Performance of Cowpea [*Vigna unguiculata* (L.) Walp) under different levels of phosphorus and potassium in combination with biofertilizers

Abstract

A field experiment entitled "Performance of cowpea [*Vigna unguiculata* (L.) Walp) under different levels of phosphorus and potassium in combination with biofertilizers" was conducted at crop research farm of Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, during *kharif* 2018. The soil of the experimental field wasclay loam in texture, neutral in reaction (pH = 6.9), low in available nitrogen, low in available phosphorus, medium in available potassium and medium in organic carbon. The experiment was laid in RBD design having nine treatments and three replications. The observation revealed that grain yield (10.57 qha^{-1}), straw yield (18.94 qha^{-1}), yield attributes was high with the application of RDF ($30N+60P_2O_5+30K_2O$) kg ha^{-1} + seed inoculation with PSB and KSB than other treatments. The RDF+ seed inoculation with PSB and KSB recorded 15.89% high grain yield than RDF ($30N+60P_2O_5+30K_2O$) kg ha^{-1}. B:C was also recorded more with application of RDF + seed inoculation with PSB and KSB (2.99) and was followed by RDF + seed inoculation with PSB (2.62) whereas lowest benefit cost ration was recorded with control treatment (2.24).

Key words: Cowpea, nutrients, PSB, KSB, yield, economics

Introduction

"Pulses are important source of dietary protein and have unique ability of maintaining and restoring soil fertility through biological nitrogen fixation as well asaddition of ample amount of residues to the soil. Pulse crop leave behind reasonablequantity of nitrogen in soil to the extent of 30 kg ha^{-1}" (Reddy and Reddy, 2010). Cowpea [*Vigna unguiculata* (L.)] commonly known in India as *lobia* is one of theimportant *Kharif* pulse crop grown for vegetable, grain, forage and green manuring. Being rich in protein and containing many other nutrients, it is known as vegetable meat. The crop gives such a heavy vegetative growth and covers the ground that checks the soil erosion in problem areas and can later be ploughed down for green manure.

The major cowpea growing states are U.P, Punjab, Haryana, Rajasthan and Madhya Pradesh. In India, pulses are grown over an area of 28.14 million hectares with an annual production of 21.93 million tonnes and an average productivity of 780 kg ha^{-1} (Agricultural Statistics at a Glance, 2021). In J&K pulses are grown over an area of 16.14 thousand hectares with an annual production of 101 thousand quintals (DES, 2020-21).

Nutrients play a pivotal role in increasing the seed yield in pulses. Phosphorus is an important nutrient next to nitrogen. Indian soils are poor to medium in available phosphorus. Only about 30% of the applied phosphorus is available for crops and remaining part is converted into insoluble phosphorus. Its deficiency is most important single factor, which is responsible for poor yield of cowpea on all types of soils. "Phosphorus and potassium are major essential macronutrients for plant growth and development and soluble P and K fertilizers are commonly applied to replace removed minerals and to optimize yield" (Han and Lee, 2006). Phosphorus is the second most critical plant nutrient overall, but for pulses it assumes primary importance owing to its important role in root proliferation and thereby atmospheric nitrogen assimilation. Phosphorus is involved in metabolic and enzymatic reaction and is a constituent of ATP and ADP (Singh and Ali, 1994). "Potassium is rarely applied to pulse crops because of high content of K in the soils particularly in soils which have high K-bearing clay minerals like illite" (Pasricha and Bahl, 1996). The application of potassium regulates the utilization of other nutrients in the plant system.

