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Effect of Phosphorus and Bio-organics on Yield, Nutrient Uptake and Quality of Summer Greengram

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Abstract

Field experiment was conducted during two consecutive summer seasons of 2018 and 2019 at Agronomy Research Area, JNKVV, College of Agriculture, Tikamgarh (Madhya Pradesh). The results revealed that increasing levels of phosphorus enhanced the yield attributes, yield, total nutrient uptake and quality of summer greengram. Significantly more number of pods plant^{-1} (41.7), number of seeds pod^{-1} (9.52), 1000-seed weight (39.9 g), seed yield (1140 kg ha^{-1}), straw yield (2005 kg ha^{-1}), total nitrogen uptake (84.9 kg ha^{-1}), total phosphorous uptake (8.70 kg ha^{-1}), total potassium uptake (20.2 kg ha^{-1}) and protein content (26.7%) were recorded with the application of 60 kg P_2O_5 ha^{-1} over rest of the treatments. Application of phosphorous @ 60 kg P_2O_5 ha^{-1} resulted into an increase of seed yield over control, 20 and 40 kg P_2O_5 ha^{-1} by 144.1, 91.3 and 47.3 per cent, respectively. Application of vermicompost @ 2 t ha^{-1}+VAM significantly recorded the maximum number of pods plant^{-1} (37.9), number of seeds pod^{-1} (8.52), 1000-seed weight (36.3 g), seed yield (852 kg ha^{-1}), straw yield (1613 kg ha^{-1}), total nitrogen uptake (64.0 kg ha^{-1}), total phosphorous uptake (7.82 kg ha^{-1}), total potassium uptake (18.3 kg ha^{-1}) and protein content (26.1%) over other bio-organic treatments and increased the seed yield by 40.6, 19.0, 11.4 and 17.7 per cent over B_0 (control), B_1 (PSB) , B_2 (VAM) and B_3 (vermicompost), respectively.

Key words: *phosphorus, PSB, summer greengram, VAM, vermicompost*

Introduction

Greengram (*Vigna radiata* L. Wilczek), also known as mungbean is primarily a rainy season crop but with the development of early maturing varieties, it has also proved an ideal crop of spring and summer seasons. Phosphorus deficiency is the most important single factor, which is responsible for poor yield of greengram on all types of soil. It has beneficial effects on nodule stimulation, root development, growth and also hastens maturity as well as improves quality of crop produce. Thus, the use of phosphorus to legumes is more important than that of nitrogen as later is being fixed by symbiosis with *Rhizobium* bacteria. Use of bio-organics can also have a greater importance in increasing fertilizer use efficiency. Indian soils are poor to medium status in available nitrogen and available phosphorus. The seed of pulses is inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the microbial fixation of nitrogen for the plant growth. The inoculation of seeds with suitable PSB culture increased the green pod yield over uninoculated control. The association of PSB and pulse plants helps in improving fertility of soil and is a cost effective method of phosphate fertilization in legumes[10]. Symbiosis between plant roots and certain soil fungi *e.g.*, vesicular arbuscular mycorrhiza (VAM) plays an important role in phosphorus cycling and its uptake by plants[12]. Vermicompost is also valuable and suitable cost-effective organic manure which have a special place as a best alternative in the sustainable agriculture and organic cultivation[9]. Keeping in view the above facts, the present study was carried out during two consecutive summer seasons of 2018 and 2019 to assess the effect of phosphorus levels and different bio-organics on yield, total nutrient uptake and quality of summer greengram in Tikamgarh district under Bundelkhand region of Madhya Pradesh.

Materials and Methods

Field experiment was conducted at Agronomy Research Area, JNKVV, College of Agriculture, Tikamgarh (24° 43'N latitude, 78° 49' E longitude at an altitude of 358 m above mean sea level), Madhya Pradesh (India) during two consecutive *summer* seasons of 2018 and 2019. The soil of experimental field was medium to deep black and clayey loam in texture having pH 7.1, EC 0.12 dS m^{-1}, organic carbon 0.5%, available N 266 kg ha^{-1}, available P_2O_5 26 kg ha^{-1} and available K_2O 255 kg ha^{-1}, respectively. The experiment was conducted in factorial randomized block design (FRBD) with three replications and comprised of four phosphorus levels (P_0: Control, P_1: 20kg ha^{-1}, P_2: 40 kg ha^{-1} and P_3: 60 kg ha^{-1}) and five bio-organics (B_0: Control, B_1: Phosphorus soluble bacteria (PSB) @ 5 g per kg seed, B_2: Vascular arbuscular mycorrhiza (VAM) @ 10 kg ha^{-1} B_3: Vermicompost @ 2 t ha^{-1} and B_4: Vermicompost @ 2 t ha^{-1} + VAM. The greengram variety TMB-37 was sown in lines 30 cm apart using a seed rate of 20 kg ha^{-1}. The full recommended doses of nitrogen (20 kg N ha^{-1}), potassium (20 kg K_2O ha^{-1}) and phosphorus (as per treatments) were applied as basal. These nutrients were applied through urea (46% N), SSP (16% P_2O_5) and MOP (60% K_2O). Bio-organics were applied as per treatments as basal. The crop was irrigated at different stages according to need. All other agronomic and plant protection measures were applied as per recommendations. Yield attributes and yields recorded were number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}). The seed and straw samples were analysed for the nitrogen content by Micro Kzeldahl method. Phosphorous and potassium in digest ($HClO_4$:HNO_3, 9:4) were determined by adopting standard methods. The nutrients uptake by seed and straw were calculated by multiplying nutrient content with seed and straw yield. Total nutrient uptake in seed and straw was obtained by summarized the nutrient uptake in seed and straw. Protein content in seed was calculated by multiplying N concentration in grain by the factor of 6.25. The results of both the years were more or less similar and hence two years data were pooled and analyzed statistically to draw suitable inference as per standard ANOVA technique.

