NS		0.52	NS		NS
P × R × PSB		0.86	NS		0.90	NS		NS

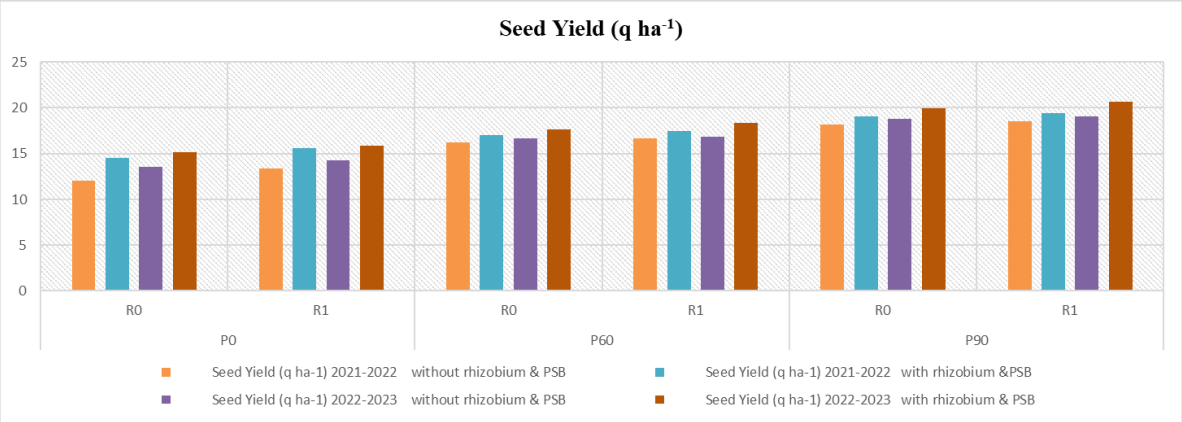

Fig. 1(a). Effect of different treatment combinations on Seed yield (q ha^{-1}) of field pea

Table 3. Effect of different treatment combinations on stover yield (q ha^{-1}) of field pea

Treatments		Stover Yield (q ha^{-1})						
		2021-22			2022-23			
		PSB$_0$	PSB$_1$	Mean	PSB$_0$	PSB$_1$	Mean	Pooled
P$_0$	R$_0$	35.60	36.41	36.01	36.68	37.29	36.99	36.50
	R$_1$	36.05	37.56	36.81	37.22	38.75	37.99	37.40
	Mean	35.83	36.99	36.41	36.95	38.02	37.49	36.95
P$_{60}$	R$_0$	39.10	39.76	39.43	41.08	42.85	41.97	40.70
	R$_1$	39.35	40.64	40.00	41.40	43.33	42.37	41.18
	Mean	39.23	40.20	39.71	41.24	43.09	42.17	40.94
P$_{90}$	R$_0$	42.80	44.32	43.56	44.74	45.74	45.24	44.40
	R$_1$	43.36	44.68	44.02	45.12	46.59	45.86	44.94
	Mean	43.08	44.50	43.79	44.93	46.17	45.55	44.67
Overall Mean		39.38	40.56	39.97	41.04	42.43	41.74	40.86
		S.Ed±	**C.D. at 5%**		**S.Ed±**	**C.D. at 5%**		**C.D. at 5%**
P		1.02	2.12		1.06	2.2		0.52
R		0.83	NS		0.87	NS		0.42
PSB		0.83	NS		0.87	NS		0.42
P × R		1.44	NS		1.51	NS		NS
P×PSB		1.44	NS		1.51	NS		NS
R×PSB		1.18	NS		1.23	NS		NS
P × R× PSB		2.04	NS		2.13	NS		NS

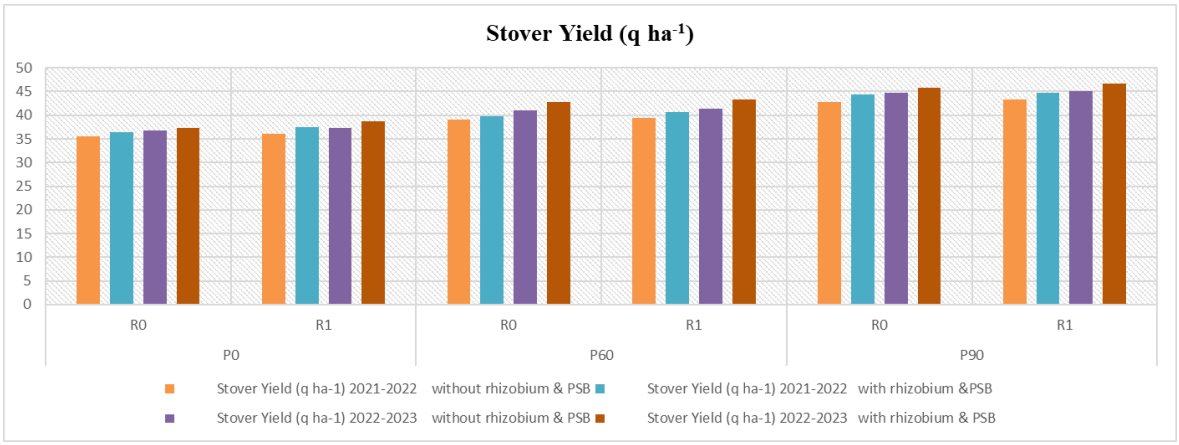

Fig. 2(a). Effect of different treatment combinations on Stover yield (q ha^{-1}) of field pea

