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Effect of Phosphorus Levels and PSB on Productivity and Nutrient Uptake of Green Gram [*Vigna radiata* (L.) Wilczek] under Custard Apple (*Annona Squamosa*) Based on Agri-Horti System

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Abstract A field experiment was conducted during *kharif* season of 2011-12 to evaluate the effect of phosphorus levels and PSB on productivity and nutrient uptake of green gram [*Vigna radiata* (L.) Wilczek] under custard apple (*Annona squamosa*) based on agri-horti system. Treatments consisted of green gram Control, 20, 30, 40 Kg P_2O_5 ha^{-1}, PSB (S_1) + 20, 30 , 40 kg P_2O_5 ha^{-1}, PSB (S_2) + 20, 30, 40 kg P_2O_5 ha^{-1}, PSB (S_1)+ PSB (S_2) + 20, 30, 40 kg P_2O_5 ha^{-1} during *kharif* 2011-12. The number of pods $plant^{-1}$, pod length, number of grains pod^{-1}, nitrogen, phosphorus and potassium content in grain and straw and nitrogen, phosphorus and potassium content by grain and straw were increased with the application of 40 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) significantly higher over the control, 20 kg P_2O_5 ha^{-1} and 30 kg P_2O_5 ha^{-1}. The seed inoculation with PSB (S_1) + PSB (S_2) under the application of 40 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) recorded the maximum grain and straw yield at par with 40 kg P_2O_5 h^{-1} either under PSB (S_2), 40 kg P_2O_5 ha^{-1} + PSB (S_1) and 30 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) significantly higher over rest treatment combination.

Keywords Green gram, Seed inoculation, PSB, Phosphorus level, Yield attributes.

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Introduction

In India, shrinking land resourcess coupled with burgeoning population exerting hugr pressure on the farmers, researchers and agricultural policy makers to meed the food grain requirement of nation. This enforces to search out for newer vistas. Agro forestry system with judicious mixing of crop, tree and grasses meet all basic requirements of mankind and this livestock.

Pulses are consumed all over the world ; their consumption is higher in those parts of the world where animal proteins are scare and expensive [1]. They are also an important component of cropping systems in marginal and sub-marginal areas of dry land farms as 92% of the pulse production in India is realized from dry lands or the areas depending on rains. Greengram commonly known as Moongbean or moong. It contains 24.3% protein fairly rich in carbohydrates and also contains small amount of riboflavin and thiamine, also rich in phosphorus and iron [2].

The important greengram growing states are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar. Though India is the largest producer of pulses in the world, the per capita consumption over the years has come down from 61 g day^{-1} in 1951 to 30 g day^{-1} in 2008 [3]. In India pulses are grown in nearly 23.28 million hectare area with production status of nearly 14.66 million tonnes at an average productivity level of 630 kg ha^{-1} [4].

Agri-horti system markedly increases the return per unit of land mainly during early stage of horticultural fruit trees. Fruit tree based agroforestry involves intentional and simultaneous association of annual or perennial crops with perennial fruit-producing trees on the same land unit. In India, green gram occupies 3.7 million hectares and contributes to 1.57 million tonnes in pulse production. Custard apple (*Annona squamosa* L.) is distributed throughout the tropics and is pre eminently a desert fruit, normally eaten fresh. The vitamin C content is appreciable (35—42 mg/100 g) and slightly higher than in grape fruit. Nitrogen requirement of pulse crops is very low than other crops because nitrogen needed only for establishment of plant, after that plant fulfill their requirement through symbiotic nitrogen fixation.

It is a well established fact that phosphorus is one of the most important substances such as phosphate and protein. It also takes part in energy fixing and releasing process in plant. It also induces root proliferation and nodulation. It is essential that green gram should not suffer due to inadequate mineral nutrient especially phosphorus. Since chemical fertilizers are scarce and costly, it is necessary to use them economically in combination with phosphorus and PSB, as green gram shows high response to high phosphorus level and PSB.

Inoculation of seed with PSB culture may increase the production and productivity of mungbean crops as reported by Srivastava and Ahlawat [5]. The nutrient requirement of crop is met by the chemical fertilizers. However, fertilizer alone cannot sustain productivity of land in modern farming.