Results and Discussion

Effect of phosphorous and bio-organics on yield attributes and yield

The yield attributing characters namely number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-seed weight were significantly influenced by different levels of phosphorus (Table 1). Application of 60 kg P_2O_5 ha^{-1} registered significantly the maximum number of pods $plant^{-1}$ (41.7), number of seeds pod^{-1} (9.52), 1000-seed weight (39.9 g), Seed yield (1140 kg ha^{-1}) and straw yield (2005 kg ha^{-1}) followed by application of phosphorous @ 40 and 20 kg P_2O_5 ha^{-1}, whereas the lowest values for all these yield attributes (29.1, 6.98, 31.4g, 467 kg ha^{-1} and 1260 kg ha^{-1}, respectively) were reported under control. Application of phosphorous @ 60 kg P_2O_5 ha^{-1} resulted into an increase of seed yield over control, 20 and 40 kg P_2O_5 ha^{-1} by 144.1, 91.3 and 47.3 per cent, respectively. The enhanced yield attributes and yield could be due to adequate supply of phosphorus during early stage of growth which resulted into improved vegetative growth, thereby increasing the sink in terms of flowering and grain setting. Better development of the plants in term of plant height, number of branches and dry biomass production leading to increased bearing capacity of greengram. The higher seed yield with phosphorus @ 60 kg P_2O_5 ha^{-1} might be due to strong sink components *viz.*, more number of pods $plant^{-1}$ and more number of seeds pod^{-1} as well as test weight in comparison to control and other phosphorus levels. Similar findings were also reported by other workers[3,5,11]. The lowest value of yield attributes and seed yield (kg ha^{-1}) with control might be due to poor vegetative growth which reflected into reduced sink components *i.e.*, yield attributes resulting in poor seed yield.

Table 1: Effect of different phosphorus levels and bio-organics on yield attributes and yield of summer greengram (Pooled over two years)

Treatments	Number of pods ($plant^{-1}$)	Number of seeds (pod^{-1})	1000-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Phosphorus levels (P_2O_5 kg ha^{-1})					
P_0: Control	29.1	6.98	31.4	467	1260
P_1: 20	32.0	7.67	32.2	596	1385
P_2: 40	35.6	8.47	35.6	774	1529
P_3: 60	41.7	9.52	39.9	1140	2005
S.Em±	1.06	0.14	0.55	22.4	26.3
CD (P=0.05)	**3.18**	**0.41**	**1.65**	**67.3**	**79.0**
Bio-organics					
B_0: Control	31.7	7.6	32.4	606	1440
B_1: PSB	34.0	8.14	34.7	716	1545
B_2: VAM	34.8	8.32	35.5	765	1574
B_3: Vermicompost @ 2 t ha^{-1}	34.7	8.23	35.1	724	1552
B_4: Vermicompost @ 2 t ha^{-1} + VA M	37.9	8.52	36.3	852	1613
S.Em±	1.18	0.15	0.61	25.0	29.4
CD (P=0.05)	**3.54**	**0.46**	**1.84**	**75.2**	**88.3**

The perusal of data in Table 2 also indicates that application of bio-organics significantly increased the yield attributes and yield of greengram. Application of vermicompost @ 2 t ha^{-1} + VAM resulted into significantly the maximum number of pods $plant^{-1}$ (37.9), number of seeds pod^{-1} (8.52), 1000-seed weight (36.3 g), Seed yield (852 kg ha^{-1}) and straw yield (1613 kg ha^{-1}) followed by B_2 (34.8, 8.32, 35.5g, 765 kg ha^{-1} and 1574 kg ha^{-1}), B_3 (34.7, 8.23, 35.1g, 724 kg ha^{-1} and 1552 kg ha^{-1}), B_1 (34.0, 8.14, 34.7g, 716 kg ha^{-1} and 1545 kg ha^{-1}), whereas the lowest values for all these parameters (31.7, 7.60, 32.4g, 606 kg ha^{-1} and 1440 kg ha^{-1}, respectively) were observed under control. Application of vermicompost @ 2 t ha^{-1} + VAM increased the seed yield by 40.6, 19.0, 11.4 and 17.7 per cent over B_0, B_1, B_2 and B_3, respectively. The higher yield attributes and yield was due to improved vegetative growth which provided more sites for the translocation of photosynthates and ultimately resulted into significant enhancement in yield attributes and yield. Apart from this the application of vermicompost @ 2 t ha^{-1} + VAM created improved nutritional environment in rhizosphere as well as utilization in plant system leading to enhanced translocation to reproductive structures *viz*., pods, grains and other plant parts. Results of the present study are also supported by other researchers [2,4,9].