Table 4. Effect of Phosphorus and Biofertilizers on cost of cultivation and gross return of field pea in consecutive years

S. No.	Treatments	Cost of cultivation (₹)			Gross return (₹)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
1.	T_1	34150	34940	34545.00	70380	78670	74525.000
2.	T_2	34310	35055	34682.50	73646	82469	78057.500
3.	T_3	34350	35095	34722.50	79509	87482	83495.500
4.	T_4	34510	35255	34882.50	85252	91713	88482.500
5.	T_5	37150	37895	37522.50	88801	96094	92447.500
6.	T_6	37310	38055	37682.50	90805	97284	94044.500
7.	T_7	37350	38095	37722.50	92774	101569	97171.500
8.	T_8	37510	38255	37882.50	95262	105526	100394.00
9.	T_9	38646	39391	39018.50	99348	108211	103779.50
10.	T_{10}	38806	39551	39178.50	101178	109683	105430.50
11.	T_{11}	38846	39591	39218.50	104195	114701	109448.00
12.	T_{12}	39006	39751	39378.50	106055	118535	112295.00

Table 5. Effect of phosphorus and biofertilizers on net return and benefit cost ratio of fieldpea in consecutive years

S. No.	Treatments	Net return (₹)			Benefit cost ratio (₹)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
1.	T_1	36230	43775	40002.50	1.06	1.25	1.16
2.	T_2	39336	47414	43375.00	1.15	1.35	1.25
3.	T_3	45159	52387	48773.00	1.31	1.49	1.40
4.	T_4	50742	56458	53600.00	1.47	1.60	1.54
5.	T_5	51291	58199	54745.00	1.38	1.54	1.46
6.	T_6	53495	59229	56362.00	1.44	1.56	1.50
7.	T_7	55424	63474	59449.00	1.48	1.67	1.58
8.	T_8	57752	67271	62511.50	1.54	1.75	1.66
9.	T_9	60702	68820	64761.00	1.57	1.76	1.67
10.	T_{10}	62372	70132	66252.00	1.60	1.77	1.69
11.	T_{11}	65349	75110	70229.50	1.68	1.89	1.79
12.	T_{12}	67049	78784	72916.50	1.72	1.98	1.85

3. RESULTS AND DISCUSSION

The data pertaining to economics of fieldpea was studies in terms of cost of cultivation, gross return, net return and benefit: cost ratio which have been presented in Tables 4 & 5. The ultimate purpose of any research or technology is its acceptability by farmer and this is directly related with the economic viability of that findings. Gain and loss of any agricultural practice depends upon the input cost and output price. A short discussion is made here under on economic feasibility of present experiment. Maximum cost of cultivation (₹ 39006 & ₹39751), gross return (106055₹/ha &118535₹/ha), net return (67049₹/ha & 78784₹/ha) and benefit : cost ratio (1.72 & 1.98) were obtained in treatment T_{12} : 90 kg P+ with *Rhizobium* + with PSB (P_{90} R_1 PSB_1)while minimum cost of cultivation (₹34150 & ₹34895), gross return (70380₹/ha &78670₹/ha), net return (36230₹/ha & 43775₹/ha) and benefit : cost ratio (1.06&1.25) was calculated with treatment T_1 : 0 kg P+ without *Rhizobium* + without PSB ($P_0R_0PSB_0$) resulted respectively. This might be due to higher growth and yield attributes resulting in more seed and stover yield with full recommended dose of phosphorus (Bhat et al., 2002) and dual inoculation with *Rhizobium*+ PSB (Sachan et al., 2024). Tables 2 & 3 recorded the grain and stover yield which supports economical. In order to be economical, unit fertilizers should be applied if their yield increase in excess of their cost is greater than the cost of the fertilizers used. Unless the fertilizer increases if the application does not produce enough income to cover its cost, the application is not economical and will not be benefited, yield increases continuously. It is essential to apply essential elements in the right proportion and quantity to increase profit (Singh et al., 2018). The cost of cultivation was minimum where nutrients applied without phosphorus & bio-fertilizers compared to nutrients applied with phosphorus and bio-fertilizers. Based on two-year data, the maximum gross return and net return was found with P_{90}

R_1PSB_1 (T_{12}) (Mishra et al., 2010). This significant finding is supported by the research conducted by esteemed scholars such Sims et al. (2000), Gajera et al. (2014), Singh et al. (2005), Yadav et al. (2013), Kumari et al. (2022), Joharika et al. (2023) Khajuria et al. (2023) and Sachan et al. (2024), Yadav et al. (2021).

4. CONCLUSION

In the light of results summarized above in conclusion, the application of P_{90} R_1PSB_1 (T_{12}) had maximum cost of cultivation also produced high values of gross return, net return and benefit: cost ratio that was found. Therefore, phosphorus application and combined inoculation with Rhizobium + PSB can be used to boost the production of field pea **(***Pisum sativum* L.). Hence, we can recommend T_{12} for field pea growing farmers in central plains of Uttar Pradesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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