Biofertilizers are preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic micro-organisms used for application to seed or composting areas with the objective of increasing the number of such micro-organisms and accelerating those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. Biofertilizers have been used to convert insoluble rock P material into soluble forms available for plant growth and are capable of solubilizing rock K. The inoculation of seeds with PSB culture increases the green pod yield of mung bean over uninoculated control (Vaisya *et al*. 1983). The phosphate solubilizing bacteria are aerobic and heterotrophic in nature. Large numbers of microorganism have been tested and inoculants of *Bacillus megatherium*, *Pseudomonas straita Pseudomonas extremorientalis* and *Bacillus polymixa* are found suitable and available for seed inoculation. These bacteria solubilize phosphate added in soil, thus make it available to plants for their healthy growth. Under favourable conditions, they can solubilize 20-30% of insoluble phosphate and may increase yield of crops by 10-30 % (Tilak and Annapurna, 1993). Therefore, there may be a substantial saving of applied phosphorus and potassium when seeds are inoculated with phosphate solubilizing and potassium solubilizing bacteria inoculants. "Mineral potassium solubilization by microbes which enhances crop growth and yield when applied with a cheaper source of rock potassium may be agronomically more useful and environmentally more feasible than soluble K" (Rajan *et al*. 1996).

The information on the combined influence of phosphorus and potassium with bacterial inoculation is meager and very little work has been done in temperate hilly region of Kashmir. Therefore an experiment **"Performance of Cowpea [*Vigna unguiculata* (L.)**

Walp] under different levels of Phosphorus and Potassium in combination with bio-fertilizers" was conducted at Wadura Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir.

Materials and Methods

The experiment was conducted at Crop Research Farm of Division of Agronomy, Faculty of Agriculture Wadura Sopore, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir during *Kharif* 2018. Climatically the experimental site falls in temperate zone of north western Himalaya characterized by hot summers and very cold winters. the soil of the experimental field was clay loam in texture, medium in organic carbon, low in available nitrogen, low in available phosphorus and medium in available potassium with neutral pH. The experiment comprised of nine treatment combinations *viz.*, T_1: (Control), T_2: (PSB + KSB), $T_{3:}$ 100% RDF (30N, 60 P_2O_5, 30 K_2O) kg ha^{-1}, $T_{4:}$ 100% (P_2O_5, K_2O) of RDF + seed inoculation with PSB, T_5: 100% (P_2O_5, K_2O) of RDF + seed inoculation with KSB, T_6: 100% (P_2O_5, K_2O) + seed inoculation with PSB + KSB, T_7: 100% P_2O_5 + 75% K_2O of RDF + seed inoculation with KSB, T_8: 75%P_2O_5 + 100% K_2O of RDF + seed inoculation with PSB and T_9: 75% (P_2O_5, K_2O) of RDF + seed inoculation with PSB + KSB. The experiment was laid out in RBD. The test variety used in the experiment was Shalimar Cowpea-1.

Total number of pods of five randomly marked plants in the penultimate rows of each plot were counted, averaged and expressed as pods $plant^{-1}$. Number of seeds were recorded from five representative pods taken from tagged plants. The average value was calculated by dividing with five to express the number of seeds pod^{-1}. The average pod length of five randomly selected pods was measured and recorded from each plot. The average weight of pods was recorded from the randomly selected plants from each treatment and the average was worked out. Seed samples collected treatment wise during threshing were winnowed, cleaned and dried. From these seed samples thousand seeds were counted and weighed treatment wise and then expressed as 1000-seed weight in grams. The grain yield obtained from each plot was thoroughly cleaned, sun dried and weighed treatment wise and expressed in q ha^{-1}. The straw yield of each plot was sun dried and then weighed treatment wise and expressed in q ha^{-1}. The total green pod yield and green fodder yield of each net plot was recorded and was expressed as biomass yield in q ha^{-1}. It was calculated by dividing the economic yield *i.e.*, grain yield to the biological yield *i.e.*, grain yield + straw yield. Benefit cost ratio was determined by dividing the net returns with cost of cultivation and expressed as benefit over 1 rupee invested.

