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ISSN: 0974-4908
Res. Environ. Life Sci.
9(11) 1344-1346 (2016)

Effect of sources and levels of phosphorus with PSB on productivity of blackgram [*Vigna mungo* (L.) Hepper] under rainfed condition

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(Received: January 14, 2016; Revised received: August 19, 2016; Accepted: August 26, 2016)

Abstract: A field experiment was conducted during *kharif* season of 2014-2015 on sandy loam soil to find out the appropriate dose of phosphorus through different sources with or without application of PSB (phosphorus solubilizing bacteria) for blackgram. The treatment comprises six levels of phosphorus (10+PSB, 20+PSB, 30, 30+PSB, 40 and 40+PSB) applied through two sources of phosphorus i.e. single super phosphate (SSP) and di-ammonium phosphate (DAP). Nodules dry weight /plant (0.015 mg/plant), seeds/pod (43.33), seed yield (652 kg/ha) and straw yield (1003 kg/ha) were significantly higher under application of phosphorus sources through DAP. Application of phosphorus at 40 kg P_2O_5 /ha with PSB was recorded significantly maximum plant height, root spreading, seed yield (607 kg/ha) and straw yield (979 kg/ha). Significantly higher net returns (₹16,701) and returns per rupee invested (1.94) were recorded in addition of 40 kg P_2O_5 /ha +PSB treatment. Combined addition of 40 kg P_2O_5 /ha + PSB through DAP gave significantly superior seed yield (652 kg/ha) and net returns (19,614 /hectare).

Key words: Phosphorus sources, Phosphorus levels, PSB and blackgram

Introduction

Black gram [*Vigna mungo* (L.) Hepper] is the an important pluse crop grown in India. It occupies unique position in Indian agriculture. Among the pulses, it stands fourth in production and acreage. In India, it is grown on an area of about 3.06 million ha. production of 1.70 million tonnes with an average productivity of 555 kg per hectare (Anonymous, 2013-14). In Madhya Pradesh, it is grown in about 862 thousand hectare with an average production of 357.9 tonne and productivity of 415 kg/ha (Anonymous, 2014-15). India is the largest producer as well as consumer of blackgram. Phosphorus is second most critical plant nutrient but for pulse, it assumes primary importance owing to its important role in root proliferation and thereby atmospheric nitrogen fixation (Negi *et al.,* 1985). It is involved in several energy transformation and biochemical reactions. Phosphatic fertilizers have low efficiency of utilization due to chemical fixation in soil (Gour, 1993) and due to poor solubility of native soil phosphorus, sometimes there is a buildup of insoluble phosphorus as a result of chemical phosphorus application (Dubey, 1997). Application of phosphorus plays an important role in growth, development and maturity of crop. Its helps to increase grain yield, seed quality, regulate the photosynthesis, govern physico-bio chemical process and also in development of roots and nodulation. Therefore application of phosphorus is must incentive coupled with organic manure (Vermicompost), and bio-fertilizers PSB. Based on these circumstances emphasis has been given to use phosphorus solubilizing bio-fertilizer (PSB) which have been found useful in enhancing phosphorus availability to plant through solubilization, and increasing the seed yield (Bhattacharya and Jain, 2000). Many investigators reported that crop utilizes only 15- 20% of the applied phosphorus and rest is retained in the form which is not readily available to the crop. In central and northern India, most of the cultivated area of blackgram is confined in *kharif* mansoon season under rainfed condition. Keeping in the above view, the present study was undertaken to find out the appropriate dose of phosphorus with PSB for rainfed condition.

Materials and Methods

A field experiment was conducted at Agriculture Farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalay, Chitrakoot, (25^0 10 N latitude and $80^0$52 E longitude and about 190-210 meter above mean sea level) Satna (M.P.) during *kharif* season of 2014-15. The rainfall received during the crop season (June to October 2014) was 1153.5 mm in 45 rainy days. The soil was sandy loam with neutral pH (7.46), low in available nitrogen (201.6 kg/ha) medium in available phosphorus (20.11 kg/ha) and potassium (201.5 kg/ha). The treatments comprises six levels of phosphorus (10+PSB, 20+PSB, 30, 30+PSB, 40 and 40+PSB) applied through two sources of phosphorus i.e. SSP and DAP. The experiment was laid out in a Factorial Randomized Block design with 3 replication (Panse and Sukhatme, 1978). Black gram variety Azad urd -1 was sown in field (540 m^2) on July 24, 2014 at a row spacing of 30 cm with seed rate of 20 kg/ha. Thinning was done at 20 days after sowing to keep the plant to plant spacing of 5 cm. Uniform dose of 20 kg nitrogen and 20 kg potash per hectare were applied through DAP, Urea and MOP common to all the plots at the time of sowing. The seeds were treated with bio-fertilizers *viz. Rhizobium* @ 20 g/kg seed, Pendimethalin 30 EC was applied as pre-emergence application @ 3.3 li /ha in order to control weeds. One hand weeding with khurpi was also done at 30 DAS. The experiment was conducted under rainfed condition, hence no irrigation applied. The picking of mature pod was done on 10 October 2014. Economic analysis of data for all the treatment were worked out on the basis of the prevailing cost of operations input and market price of the produce. All the observations were taken as per standard procedure.

