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RESEARCH PAPER

Effect of phosphorus and PSB on growth, nodulation and fertility status in different mungbean (*Vigna radiata* L.) varieties and its residual effect on fodder yield of sorghum in indo-gangetic plain zone of India

S.N. Dubey*, Rajpal Singh, Rohit Kumar **and** Sauhard Dubey
Department of Agronomy, A.S. (P.G.) College, Lakhaoti, BULANDSHAHR (U.P.) INDIA
(Email : 9411052527S@gmail.com)

Abstract : A field experiment was conducted during sammer and *Kharif* season of 2010 and 2011 at research farm of A. S, (PG) College, Lakhaoti, Bulandsahar, U.P. to Studies on phosphorus and PSB management in different varieties of summer mungbean and its effect on succeeding fodder sorghum. The Experiment was laid out in a Factorial Randomized Block Design (FRBD) keeping three-treatments of bold seeded green gram varieties (Pant-moong-5, Pusa Vishal, Pusa 9531) of in main plots and six treatments of phosphorus and biofertilizers in sub-plots. Results revealed that the different varieties of mungbean to phosphorus upto 50 kg P_2O_5 ha^{-1} and inoculation of seed with PSB (25 kg ha^{-1}) increased the plant height (49.13 and 51.15 cm), number of nodules plant^{-1} (17.35 and 16.50) and availability of nutrient N (361and 364 kg ha^{-1}), P (13.23 and 13.36 kg ha^{-1}) except K and green fodder yield (546 q ha^{-1} at harvest time) of succeeding fodder sorghum crop .

Key Words : Availability, Biofertilizers, Mungbean, Phosphorus, Sorghum, Yield

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INTRODUCTION

Pulses grown more than 100 countries covering an area of more than 65 million hectare with the more than 47 mt annual production. However, the per capita consumption of pulses was 43.3 g day^{-1} and 47.2 g day^{-1} in the year 2013 and 2014, respectively (Prasad *et al.*, 2014). Total pulse production in India during 2011-12 is estimated to be (5.6 % less than last year) 17.21 mt from the area of 24.78 mha with the average productivity 694 kg ha^{-1} (Directorete of Economics and Statistics and Ministry of Agriculture and Farmers Welfare).

Mungbean (*Vigna radiata* L.) is one of the most ancient and extensively grown leguminous crops of India. Mungbean stands third after chickpea and pigeonpea

