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Effect of Phosphorus, Sulfur and PSB on Blackgram (*Phaseolus mungo*) and its Residual Effect on Mustard (*Brassica juncea*) and Soil Properties

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Abstract

Results were recorded in the field experiment conducted during 2004—2006 on sandy loam soil. Blackgram (*Phaseolus mungo*) receiving 60 kg P_2O_5/ ha produced taller plants, more number of nodules per plant and biological yield (grain + straw) than 30 kg P_2O_5/ha and no phosphorus. Moreover, inoculation of blackgram with PSB produced taller plants, more number of nodules per plant and maximum yield of blackgram as compared to without inoculation. Similarly, plant height (cm) and number of nodules per plant and yield (grain + straw) of blackgram showed significant response to 40 kg S/ha as compared to 30 kg S/ha and no sulfur. In mustard (*Brassica juncea*) grown after blackgram, the maximum values of sulfur and phosphorus uptake and available phosphorus in soil after harvest of mustard were recorded with 60 kg P_2O_5/ha, 40 kg S/ha and inoculation with PSB applied to blackgram crop.
Key words : Blackgram, Mustard, Phosphorus, Sulfur, Phosphorus solubilizing bacteria (PSB), Residual effect.

The importance of pulses and oilseeds in agricultural economy of India is well recognized and there is an urgent need to raise their production in view of meeting an acute shortage of pulses and edible oils in India. Legumes respond to phosphorus and sulfur application. Application of phosphorus to pulse crops has been found to be effective and so called the master key element for increasing yield of pulse crops. Crop removal of sulfur is more in pulses and oilseeds (Manickam 1985). Phosphorus and sulfur utilized by the crop to which they are added are partially available to the subsequent crop and residual effect, thus become an important dimension in this management. An experiment was therefore conducted to study the effect of phosphorus, sulfur and PSB on blackgram and its residual effect on nutrient uptake in mustard and on soil properties.

Methods

Location and Soil

A field experiment was conducted during 2004—2006 at Soil Science Research Farm of Allahabad Agricultural Institute—Deemed University, Allahabad for two consecutive years. Representative soil samples (0—15 cm depth) were collected from experimental plots at the start of the experiment. The samples were air dried, powdered, passed through a 2 mm nylon sieve and analyzed for pH (in 1:2.5 soil-water suspension) (Jackson 1973), organic carbon (C) (Walkley and Black 1934), clay (international pipette method), available N (Subbiah and Asija 1956), available P (Watanabe and Olsen 1965), available K (1 M NH_4 OAc), available S (Palaskar et al. 1981).Statistical analysis was done using SPSS (version 10.0; spss Inc. 1996). The important soil properties of the experimental field were sand 60%, silt 26% and clay 14%, pH_w 7.8, OC 0.31—0.32%, available N 210—215 kg/ha, available P 23.00—23.80 kg/ha, available S 13.10—14.00 kg/ha and available K 230.50—231.30 kg/ha.

Treatments

The experiment was laid out in 3×3×2 factorial randomized block design. The treatment combinations were replicated thrice on a randomized block design.

Table 1. Effect of phosphorus, sulfur and PSB on height, number of nodules and grain and straw yield of black gram.

Treatment	Plant height (cm)			No. of nodules/ plant			Grain yield (q/ha)			Straw yield (q/ha)		
	2004	2005	Pooled	2004	2005	Pooled	2004	2005	Pooled	2004	2005	Pooled
P_2O_5 (kg/ha)												
0	31.20	31.34	31.27	11.57	11.83	11.70	6.71	6.74	6.72	25.63	25.67	25.65
30	42.07	42.31	42.19	21.17	21.70	21.43	7.56	7.58	7.57	27.41	27.47	27.44
60	49.82	50.12	49.97	27.37	28.27	27.82	8.02	8.06	8.04	28.90	28.96	28.93
CD (*P*=0.05)	0.235	0.166	0.152	0.180	0.235	0.166	0.043	0.031	0.022	0.144	0.152	0.135
S (kg/ha)												
0	33.80	33.98	33.89	13.63	13.90	13.77	6.88	6.90	6.98	25.93	25.98	25.96
20	42.12	42.33	42.23	21.30	21.90	21.60	7.50	7.54	7.52	27.24	27.29	27.26
40	47.17	47.45	47.31	25.17	26.00	25.58	7.90	7.94	7.92	28.77	28.83	28.80
CD (*P*=0.05)	0.235	0.166	0.152	0.180	0.235	0.166	0.043	0.031	0.022	0.144	0.152	0.135
PSB												
Without PSB	40.20	40.42	40.31	19.33	19.84	19.59	7.38	7.41	7.39	27.17	27.22	27.19
With PSB	41.20	42.08	41.97	20.74	21.36	21.05	7.47	7.51	7.49	27.46	27.52	27.49
CD (*P*=0.05)	0.192	0.136	0.124	0.150	0.192	0.136	0.035	0.025	0.018	0.188	0.124	0.111

The treatments comprised three levels of phosphorus (no phosphorus, 30 kg P_2O_5 kg/ha and 60 kg P_2O_5/ha), three levels of sulfur (no sulfur, 20 kg S/ha and 40 kg S/ha) and with and without inoculation of phosphorus solubilizing bacteria. All the levels of P, S and PSB were applied to the blackgram crop. The PSB culture "microphos" containing inoculum of *Pseudomonas straita* was used for inoculation of blackgram seeds based on treatment combination. The succeeding crop mustard was grown without P, S and PSB fertilization. Blackgram (T-9) was sown in last week of July and the following mustard (Pusa Bold) in last week of October. Other management practices were adopted based on recommendations of the crops.

