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Effect of levels and sources of phosphorous application on growth, yield and nutrient use efficiency of black gram (*Phaseolus mungo* L.)

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Abstract
The field experiment was conducted on black gram (T-9) during kharif season of 2015-16 in research farm of the R.V.S.K.V.V., Gwalior, to study effect of levels and sources of phosphorous application on growth, yield and nutrient use efficiency of black gram (*Phaseolus mungo* L.). The experiment was laid out in RBD comprising of 8 treatments with 4 replications. Results revealed that most of the growth and yield parameters were significantly influenced by different levels and sources of P. The highest grain and straw yield were 677.6 and 1443.4 kg ha^{-1}, respectively, in the treatment with 60 kg P_2O_5 ha^{-1} through SSP along with N_{30} K_{30} closely followed by 60 kg P_2O_5 ha^{-1} through DAP i.e. DAP (with 656.6 kg ha^{-1}) and being significantly superior over application of 20 and 40 kg P_2O_5 ha^{-1}.The phosphorus use efficiency in terms of agronomic efficiency, physiological efficiency and apparent recovery by black gram increased significantly with increasing levels and sources of P. Application of 60 kg P_2O_5 ha^{-1} had higher net returns and B.C. ratio as compared to 30 kg P_2O_5 ha^{-1}. SSP applied treatments gave more net return and B.C. ratio as compared to same doses applied by DAP.

Keywords: black gram, growth and yield, phosphorus use efficiency, economic

1. Introduction
Pulses are rich in proteins and found to be main source of protein to vegetarian people of India and particular among the many cultivated legumes. Black gram (*Phaseolus mungo* L.) is the most important pulse crop, grown across India and used as food for human and as fodder for livestock, as well as for green manuring. Besides this, crop is grown primarily for its protein rich seeds. The productivity of black gram is very poor mainly because of traditional way of cultivation. The black gram crop is resistant to adverse climatic conditions and improves the fertility of soil through biological nitrogen fixations. Phosphorus is a key nutrient for increasing productivity of pulses and the most important single factor responsible for poor productivity of pulses (Deo and Khaldelwal, 2009) [4]. The adequate supply of phosphorus to legume is more important to that of nitrogen. Phosphorus application helps in growth and development of plant in many ways. It has beneficial effect on root development, nodulation, growth and yield of pulses. It plays an important role in energy transfer reactions and in oxidation-reduction processes. Phosphorus application increases cell division, as a result of which growth is increased in legumes. Phosphorus is critical in the metabolism of plants, playing key role of cellular energy transfer, respiration and photosynthesis. It is also a structural component of the nucleic acids and many coenzymes, phospho-proteins and phospholipids. An adequate supply of P is essential from the earlier stages of plant growth (Bertrand *et al*., 2003) [1]. Therefore, the present experiment was conducted to evaluate the efficiency of P in an alluvial soil with objectives are (1) to estimate phosphorus use efficiency as influenced by different sources and levels of application and (2) to work out the economics and evaluate best source of P for black gram.

2. Material and Method
The field experiment was conducted with black gram (cv T-9) during kharif season of 2015-16 at the research farm of College of Agriculture, R.V.S.K.V.V. Gwalior (M.P.) on alluvial soil. The soil was sandy clay loam in texture i.e. 55.6% sand, 23.8% silt and 20.6% clay. A representative surface soil sample from 0-15 cm depth was collected before sowing.