*** Author for correspondence:**

among pulses (Singh *et al.*, 1994). It is a short duration pulse crop which can be grown as catch crop during *Kharif* and *Rabi* seasons. It is primarily a rainy season crop but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer seasons. The important mungbean growing states are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar. It can be grown under wide range of soil and climatic conditions. In India it occupies 3.43 mha of mungbean with a production of 1.78 mt and productivity 499 kg ha^{-1} (Directorate of Economics and Statistics). Mungbean is an excellent source of protein (25%) with high lysine content (460 mg g^{-1}) and tryptophan (60 mg g^{-1}). It also has remarkable quantity of ascorbic acid when sprouted and also bears riboflavin (0.21 mg $100g^{-1}$) and minerals (3.84 g $100g^{-1}$). Phosphorus is a major plant nutrient for mungbean next to nitrogen and required for various metabolic processes such as cell division, development, energy transport, signal transduction, macromolecular biosynthesis, photosynthesis and respiration. At present 5 per cent of the Indian soils have adequate available phosphorus. Fertility status of Indian soils as compiled from the soil testing laboratories database are: 42 per cent are under low category, 38 per cent under medium and 20 per cent under high category. The US Geological Survey, in 2006 estimated world Phosphatic Rock reserves are at about 18000 mt, whereas phosphorus resources are at about 50,000 mt. Thus, with this current level of phosphorus reserves, resources could last for 105 to 470 years and we have to utilize this resources effectively. Only 25 per cent to 30 per cent of the applied phosphorus is available to crops and remaining phosphorus is converted into insoluble phosphorus (Sathyamoorthi *et al.*, 2008). Its deficiency is the most important single factor, which is responsible for poor yield of mungbean on all types of soil. It is indispensable constituent of nucleic acids, ADP and ATP. It has beneficial effects on nodule stimulation, root development and growth and also hastens maturity as well as improves quality of crop produce. Thus, the response of phosphorus to legumes is more important than nitrogen as later is being fixed by symbiosis with Rhizobium bacteria. Biofertilizers are considered to be cost effective, eco-friendly and renewable source of non-bulky, low cost plant nutrient supplementing fertilizers in sustainable agriculture system in India. Therefore, the role of biofertilizers assumes a special significance in present context of very high costs of chemical fertilizers. The seed of pulses are inoculated with phosphorus solublizers with an objective of increasing their number in the rhizosphere and substantial increase in the phosphorus availability for the plant growth. Phosphorus solubilizing microorganisms (bacteria) enable phosphorus to become available for plant uptake after solubilization. Several soil bacteria to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphates. Some of the hydroxyl acids may chelate with calcium and iron resulting in effective solubilisation and utilization of phosphates. The study of phosphorus to legume is more important than the nitrogen because later is fixed by symbiosis with Rhizobium bacteria. Declining productivity of mungbean is mainly due to the cultivation in degraded or less fertile soil with less adoption of suitable management technology while, with availability of high yielding short duration cultivars and the suitability of growing them round the year, give a vast opportunity to fulfill the protein requirement by increasing productivity (Sharma and Khurana, 1997). To exploit the full genetic potential of improved mungbean variety is may be possible through development of best management practices and improved crop management techniques. In addition to all appropriate cultivation practices application of balanced amount or optimum dose of nutrients, particularly phosphorus can become important element apart from NPK in all the mungbean cultivation The combination of phosphorus and PSB are promotes soil fertility by increasing the nutrient availability and nutrient absorption, especially in reference to phosphorus a nutrient that is found in low levels in tropical soils (Tamang *et al.*, 2015). Increasing the number of such microorganisms and accelerate microbial process to augment to extent of the availability of the nutrient in a form, which can easily assimilated by plant. However, techniques involving optimization of fertilizer inputs (Phosphorus dose) with aim to enhance the productivity and economics of cultivating mungbean (Rajesh *et al.*, 2000). Phosphorus is essential that mungbean should not suffer due to inadequate mineral nutrient especially nitrogen and phosphorus. Since chemical fertilizers are scarce and costly, it is necessary to use them economically in combination with bio fertilizers, as mungbean shows high response to bio fertilizers. Keeping these facts into consideration the present investigation entitled Effect of phosphorus and PSB on plant growth attributes, yield, nutrient uptake and economics of mungbean and its residual effect on fodder sorghum during summer and *Kharif* season.