Results and Discussion

Shoot and root growth: Growth parameter like plant height, trifoliate/plant and dry weight/plant were numerically higher under DAP. This might be due to higher availability of phosphorus in DAP than that of SSP application which could be ascribed due to lesser fixation of phosphorus because of granular form of DAP application caused the lesser contact area with the soil compared to SSP having in powder form. In phosphorus levels, significantly superior plant height and root spreading was recorded in 40+PSB but root length was recorded higher under 40 kg P_2O_5 /ha (Table 1). This may perhaps due to reason that phosphorus helped in proliferation of root system and thus resulted in increasing the nutrient absorption by increasing the absorbing surface. Phosphorus uptake by plant roots required energy from carbohydrates. Generating that energy requires oxygen for normal root metabolism. Increasing concentrations of soil phosphorus by adequate fertilization can help offset this effect. Root length and density affect response to phosphorus since length is the major determinant of absorbing surface area (Allen *et al*., 2007).

Nodulation: Application of DAP significantly enhanced the nodules dry weight/plant and nodules/plant did not exert significantly. Nodules /plant was noted higher under 40+PSB and nodules dry weight/plant in 20+PSB and 40 kg P_2O_5/ha but did not reach up to levels of significant. This might be due to higher availability of phosphorus with PSB. Such improvement in nodulation with using PSB may have resulted in higher nitrogen fixation and greater nitrogen availability to plant. Whereas, solubilisation of fixed phosphorus by PSB probably resulted in higher phosphorus content and more uptake of phosphorus by plant and increased the nodules and their dry weight. These results are in accordance to finding of Dubey and Agrawal (1999).

Table-1: Effect of levels and sources of phosphorus and PSB on the shoot and root growth and nodulation of blackgram

Treatment	Plant ht. (cm) 55 DAS	Trifoliate/ plant 55 DAS	Dry wt./ plant (g) 55 DAS	Root length (cm) 55 DAS	Root spread (cm) 55 DAS	Root dry wt. (g) 55 DAS	No. of nodules/ plant 55 DAS	Nodules dry wt./ plant (g) 55 DAS
Phosphorus sources								
SSP	28.44	18.68	8.25	21.02	21.27	8.25	17.83	0.147
DAP	28.52	18.72	8.25	20.88	21.18	8.25	17.78	0.150
CD (P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.003
Phosphorus levels (kg P_2O_5 /ha.)								
10 + PSB	28.22	18.63	8.25	20.93	21.33	8.25	17.83	0.148
20 +PSB	28.56	18.90	8.25	20.73	21.03	8.25	17.83	0.150
30	28.53	18.63	8.25	20.99	21.11	8.25	17.67	0.147
30 +PSB	28.39	18.63	8.25	20.86	21.19	8.25	17.67	0.149
40	28.37	18.60	8.25	21.21	21.33	8.25	17.83	0.150
40 +PSB	28.81	18.80	8.25	20.97	21.35	8.25	18.00	0.148
CD (P=0.05)	0.32	N.S.	N.S.	0.26	0.21	N.S.	N.S.	N.S.