The soil was having pH 7.44, electrical conductivity 0.4 dSm^{-1}, organic carbon 4.66 g kg^{-1}, available N 204.2 kg ha^{-1}, available P 15.20 kg ha^{-1}, available K 274.8 kg ha^{-1} and available S 9.62 mg kg^{-1}. The experiment was laid out in a randomized block design with eight treatments and four replications viz., Control; N_{30} K_{30} (nitrogen @ 30 and potassium @ 30 kg ha^{-1}); N_{30} K_{30} + P_{20} (phosphorus @ 20 kg ha^{-1}) through DAP, N_{30} K_{30}+ P_{40} through DAP; N_{30} K_{30} + P_{60} through DAP, N_{30} K_{30} + P_{20} through SSP; N_{30} K_{30} + P_{40} through SSP; and N_{30} K_{30} + P_{60} through SSP. The N and K were supplemented through urea and muriate of potash, respectively. Phosphorus was applied through of SSP and DAP fertilizers as basal dose in each treatment. Black gram (cv T-9) was sown in 3rd of July using seed rate of 20 kg ha^{-1} with row to row spacing 30 cm and plant to plant distance 10 cm and harvested on 2nd week of October. Yield attributes viz., pods $plant^{-1}$, seeds pod^{-1} and test weight i.e. 1000 seeds were recorded at harvest stage. The grain and straw samples were digested with di-acid mixture (HNO_3 and $HClO_4$ in 9:3 ratio) for the estimation of P and K. Phosphorus was determined by Vanadomolybdate yellow colour method (Jackson, 1973) [6], Sulphur by turbidimetric method (Chesnin and Yien, 1951) [3] and nitrogen in plant was determined by KELPLUS system to perform the Kjeldahl method (Subbiah and Asija, 1956) [11]. The post-harvest soil samples were collected and analyzed for pH, available N (Subbiah and Asija, 1956) [11], P (Olsen *et al*., 1954), available K by extracting with CH_3COONH_4 (Jackson, 1973) [6] and sulphur by extracting with 0.15% $CaCl_2$ solution (Chesnin and Yien, 1951) [3]. Phosphorus use efficiency and agronomic efficiency (AEP), Physiological efficiency (PEP) and apparent recovery were calculated as describe by Fagerio and Filbo, *et al*. (2007) [5].

3. Result and discussion

3.1. Effect of phosphorus

Applications of both the sources of P improve the growth and yield attributes of black gram significantly over control. The application of SSP proved superior to DAP in respect of yield attributes i.e. number of pods $plant^{-1}$, seeds pod^{-1} and test weight (1000 seeds) were also significantly affected by phosphorus levels. The maximum values of number of pods $plant^{-1}$ (36.69), seeds pod^{-1} (7.57) and test weight (35.05 g) were recorded with on application of 60 kg P_2O_5 ha^{-1} (Table 1). The highest values of all these yield parameters were recorded fewer than 40 and 20 kg P_2O_5 ha^{-1} and the lowest were noted with control. Increasing levels of phosphorus applied through both sources significantly increased these parameters over control. It may be due to the fact that P enhances the metabolism of plants, playing a role in cellular energy transfer, respiration and photosynthesis. It is also a structural component of the nucleic acids and of many coenzymes, phospho-proteins and phospholipids. The application of different sources of P significantly influenced the yield of black gram over control. The grain yield was significantly higher with the application of SSP than DAP. However, it is clear from the results (Table 1) that the seed and straw yield of blackgram increased significantly with increasing the level of phosphorus applied through either SSP or DAP. The maximum yield of seed (677.6 kg ha^{-1}) and straw (1443.4 kg ha^{-1}) was recorded with the application of 60 kg P_2O_5 ha^{-1} through SSP along with $N_{30}K_{30}$ closely followed by (656.6 kg ha^{-1}) 60 kg P_2O_5 ha^{-1} through DAP. These treatments were significantly superior over application of 20 and 40 kg P_2O_5 ha^{-1}. It may be increased due to availability of phosphorus in soil. A linear increase in the yield up to 60 kg P_2O_5 ha^{-1} of black gram and pigeon pea was also reported by Trivedi and Singh, (1999) [12] and Kumar and Singh (2011) [7]. It is evident from the results that phosphorus applied through single super phosphate showed has edge di-ammonium phosphate at each levels of application. That may be attributed to the addition of S through SSP, as the experimental soil was deficient in available S.

Table 1: Effect of P application on seed and straw yield of black gram.

Treatments	Pod (No. $plant^{-1}$)	Seed (No. pod^{-1})	1000 -Seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Control	17.15	5.28	31.32	328.3	704.2
N_{30} K_{30}	22.86	6.54	33.21	408.2	875.7
N_{30} K_{30} + P_{20} through DAP	27.83	7.27	34.19	484.0	1038.2
N_{30} K_{30} + P_{40}through DAP	33.13	7.34	34.60	564.0	1284.7
N_{30} K_{30} + P_{60} through DAP	35.38	7.54	34.61	656.6	1443.4
N_{30} K_{30} + P_{20} through SSP	27.23	7.08	33.79	500.9	1074.4
N_{30} K_{30} + P_{40}through SSP	32.66	7.15	34.33	606.1	1278.8
N_{30} K_{30} + P_{60} through SSP	36.69	7.57	35.05	677.6	1436.0
C D ($P \le 0.05$)	3.03	0.62	1.74	62.4	117.0