Keeping these facts into consideration the present investigation was conducted to study the effect of phosphorus and PSB levels on growth and yield of green gram under custard apple based agri-horti system.

Materials and Methods

A field experiment was conducted during *kharif* of 2011-12 at the Instructional Farm, of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur which is situated in Vindhyan region of district Mirzapur (25°10´ latitude, 82°37´ longitude and at an altitude of 427 meters above mean sea level) occupying over an area of more than 1000 ha where variety of crops like agricultural, horticultural, medicinal and aromatic plants are grown. Vindhyan soil comes under rainfed and invariably of poor fertility status. This region comes under agro-climatic zone III A (semi-arid eastern plain zone). The annual rainfall was 267.94 mm with maximum and minimum temperatures ranged between 39.65 °C and 8.12 °C, respectively during *kharif*, 2011. The total rainfall during the crop season was 1080 mm, maximum and minimum temperature fluctuated between 34.7°C and 16°C and relative humidity between 94 and 33%. The soil of the experimental field was sandy loam-silt in texture with low drainage i.e. having pH 6.5. It was moderately fertile, being low in available organic carbon (0.23%), available nitrogen (175.50 kg ha^{-1}), and medium in available phosphorus (11.25 kg ha^{-1}) and potassium (185.7 kg ha^{-1}). The experiment was laid out in Randomized Block Design with Agri-horti system (fruit based Agroforestry system) viz., custard apple based Agri-horti system. Treatments were replicated thrice. The experiment compared 13 treatments viz. uninoculation of seed (Control) each under, 20 kg P_2O_5, 30 kg P_2O_5, and 40 kg P_2O_5 single inoculation of PSB strain BHU JY–01 each under 20 kg P_2O_5, 30 kg P_2O_5 and 40 kg P_2O_5 and single inoculation of PSB strain BHU JY-13 each under 20 kg P_2O_5, 30 kg P_2O_5 and 40 kg P_2O_5 and dual inoculation of PSB BHU JY-01 and BHU JY-13 each other 20 kg P_2O_5, 30 kg P_2O_5 and 40 P_2O_5 ha^{-1} fertility levels. The requisite quantity of seed at the rate of 15 kg for green gram was sown. The seed were sown with help of *kudal* directly in rows 30 × 10 cm apart. The experiment was carried out with six years old custard apple trees planted at 5 × 5 meter. Total quantity of nitrogen, phos-

Table 1. Effects of phosphorus levels and PSB on number of Trifoliate leaves plant^{-1}, number of branches plant^{-1} and plant height of green gram. NS–Not significant.

Treatments	Number of pods plant^{-1}	Number of grains pod^{-1}	Pod length (cm)	1000-grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Net returns (Rs ha^{-1})	B:C
T_1 (Control)	7.73	6.93	5.14	23.28	711.89	2189.75	22.84	47506.96	2.21
T_2 (20 kg P_2O_5 ha^{-1})	8.07	8.80	5.43	24.42	772.17	2305.02	23.07	50170.16	2.24
T_3 (30 kg P_2O_5 ha^{-1})	9.20	9.00	6.24	25.60	799.81	2392.40	23.38	51409.20	2.26
T_4 (40 kg P_2O_5 ha^{-1})	10.00	9.20	6.50	27.23	826.66	2462.70	25.13	52579.03	2.27
T_5 (PSB (S_1)+(20 kg P_2O_5 ha^{-1})	9.40	9.00	6.30	26.25	823.08	2440.06	23.98	53158.10	2.38
T_6 (PSB (S_1)+(30 kg P_2O_5 ha^{-1})	10.20	9.33	6.59	27.60	846.87	2537.49	25.65	54200.32	2.38
T_7 (PSB (S_1)+(40 kg P_2O_5 ha^{-1})	10.80	10.00	6.75	28.31	918.14	2758.57	26.99	58038.99	2.50
T_8 (PSB (S_2)+(20 kg P_2O_5 ha^{-1})	9.60	9.00	6.37	26.99	839.11	2423.33	24.27	54014.73	2.41
T_9 (PSB (S_2)+(30 kg P_2O_5 ha^{-1})	10.40	9.60	6.61	27.87	858.71	2557.40	26.02	54881.03	2.41
T_{10} (PSB (S_2)+(40 kg P_2O_5 ha^{-1})	11.00	10.20	6.85	28.71	942.26	2786.32	27.38	59407.21	2.56
T_{11} (PSB (S_1)+(PSB (S_2)+20 kg P_2O_5 ha^{-1})	9.80	9.00	6.43	26.91	843.42	2481.38	24.80	54323.87	2.43
T_{12} (PSB (S_1)+(PSB (S_2)+30 kg P_2O_5 ha^{-1})	10.60	9.80	6.70	28.06	902.06	2713.36	26.51	57484.58	2.52
T_{13} (PSB (S_1)+(PSB (S_2)+40 kg P_2O_5 ha^{-1})	11.20	10.40	6.96	28.86	959.34	2860.87	27.81	60443.37	2.60
SEm±	0.42	0.33	0.52	1.91	31.37	48.48	0.31	47506.96	2.21
CD (p = 0.05)	1.23	0.95	1.52	NS	91.55	141.51	0.91	50170.16	2.24