MATERIAL AND METHODS

The field experiment was conducted during two consecutive years of 2010 and 2011 during the sammer and *Kharif* season at Research Farm of A. S. (P.G.) College, Lakhaoti (Bulandshahr), Uttar Pradesh. The latitude and longitude of the experimental site are 28.4° N and 77.1°E, respectively with an elevation of about 207 m above mean sea level, it has semi-arid and subtropical climat characterized by extreme hot summer and cool winter. The soil of the experimental site was sandy loam with pH (8.10) and EC (0.36 dSm^{-1}) of soil water suspension, low in organic carbon 3.9 g kg^{-1} and the status of soil low in available nitrogen, available phosphorus and potassium was medium. The experiment was designed in Factorial Randomized Block Design keeping three-treatments of bold seeded mungbean varieties (Pusa. Vishal. Pant mung -5 and Pusa 9531) in main plots and six treatments (T_1-0 kg P_2O_5 ha^{-1}, T_2 - 0 kg P_2O_5 ha^{-1} + 25 kg PSB ha^{-1}, T_3-25 kg P_2O_5 ha^{-1}, T_4-25 kg P_2O_5 ha^{-1} + 25 kg PSB ha^{-1}, T_5-50 kg P_2O_5 ha^{-1} and T_6-50 kg P_2O_5 ha^{-1} + 25 kg PSB ha^{-1}) of phosphorus and bio-fertilizers in sub-plots with four replications. Land was ploughed and cross ploughed, weeds and stubbles were removed sincerely. All variety of mungbean sown @15 kg seeds ha^{-1} with a spacing of 30 x 20 cm. The total numbers of treatments were 18 and number of plots was 72 with gross plot size was 12 m (5m x 2.4 m). The phosphorus was supplied through single super phosphate (16%) and PSB was inoculated @ 25 g kg^{-1} of seed and 2 hr shade dried before sowing. N and K fertilizer was applied as recommended at 20 kg N (starter dose) from urea and 30 kg K from MOP ha^{-1}, respectively after preparing land. Plant height (at harvest) and number of nodules $plant^{-1}$ and green fodder yield (at 30 DAS and at harvest) of sorghum were measured from five sampled plants for understanding growth and quality of mungbean and sorghum with different phosphorus level and mungbean varieties. The dried 100 g powdered of plant and soil samples were first digested with nitric acid (HNO_3) and perchloric acid ($HClO_4$) for the determination of nitrogen, phosphorus and potassium content through Micro-Kjeldahl method. Phosphorus was determined by spectrophotometer, while potassium was determined by flame photometer (Khalil and Mannan, 1990). In the present investigation, the green fodder yield of sorghum was obtained separately just after harvesting from the net plot after air drying and finally converted into q ha^{-1}. All the recommended cultural and plant protection measures were followed throughout the experimentation.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Plant height (cm):

All the stages of crop grown variety Pusa Vishal produced significantly taller plants (49.13 and 51.15 cm) with the application of 50 kg P_2O_5 through single super phosphate (SSP) along with 25 kg PSB ha^{-1} as compared to remaining does of phosphorus, PSB and remaining

Table 1: Effect of different varieties, phosphorus and PSB on plant height and number of nodules/plant of mung bean during 2010-2011

Treatments	Plant height (cm) at harvest						Number of nodules/ plant					
	Pusa Vishal		Pant M-5		Pusa 9531		Pusa Vishal		Pant M-5		Pusa 9531	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1-0 kg P_2O_5/ ha	29.43	30.18	27.90	28.45	26.85	28.05	9.40	9.35	9.20	8.58	8.89	8.35
T_2-0 kg P_2O_5/ ha+25 kg PSB/ha	34.18	34.06	32.68	32.70	32.15	32.50	10.13	10.53	9.78	9.23	9.50	9.15
T_3-25 kg P_2O_5/ ha	36.23	37.40	36.38	37.63	33.93	35.80	12.03	11.75	12.35	11.58	11.75	11.57
T_4-25 kg P_2O_5/ ha+25kg PSB/ha	44.23	44.63	42.80	43.73	42.33	42.25	14.50	14.89	14.58	14.35	14.50	14.20
T_5-50 kg P_2O_5/ ha	41.95	43.55	41.08	41.38	40.43	40.58	13.13	13.60	13.15	12.73	12.64	12.41
T_6-50 kg P_2O_5/ ha+25 kg PSB/ha	49.13	51.15	49.25	49.72	47.36	48.78	17.35	16.50	17.06	16.58	16.50	16.37
C.D. between varietyes (P=0.05)	0.19	0.21	NS	NS	NS	NS	0.04	0.05	NS	NS	NS	NS
C.D. between fertilizer (P=0.05)	0.37	0.41	NS	NS	NS	NS	0.08	0.10	NS	NS	NS	NS

NS= Non-significant

varieties at all stages of crop growth during both the seasons (Table 1). The marginally differences plant height observe between application of 50 kg P_2O_5 + 25 kg PSB and 25 kg P_2O_5 along with 25 kg PSB ha^{-1} both the year during crop growth period. These results are in agreement with the findings of Bhatt *et al*. (2013) and Pir *et al*. (2009).