Effect of phosphorous and bio-organics on total nutrient uptake and protein

Results (Table 2) indicated that application of phosphorous @ 60 kg P_2O_5 ha^{-1} significantly increased the total uptake of N (84.9 kg ha^{-1}), P (8.70 kg ha^{-1}), K (20.2 kg ha^{-1}) and protein content (26.7%) over rest of the phosphorous treatments. However, it was at par with application of phosphorous @ 40 kg P_2O_5 ha^{-1} (84.9 kg ha^{-1} total N uptake, 8.70 kg ha^{-1} total P uptake, 20.2 kg ha^{-1} total K uptake and 25.4% protein content). Higher dose of phosphorus improved the nutritional environment in rhizosphere as well as in plant system leading to greater uptake and translocation of nutrients especially of N and P in reproductive structures which led to higher concentration and uptake. Uptake of nutrients is the function of their concentration in plant and grain and straw yields, the higher concentration of these nutrients coupled with significantly higher grain and straw yield improved the total uptake of N, P and K. Protein concentration is essentially the manifestation of N concentration in grain. Hence, increased N concentration might have also enhanced the protein content. These results corroborate the findings of other workers in greengram[1,6,12].

Table 2: Effect of different phosphorus levels and bio-organics on total nutrient uptake and protein content of summer greengram (Pooled over two years)

Treatments	Total nutrient uptake (kg ha^{-1}) in seed and straw			Protein content (%)
	Nitrogen	Phosphorous	Potassium	
Phosphorus levels (P_2O_5 kg ha^{-1})				
P_0: Control	30.9	5.03	13.3	23.2
P_1: 20	40.9	5.33	14.2	24.9
P_2: 40	58.1	6.90	16.7	25.4
P_3: 60	84.9	8.70	20.2	26.7
S.Em±	2.08	0.23	0.33	0.34
CD (P=0.05)	**6.23**	**0.69**	**0.99**	**1.03**
Bio-organics				
B_0: Control	41.7	5.55	14.6	22.7
B_1: PSB	51.4	5.71	15.0	23.7
B_2: VAM	57.4	6.91	16.2	24.6
B_3: Vermicompost @ 2 t ha^{-1}	53.1	6.30	15.4	24.5
B_4: Vermicompost @ 2 t ha^{-1} + VA M	64.0	7.82	18.3	26.1
S.Em±	1.34	0.17	0.29	0.35
CD (P=0.05)	**4.04**	**0.51**	**0.87**	**1.05**

The perusal of data in Table 2 also indicates that application of vermicompost @ 2 t ha^{-1} + VAM recorded the significantly higher total nutrient uptake N (64.0 kg ha^{-1}), P (7.82 kg ha^{-1}), K (18.3 kg ha^{-1}) and protein content (26.1%) followed by B_2 (VAM), B_3 (vermicompost), B_1 (PSB) and B_0 (control). The increased total uptake of nutrients with application of vermicompost @ 2 t ha^{-1} + VAM can be ascribed to the increased availability of N, P and K to the plants. This might also be due to the improved nutritional environment in rhizosphere as well as utilization in the plant system leading to enhanced translocation to reproductive structures *viz*., pods, grains and other plant parts. The N, P and K might have been utilized in greater quantities due to their abundant availability. Another reason for higher nitrogen concentration might be due to increased activity of nitrate reductase in synthesis of protein in grains because it is a primary component of amino acids which are the building blocks of protein molecules. Findings of other workers in greengram also support to the present investigation[9,12]. Similarly, VAM increased the uptake of nutrients through reduction of the distance that nutrient must diffuse to plant roots by accelerating the rate of nutrient absorbing surface and finally by chemically modifying the availability of nutrient for uptake by plant through mycorrhizal hyphae. Since, protein concentration of grain is essentially a manifestation of N concentration. Increased N concentration, due to grain inoculation with VAM and vermicompost resulted in higher protein concentration because of their beneficial role in enhancing N concentration in grain. Similar findings were also reported by other workers[8,9].

Conclusion

In conclusion, application of 60 kg P_2O_5 ha^{-1}exhibited superiority over other levels of phosphorous in terms of yield, nutrient uptake and quality. Similarly, combined application of vermicompost @ 2 t ha^{-1} + VAM also increased the seed yield, nutrient uptake and quality over alone application of PSB, VAM and vermicompost, respectively.

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