phorus and single super phosphate as per treatments in the form of urea (46% N), diammonium phosfate (18% N and 46% P_2O_5) and single super phosfate (16% SSP) respectively were applied below the seeds at the time of sowing of crop. Seed was treated with PSB as per treatment. Different parameters were evaluated following the standard procedure.

Results and Discussion

Yield attributes and yield

The number of pods plant^{-1}, pod length, number of grains pod^{-1}, 1000-grain weight and harvest index significantly increased with the application of 40 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2). The seed inoculation of PSB (S_1) + PSB (S_2) with the application of 40 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) recorded the maximum grain yield which was at par with 40 kg P_2O_5 ha^{-1} + PSB (S_2), 40 kg P_2O_5 ha^{-1} + PSB (S_1) and 30 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) (Table 1). Enhanced vegetative growth in terms of dry matter production and branches plant^{-1} provided more sites for the translocation of photosynthesis and ultimately resulted in increased number of yield parameters.

This study was also done by other authors that the effects of P application at 20, 40 and 60 kg P_2O_5 ha^{-1} on the yield components of green gram cv K 851 showed positive effects of P application on pods plant^{-1}, grains pod^{-1} and test weight [6].

The yield parameters viz., number of pods plant^{-1}, grains pod^{-1}, pod length and test weight were significantly benefitted with the availability of nutri-

Table 2. Effects of phosphorus levels and PSB on nitrogen, phosphorus and potassium content (%) in grain and straw of green gram.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 (Control)	3.34	1.18	0.40	0.179	0.710	1.50
T_2 (20 kg P_2O_5 ha^{-1})	3.39	1.24	0.42	0.183	0.720	1.52
T_3 (30 kg P_2O_3 ha^{-1})	3.45	1.32	0.45	0.186	0.730	1.53
T_4 (40 kg P_2O_5 ha^{-1})	3.67	1.58	0.52	0.197	0.770	1.57
T_5 (PSB (S_1)+20 kg P_2O_3 ha^{-1})	3.53	1.41	0.47	0.187	0.740	1.54
T_6 (PSB (S_1)+30 kg P_2O_3 ha^{-1})	3.71	1.64	0.53	0.198	0.780	1.57
T_7 (PSB (S_1)+40 kg P_2O_5 ha^{-1})	3.79	1.80	0.56	0.205	0.800	1.59
T_8 (PSB (S_2)+20 kg P_2O_5 ha^{-1})	3.56	1.47	0.49	0.193	0.750	1.55
T_9 (PSB (S_2)+30 kg P_2O_5 ha^{-1})	3.74	1.70	0.54	0.200	0.790	1.58
T_{10} (PSB (S_2)+40 kg P_2O_5 ha^{-1})	3.83	1.84	0.57	0.207	0.810	1.60
T_{11} (PSB (S_1)+PSB (S_2)+20 kg P_2O_5 ha^{-1})	3.62	1.53	0.50	0.195	0.743	1.56
T_{12} (PSB (S_1)+PSB (S_2)+30 kg P_2O_5 ha^{-1})	3.76	1.77	0.55	0.202	0.790	1.59
T_{13} (PSB (S_1)+PSB (S_2)+40 kg P_2O_5 ha^{-1})	3.86	1.87	0.58	0.211	0.823	1.60
SEm±	0.04	0.03	0.01	0.004	0.009	0.02
CD (p = 0.05)	0.12	0.09	0.03	0.011	0.025	0.05

ents through PSB (S_1), PSB (S_2) and phosphorus levels during crop growing season, which ultimately contributed towards higher yield. The role of microorganisms in solubilizing inorganic phosphates in soil and making them available to plants is well known [7] they are called phosphate solubilizers (PSB) and they convert the insoluble phosphates into soluble forms by acidification, chelation, exchange reactions and production of gluconic acid [8]. Inoculation of PSB has resulted in improving growth, yield and phosphorus uptake in several crops [9].