Number of nodules plant^{-1}:

Number of nodules plant^{-1} increased significantly in Pusa Vishal with advancement of stage 30 DAS, 60 DAS and at harvest as to compared to remaining varieties (Pant M-5 and Pusa 9531). The highest (17.35 and 16.50) numbers of nodules plant^{-1} produced with the application of 50 kg P_2O_5 along with 25 kg PSB ha^{-1} in all the three varieties (Pusa Vishal, Pant Moong-5 and Pusa 9531). On both the years of observation (Table 1) it could be gathered that with successive increment in the dose of phosphorus, there has been a significant positive addition in the number of nodules plant^{-1}. Application of phosphate to solubilizing bacteria proved to be effective in developing significantly higher number of nodules plant^{-1}. The application of 25 kg PSB ha^{-1}. Produced higher number of 10.13 and 10.53 nodules plant^{-1} against 9.40 and 9.35 nodules plant^{-1} not getting PSB in both the years 2010 and 2011. Phosphorus is an indispensable, constituent of nucleic acid, ADP and ATP. It has beneficial effects on nodulation, root development, growth

Table 2: Residual effect of different varieties of mung bean and combination of phosphorus and PSB on fodder yield (q/ha) of succeeding sorghum crop during 2010-2011

Treatments	Fodder yield (q/ha)											
	Green fodder at 30 DAS						Green fodder at harvest					
	Pusa Vishal		Pant M-5		Pusa 9531		Pusa Vishal		Pant M-5		Pusa 9531	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1-0 kg P_2O_5/ ha	251	252	245	245	261	263	463	464	456	457	450	451
T_2-0 kg P_2O_5/ ha+25 kg PSB/ha	258	259	252	253	246	247	480	483	474	475	467	468
T_3-25 kg P_2O_5/ ha	264	266	259	260	254	256	490	492	485	486	477	479
T_4-25 kg P_2O_5/ ha+25kg PSB/ha	279	281	274	274	268	269	521	523	516	518	508	511
T_5-50 kg P_2O_5/ ha	272	273	267	268	260	261	512	514	502	503	496	498
T_6-50 kg P_2O_5/ ha+25 kg PSB/ha	334	335	325	326	322	323	546	547	536	538	528	530
C.D. between varietyes (P=0.05)	1.43	0.20	NS	NS	NS	NS	2.45	2.49	NS	NS	NS	NS
C.D. between fertilizer (P=0.05)	2.86	0.39	NS	NS	NS	NS	4.88	4.96	NS	NS	NS	NS

NS= Non-significant

Table 3: Avaliability of nutrient after harvest of different varieties of mung bean as influenced by combination of phosphorus and PSB during 2010-2011

Treatments	Uptake (kg/ha)																	
	Nitrogen						Phosphorus						Potassium					
	Pusa Vishal		Pant M-5		Pusa 9531		Pusa Vishal		Pant M-5		Pusa 9531		Pusa Vishal		Pant M-5		Pusa 9531	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1-0 kg P_2O_5/ ha	335	336	332	331	328	326	8.44	8.40	8.22	8.18	8.10	8.00	136	135	134	133	132	131
T_2-0 kg P_2O_5/ ha+25 kg PSB/ha	338	339	336	334	332	330	9.88	9.91	8.98	8.81	8.68	8.74	134	132	132	130	129	129
T_3-25 kg P_2O_5/ ha	342	344	338	339	334	335	9.78	9.80	8.67	7.71	8.25	8.28	131	131	128	127	126	125
T_4-25 kg P_2O_5/ ha+25kg PSB/ha	351	352	337	349	343	344	12.26	12.30	12.12	12.16	11.85	11.88	128	128	126	125	125	124
T_5-50 kg P_2O_5/ ha	348	347	343	344	338	339	11.56	11.52	10.78	10.73	10.41	10.44	125	124	123	122	121	121
T_6-50 kg P_2O_5/ ha+25 kg PSB/ha	361	364	358	359	354	355	13.23	13.36	13.00	13.21	12.12	12.18	121	120	119	119	118	118
C.D. between varietyes (P=0.05)	1.49	1.46	NS	NS	NS	NS	0.12	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.D. between fertilizer (P=0.05)	2.98	2.92	NS	NS	NS	NS	0.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