Table-2: Effect of levels and sources of phosphorus and PSB on the yield attributes, yield and economics of blackgram

Treatment	Pods/ plant	Pod length/ plant (cm)	Pod wt/ plant (g)	No. of seed/ pod	Seed wt/ plant (g)	1000 seed wt (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Rupee invested (Rs.)
Phosphorus Sources												
SSP	19.67	44.00	4.05	40.94	6.50	34.30	498	909	19118	29899	10781	1.63
DAP	19.89	44.04	4.02	41.67	6.47	34.30	557	946	18791	33412	14622	1.86
CD (P=0.05)	N.S.	N.S.	N.S.	0.64	N.S.	N.S.	6	8	-	381	381	0.026
Phosphorus levels (kg P_2O_5 /ha.)												
10 + PSB	19.50	44.20	4.04	41.00	6.39	34.08	453	835	17761	27203	9442	1.61
20 +PSB	20.67	44.10	4.15	41.00	6.54	34.53	538	948	18432	32272	13840	1.84
30	19.67	43.97	4.09	41.50	6.52	34.47	490	910	19080	29421	10341	1.62
30 +PSB	20.67	43.87	3.92	41.67	6.46	34.40	563	966	19096	33747	14650	1.86
40	19.33	44.00	3.94	41.17	6.58	34.03	515	925	19671	30904	11233	1.65
40 +PSB	18.83	44.00	4.05	41.50	6.44	34.28	607	979	19687	36387	16701	1.94
CD(P=0.05)	0.72	N.S.	0.12	N.S.	N.S.	N.S.	11	14	-	659	659	0.034

Table-3: Interaction effect of sources and levels of phosphorus on the seed yield and net returns of blackgram

Phosphorus	Seed yield (kg/ha)		Net returns (Rs./ha)	
Levels (kg P_2O_5 /ha)	SSP	DAP	SSP	DAP
10 + PSB	441	466	8638	10246
20 +PSB	511	565	12034	15647
30	460	520	8384	12297
30 +PSB	540	584	13168	16132
40	476	554	8673	13794
40 +PSB	561	652	13787	19614
CD(P= 0.05)	16	933		

Yield and yield attributes: Application of DAP significantly enhanced the seeds/pod, seed and straw yield. Almost similar pattern was also observed on pod/plant and pod length /plant but these yield attributes did not varied significantly. The better performance of DAP compare to SSP might be attributed to readily available phosphorus resulting in better absorption and utilization of phosphorus by plant and presence of other important plant nutrients besides increasing phosphorus availability (Sacchidanand *et al.,* 1980). Yield attributes, *viz.* pods / plant and pod weight/plant increased significantly with phosphorus application up to 20+PSB. Such response, might be due to the adequate supply of phosphorus resulted in producing large productive parts (Sarkar and Banik, 1991; Rathor *et al.,* 2010). The availability of phosphorus with PSB applied causing vigorous growth, initiating more number of flower buds in the plant there by increasing pods/ plant, pod weight /plant and seeds /pod (Reddy and Swamy, 2000). Seed (607 kg/ha) and straw yield (979 kg/ha)was recorded significantly superior with increment of 40+PSB over rest of treatment. It may be due to vigorous start to plant and strengthen straw by the higher dose of phosphorus application. (Singh *et al.,* 2001).

Economics: In general gross returns, net returns and returns per rupee invested of DAP were significantly superior as compared to SSP (Table 2). This could be ascribed due to higher seed and straw yield and lower cost of cultivation. Application of 40+PSB gave significantly more gross returns, net returns and returns per rupee invested. This could be explained due to significantly higher value of seed yield and straw yield, which monetary increase was much higher compared to enhance in cost of increment doses of phosphorus.

Interaction: Application of 40 kg P_2O_5 /ha applied through DAP with PSB inoculation resulted in the significantly highest seed yield (652 kg/ha) (Table 3). This increase in seed yield was higher by 48% (211 kg/ha) over 10 +PSB. The second best treatment was 20 kg P_2O_5 /ha through DAP +PSB. It is thus clear from the results that SSP was less effective as compared to DAP as a sources of phosphorus. However, when this sources of phosphorus was used with PSB, the seed yield increased significantly over its application at same level without PSB. Hence, PSB increased the efficiency of this insoluble source of phosphorus. The response of DAP was better than SSP with PSB and without PSB. The trends of the results were in conformity with those reported by Jaggi and Sharma (1992), Reddy and Swami (2000) Singh *et al.* (2001).Applications of DAP ×40 +PSB also resulted in highest net return per hectare (Rs. 19,614/ ha).

It may be concluded that DAP was proved to be superior than SSP. However, application of 40 +PSB was found the appropriate dose of phosphorus for higher productivity and profitability of blackgram under rainfed condition.

Acknowledment

The authors are grateful to the Vice Chancellor of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalaya, Chitrakoot, Satna (M.P.) India and Dean, Faculty of Agriculture of same institute for facilities provided to carry out the present investigation.

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