Results and Discussion

Effect of Phosphorus and PSB

Increasing levels of phosphorus up to 60 kg P_2O_5/ha in blackgram resulted in a significant increase in plant height and no. of nodules/plant (Table 1). Inoculation of seeds with PSB resulted significant increase in growth in terms of height and no. of nodules/plant (Table 1). The over all improvement in crop growth with phosphorus application seems to be on account of its pivotal role in early formation of roots resulting into greater nutrient uptake, which might have increased the photosynthesis and then translocated to different parts for promoting meristematic development in potential apical buds and intercalary meristems and greater biological N-fixation through enhancement in nitrogenace activity. Similar results were also observed by Venkateshwarlu et al. (1988), and Sharma and Singh (1997).

Blackgram fertilized with 60 kg P_2O_5/ha and seeds inoculated with PSB significantly increased the grain and straw yield over no phosphorus and without inoculation (Table 1). The increase in grain and straw yield with 60 kg P_2O_5/ha being 19.52, 19.58 and 19.64% respectively over no phosphorus in 2004, 2005 and in pooled data. While it was 1.22, 1.35 and 1.35% respectively higher due to inoculation than without inoculation in 2004, 2005 and in pooled data. This could be attributed to overall improvement in crop growth and as phosphorus plays an important role in development and other processes of plant towards sink development. Mahajan et al. (1985) and Dubey (1996) observed similar results from different experiments.

Effect of Sulfur

Sulfur fertilization at 40 kg/ha significantly in-

Table 2. Residual effect of phosphorus, sulfur and PSB on yield (grain+straw) and nutrient uptake of mustard.

Treatment	Grain yield (q/ha)			Straw yield (q/ha)			Total phosphorus uptake (kg/ha)			Available phosphorus in soil (kg/ha)		
	2004	2005	Pooled	2004	2005	Pooled	2004	2005	Pooled	2004	2005	Pooled
P_2O_5 (kg/ha)												
0	10.98	11.03	11.01	34.32	34.39	34.35	9.16	9.30	9.23	22.87	22.29	22.58
30	12.74	12.82	12.78	41.65	42.99	42.32	13.65	13.87	13.76	27.22	26.34	26.78
60	14.21	14.29	14.25	47.97	48.10	48.04	18.26	18.61	18.43	30.20	29.77	29.98
CD (*P*= 0.05)	0.048	0.055	0.048	0.353	0.088	0.203	0.236	0.277	0.244	0.042	0.049	0.037
S (kg/ha)												
0	11.38	11.42	11.40	35.63	35.72	35.68	11.62	11.77	11.69	26.33	25.74	26.04
20	12.83	12.90	12.87	42.49	42.99	42.74	14.03	14.27	14.15	26.77	26.09	26.43
40	13.72	13.82	13.77	45.82	46.77	46.29	15.42	15.74	15.58	27.19	26.57	26.88
CD (*P*=0.05)	0.048	0.055	0.048	0.353	0.088	0.203	0.236	0.277	0.244	0.042	0.049	0.037
PSB												
Without PSB	12.49	12.55	12.52	40.57	41.39	40.98	13.02	13.20	13.11	26.12	25.51	25.81
With PSB	12.80	12.88	12.48	42.06	42.26	42.16	14.36	14.65	14.50	27.40	26.76	27.08
CD (*P*=0.05)	0.039	0.045	0.039	0.288	0.072	0.166	0.193	0.226	0.199	0.035	0.040	0.030

creased the growth of blackgram plants over no sulfur (Table 1). Improvement in plant growth by sulfur application might be due to its role in the formation of amino acids viz., cysteine, cystine, methionine and synthesis of protein and vitamins (Tandon 1991). The trend of response to applied sulfur in respect to yield of blackgram was similar to growth attribute (Table 1). The percentage increase in grain yield with 40 kg S/ha over no sulfur was 14.82, 15.10 and 13.50 respectively in 2004, 2005 and in pooled data. The improvement in yield components might have resulted from favorable influence of sulfur on growth characters and greater portioning of metabolites and adequate translocation of nutrients to development. Grain yield increase was largely a function of improved and consequent increase in yield attributes. The results are justified in conformity with those of Karwasara and Roy (1984).

Residual Effect on Mustard

Application of 60 kg P_2O_5/ha preceding blackgram recorded greater residual effect on yield (grain + straw) and uptake of nutrients in mustard when compared with lower levels of phosphorus, sulfur and PSB (Table 2). Over the seasons, the grain yield of mustard increased 29.42, 29.56 and 29.43% by 60 kg P_2O_5/ha and 20.56, 21.02 and 20.80% by sulfur at 40 kg/ha applied to preceding crop blackgram as compared to their lower levels. The increased vigor and growth of plants resulting from the residual effect of phosphorus led better development of yield attributes and finally led to increased yield of mustard. The marked improvement in productivity of mustard crop with residual sulfur could be ascribed to enhancement of SO_4^{-3}–S content of soil and might have modified soil environment for growth and development of mustard crop. Similar results were also observed by Yadav et al. (2000).

Phosphorus uptake by mustard was significantly increased in linear fashion with increasing levels of phosphorus, sulfur and PSB and maximum uptake was recorded by higher levels applied to preceding blackgram (Table 2). The increased phosphorus uptake by plants could be explained that the residual phosphorus in addition to its own absorption might have helped the plants to absorb more nutrients from soil and reasonable to interfere that mustard crop tried in the experiment have enough capacity to derive phosphate which was applied to previous crop and

increase in phosphorus uptake by sulfur levels might be due to synergistic interaction of sulfur with phosphorus.

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