Results and Discussion

Yield attributes and yield

The data pertaining to number of pods per plant as affected by various treatments are presented in Table 1. It is evident from the data that number of pods per plant significantly increased with increasing fertility levels. Treatment 100% RDF (P_2O_5 and K_2O) kg ha^{-1}+ seed inoculation with PSB + KSB significantly recorded higher number of pods per plant, whereas control treatment recorded lower number of pods per plant as compared to other treatments. A critical examination of data revealed that 100% RDF (P_2O_5 and K_2O) kg ha^{-1} + seed inoculation with PSB + KSB brought about a significant influence on number of seeds pod^{-1} over rest of treatments. Application of 100% RDF (P_2O_5 and K_2O) kg ha^{-1} + seed inoculation with PSB + KSB recorded maximum number of seeds pod-1 (8.72) and represented a significant increase of 40.64% over control (Table 1). It is evident from data (Table 1) that pod length significantly increased with increasing levels of fertility. The maximum pod length of 11.52 cm recorded under treatment 100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB was 32.5% and 11.8 % higher over control and 100% RDF (P_2O_5, K_2O) respectively. Also, the lowest pod length of 8.69 cm was recorded under treatment control which was at par with seed inoculation with PSB + KSB. The perusal data (Table 1) revealed that there was a significant increase in average weight of pod due to application of different fertility levels. Maximum pod weight (5.24 g) was recorded under treatment 100% RDF (P_2O_5,K_2O) + seed inoculation with PSB +KSB which was found superior over other treatments whereas, the minimum pod weight (3.41g) was found under treatment control which in turn was statistically at par with seed inoculation with PSB + KSB.

The results indicated that application of 100%RDF (30N, 60P_2O_5, 30K_2O) kg ha^{-1} + seed inoculation with PSB + KSB significantly increased number of pods $plant^{-1}$ and grains pod^{-1}. The higher growth characters (plant height, LAI) under the influence of different fertility levels might have played a significant role in producing more photosynthates. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of pods $plant^{-1}$ and grains pod^{-1}. It appears that application of 100%RDF (30N, 60P_2O_5, 30K_2O) kg ha^{-1}+ seed inoculation with PSB + KSB not only supplied adequate quantity of NPK but also might have played a major role in improving physic-chemical and biological properties of soil which might have resulted in the improvement of crop growth and finally enhancing yield attributes of the test crop. Besides, the marked improvement in the productivity of individual plant due to seed inoculation with

Table 1: Effect of different fertility levels on yield attributes of cowpea

Treatments	Pod length (cm)	Pod weight (g)	Pods $plant^{-1}$	Grains pod^{-1}	Test weight (g)

Control	8.69	3.41	6.28	6.20	63.14
PSB+KSB	8.78	3.51	6.35	6.34	63.35
100%RDF P&K	10.28	4.72	8.11	8.08	64.69
100%RDF P&K+PSB	10.91	4.76	8.19	8.13	64.72
100%RDF P&K+KSB	10.92	4.79	8.17	8.11	64.81
100%RDF+PSB+KSB	11.52	5.24	8.96	8.72	65.89
100%P+75%K+KSB	9.98	4.64	7.78	8.09	63.56
75%P+100%K+PSB	9.96	4.63	7.79	8.09	63.44
75%P&K+PSB+KSB	9.85	4.36	7.65	7.67	63.42
SEm±	**0.17**	**0.40**	**0.22**	**0.19**	**0.768**
C.D ($p \leq 0.05$)	**0.51**	**1.11**	**0.67**	**0.58**	**NS**

PSB and KSB might be due to its profound effect on dry matter production along with accumulation of nutrients. Thus, the greater availability of both these growth inputs might have maintained adequate supplies as per need of plant for yield impact on improving productivity of individual plant which could be ascribed to the fact that crop yield is a function of several yield attributing factors which are dependent on complementary interaction between vegetative and reproductive growth of the crop. The existence of favorable PSB and KSB had a positive influence on both the phases of crop which ultimately led to realization of greater yield attributes. These results are in conformity with the earlier findings of Vimla and Natarajan (2000), Hamayun *et al*. (2011) and Navsare *et al.* (2016). A perusal of data (Table 1) indicates that test weight was not significantlyaffected by different fertility levels.