and also hastens maturity as well as improves quality of crop produce (Choudhary *et al.*, 2015). Such increase in nodulation, root and growth might be due to increase in number of nodules which might have supplied sufficient nitrogen by nitrogen fixation and finally enhance productivity of green gram Similar results are in confirmation with the finding of Prasad *et al.* (2014).

Availability of nutrient (NPK)/ furtility status after harvest of mungbean :

The available nitrogen in soils after harvest of the mungbean crop influenced by varieties (Pusa Vishal, Pant M-5 and Pusa 9531), phosphorus and PSB levels (Table 2).The highest nitrogen (361 and 364 kg ha^{-1}) and phosphorus (13.23 and 13.36 kg ha^{-1}) availability was recorded in plot (Pusa Vishal varietiy and application of 50 kg P_2O_5 + 25 kg PSB ha^{-1}) as compared to remaining treatments. The available nitrogen and phosphorus content in soil caused significantly marked variation among all the treatments at harvest of the crop. PSB inoculated plot significantly increased available nitrogen and phosphorus content in soils as compared to control plots except potassium during both the years 2010 and 2011. Application of phosphorus and PSB increased total biomass (seed and straw) in mungbean by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency. Phosphorus application favourably responded to buildup N, P and K status of the soil after harvest of greengram). Increasing trend for buildup of N, P and K status was noted with increase in level of phosphorus. Phosphorus application increased root nodulation which might have promoted microbial activity and thereby higher mineralization. Further, the release of organic acids and hormones due to phosphor bacterial activity might have helped in availability of nutrients These findings are found relevant to Bhatt *et al.* (2013).

Green fodder yield of succedding sorghum crop :

Phosphorus leve land varietal performance of moong bean continued to dominate in sorghum also the green fodder yield of sorghum was significantly higher (334, 335 and 546, 547 q ha^{-1} at 30 DAS and at harvest) with the application of 50 kg P_2O_5 along with 25 kg ha^{-1} in Pusa Vishal plot than remaining treatments (Table 3). The plot getting PSB in moong bean had residual effect on fodder sorghum, which gave significantly higher fodder yield than that plot which was not which was not applied in moong bean. The significantly highest green fodder yield (at 30 DAS and at harvest) of sorghum was recorded in Puas Vishal variety could be attributed to higher plant height at harvest, higher yield ha^{-1}, nutrient uptake as compared to Pant 5 and Pusa 9531 plot. Residual effect of preceeding crop (Puas Vishal variety) content higher N,P and K this might due to better growth of mungbean and enhanced the availability of N,P and K in soil for succedding sorghum crop during both the years 2010 and 2011, The similar findings were also reported by Rajesh *et al.* (2000) and Gupta and Sharma (2006).

Conclusion:

The results obtained from the present research work indicated that Puas Vishal variety treated with 50 kg P_2O_5 along with 25 kg ha^{-1} produced significantly maximum plant height (cm), nodules plant^{-1}, improve the fertility status (availability of NPK) after harvest of mungbean and therefore, it is recommended that Puas Vishal variety should be sown under indo-gangetic plain zone of India the with the application of phosphorus for growth, nodulation and better green fodder yield of succedding sorghum crop due to proper availability of N,P and K in soil after harvesting of preceeding mungbean crop in comparison to other treatments.

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