Nutrient content and uptake

The nitrogen, phosphorus and potassium content in grain and straw and nitrogen, phosphorus and potassium by grain and straw increased progressively with increasing level of phosphorus up to 40 kg P_2O_5

Table 3. Effects of phosphorus levels and PSB on nitrogen, phosphorus and potassium uptake by grain and straw (kg ha^{-1}) of green gram.

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 (Control)	23.75	8.38	2.85	1.27	5.05	10.68
T_2 (20 kg P_2O_5 ha^{-1})	26.20	9.57	3.27	1.41	5.56	11.74
T_3 (30 kg P_2O_3 ha^{-1})	27.59	10.56	3.60	1.49	5.84	12.24
T_4 (40 kg P_2O_5 ha^{-1})	30.37	13.03	4.33	1.63	6.37	12.98
T_5 (PSB (S_1)+20 kg P_2O_3 ha^{-1})	29.03	11.58	3.84	1.54	6.09	12.68
T_6 (PSB (S_1)+30 kg P_2O_3 ha^{-1})	31.39	13.89	4.52	1.68	6.61	13.30
T_7 (PSB (S_1)+40 kg P_2O_5 ha^{-1})	34.77	16.56	5.17	1.89	7.35	14.63
T_8 (PSB (S_2)+20 kg P_2O_5 ha^{-1})	29.84	12.33	4.11	1.62	6.29	13.01
T_9 (PSB (S_2)+30 kg P_2O_5 ha^{-1})	32.14	14.57	4.64	1.72	6.78	13.57
T_{10} (PSB (S_2)+40 kg P_2O_5 ha^{-1})	36.09	17.31	5.37	1.95	7.63	15.08
T_{11} (PSB (S_1)+PSB (S_2)+20 kg P_2O_5 ha^{-1})	30.53	12.90	4.25	1.64	6.27	13.16
T_{12} (PSB (S_1)+PSB (S_2)+30 kg P_2O_5 ha^{-1})	33.89	16.00	4.96	1.82	7.13	14.34
T_{13} (PSB (S_1)+PSB (S_2)+40 kg P_2O_5 ha^{-1})	37.06	17.94	5.56	2.02	7.90	15.38
SEm±	1.54	0.54	0.22	0.13	0.44	0.78
CD (p = 0.05)	4.49	1.58	0.63	0.38	1.29	2.27

ha^{-1} + PSB (S_1) + PSB (S_2) (Tables 2 and 3). This might be due to more nitrogen fixation by the bacteria which in turn helped in better absorption and utilization of all the plant nutrients, thus resulting in more N and P contents in grain and straw. This beneficial influence might be due to better root establishment by nodulation, phosphorus fixation from the atmosphere. Phosphorus is second only to nitrogen as the most limiting element for plant growth. Phosphorus promotes nitrogen fixation in legume crops and is essential for photosynthesis, energy and sugar production [10].

Net returns and B:C Ratio

It is evident from the data that among different phosphorus levels and dual inoculation of seed with PSB the maximum net return and benefit: cost ratio was recorded with the application of 40 kg P_2O_5 ha^{-1} + PSB (S_1) + PSB (S_2) (60443 Rs ha^{-1}) and (2.60) (Table 1). Similar result was also found by other authors [11].

Conclusion

The dual inoculation of green gram variety Smrat intercropped in alleys of custard apple with Phosfate Solubilizing Bacteria (BHU JY-01 and BHU JY-13) along with 40 kg P_2O_5 ha^{-1} fertility level proved beneficial for boosting grain yield (959 kg ha^{-1}) and gave maximum net return (Rs 60,443 ha^{-1}) and benefit: cost ratio (2.60) and thus it could be recommended for profitable production under the *Vindhyan* region of Mirzapur.

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