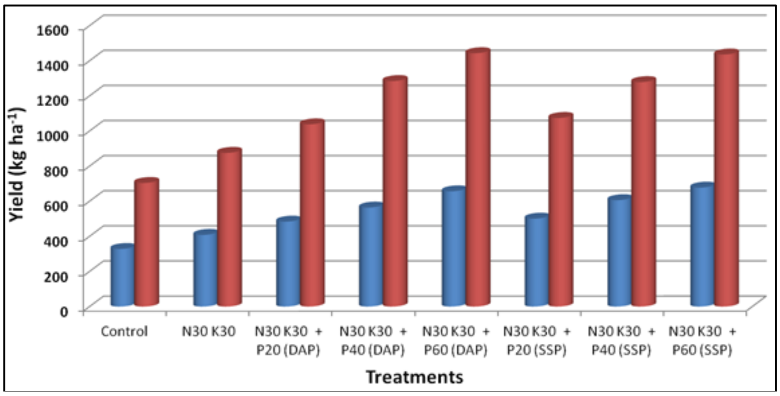

Fig 1: Effect of application on seed and straw yield of black gram

3.2. Phosphorus use efficiency

The phosphorus use efficiency (PUE) of nutrients in grain and straw increased significantly over in control with different treatments (Table 2). Under DAP applied treatments maximum value of AEP was recorded with 60 kg P_2O_5 ha^{-1} and the minimum with 20 kg P_2O_5 ha^{-1} treatments. Whereas, in SSP applied treatments, maximum value of agronomic efficiency (AEP) noted with 40 kg P_2O_5 ha^{-1} and the minimum with 60 kg P_2O_5 ha^{-1} treatments. It is revealed from results that increasing the dose of phosphorus decreased the physiological efficiency (PEP) because the P applied to black gram is subjected to P fixation. Similar results were also reported by Kushwaha (2011) [8] in chickpea crop. Under DAP applied treatments maximum value of recovery efficiency (REP) (13.40%) was recorded with 60 kg P_2O_5 ha^{-1}. Whereas, in SSP applied treatments, maximum value of REP (14.08%) was noted with 40 kg P_2O_5 ha^{-1}. This pattern, probably due to greater P uptake per unit of P added. It is clear from result that SSP applied treatments showed higher agronomic efficiency (AEP), Physiological efficiency (PEP) and apparent recovery of P as compared to DAP applied treatments at the same level. These results confirm the finding of Nandini Devi *et al*. (2012) [9].

Table 2: Phosphorus efficiency as influenced by different treatments

Treatments	Agronomic efficiency (kg seed/ kg P_2O_5)	Physiological efficiency (kg/ kg P_2O_5)	Apparent Recovery (%)	B:C Ratio
Control	-	-	-	1.90
N_{30} K_{30}	0	0	0	2.17
N_{30} K_{30} + P_{20} through DAP	3.79	75.80	11.45	2.42
N_{30} K_{30} + P_{40}through DAP	3.90	68.33	13.05	2.66
N_{30} K_{30} + P_{60} through DAP	4.14	67.77	13.40	2.95
N_{30} K_{30} + P_{20} through SSP	4.64	82.04	12.94	2.54
N_{30} K_{30} + P_{40}through SSP	4.95	80.45	14.08	2.93
N_{30} K_{30} + P_{60} through SSP	4.49	75.89	13.55	3.13

B: C Ratio= beneficial cost ratio

3.3. Economics

The economic feasibility in terms of net monetary return and B: C (beneficial cost ratio) ratio showed that application of 60 kg P_2O_5 ha^{-1} had higher net returns and B: C ratio as compared to 20 kg P_2O_5 ha^{-1}. This might be due to increased proportion of net returns in relation to cost of cultivation. It is evident from results that SSP applied plots gave more net return and B: C ratio as compared to same doses applied by DAP because per kg of phosphorus in SSP was cheaper as compared to DAP.

4. Conclusion

On the basis of results, it may be concluded that the present investigation, seed yields are affected by different P sources and increased with the increasing level of phosphorus. The use efficiency of black gram from result that SSP applied treatments showed higher agronomic efficiency, physiological efficiency and apparent recovery of P as compared to DAP applied treatments at the same level. The economic feasibility in terms application of SSP gave more net return and B: C ratio as compared to same doses applied by DAP because per kg of phosphorus in SSP was cheaper as compared to DAP.

5. References

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