The data (Table 2) revealed that the seed yield of cowpea significantly increased with increasing different fertility levels over control. The application of 100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB, 100% RDF (P_2O_5, K_2O) treatments increased the grain yield to the tune of 44.7%and 24.9% over control, respectively. The significantly maximum

Table 2: Effect of different fertility levels on grain yield (q ha^{-1}), straw yield (q ha^{-1}), Biological yield (q ha^{-1}) and HI (%)

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Control	7.30	14.22	21.52	33.92
PSB+KSB	7.52	14.33	21.85	34.42
100%RDF P&K	9.12	17.96	27.08	33.68
100%RDF P&K+PSB	9.19	18.12	27.31	33.65
100%RDF P&K+KSB	9.16	18.11	27.27	33.59
100%RDF+PSB+KSB	10.57	18.94	29.51	35.82
100%P+75%K+KSB	8.95	17.45	26.40	33.90
75%P+100%K+PSB	8.93	17.47	26.40	33.83
75%P&K+PSB+KSB	8.51	17.21	25.72	33.09
Sem±	**0.42**	**0.26**	**0.46**	**0.41**
C.D ($p\leq0.05$)	**1.28**	**0.81**	**1.38**	**1.24**

grain yield of cowpea (10.57 qha^{-1}), was recorded with application of 100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB, over control and it is found superior over rest of the treatments. It was observed from the data presented in Table 2 that the straw yield of cowpea significantly increased with increasing different fertility levels over control. Significantly maximum straw yield (18.94 q ha^{-1}) was recorded with the application of 100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB over control. Also, treatment control was at par with seed inoculation of PSB and KSB. The data pertaining to the biological yield presented in Table 2 indicates that as compared to treatment control the application of fertility levels caused a significant increase in biological yield of cowpea under different treatments. The significantly maximum biological yield (29.57 qha^{-1}), was recorded with the application of 100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB over control. However, lowest biological yield was recorded in control which in turn was at par with seed inoculation of PSB and KSB. Harvest index was significantly influenced by different fertility levels. Data presented in Table 2 revealed that harvest index recorded with the application of (100% RDF (P_2O_5, K_2O) + seed inoculation with PSB + KSB) was significantly superior over rest of the treatment. Yield is the net result of various agronomic inputs influencing growth and yield attributing characters during the life cycle of the crop. The efficiency of different factors is judged mainly by their contribution towards economic yield. Significantly higher grain yield, straw yield, biological yield and harvest index were obtained with application of 100%RDF (30N, $60P_2O_5$, $30K_2O$) kg ha^{-1} + seed inoculation with PSB + KSB. Higher yield of cowpea obtained with the nutrient management practices was mainly due to their positive effect on various yield contributing characters like pods $plant^{-1}$, number of grains pod $^{-1}$and growth characters (LAI, dry matter accumulation) etc. Nadeem *et al.* (2003) and Azad *et al.* (2010) also found significant and consistent increase in grain and straw yield with combined application of organic and mineral fertilizers.

Economics

Perusal of data presented in Table 3 indicated that different fertility levels influenced the relative economics of the crop. Highest net return (1,37,527), gross return (2,06,512), and B:C ratio (2.99) was observed with treatment 100%RDF (30N, $60P_2O_5$, $30K_2O$) kg ha^{-1} + seed inoculation with PSB + KSB. Whereas, lowest economics return was observed with treatment (control). The corresponding value for net return, gross return and B:C ratio was 79,191, 1,42,966 and 2.24, respectively. The efficiency of a treatment is finally decided in terms of the economics (benefit cost ratio) of that treatment. In the present study higher benefit cost ratio obtained with the treatment 100%RDF (30N, $60P_2O_5$, $30K_2O$) kg ha^{-1} + seed inoculation with PSB + KSB is due to the higher grain and straw yield obtained with this treatment whereas lower benefit cost ratio obtained with the control treatment is due to the lower grain and straw yield in control treatment. Ghetiya *et al.* (2017), and Ravindra Singh and Agarwal (2004) also reported the similar results.

Conclusion

From the results of the present investigation, it is concluded that for obtaining higher obtaining higher yield and economics of Cowpea, it should be applied with 100% RDF (30N, $60P_2O_5$, $30K_2O$)kg ha^{-1} + seed inoculation with PSB + KSB.

Table 3: Economics of cowpea as affected by different fertility levels

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C
T1:Control	63775	142966	79191	2.24
T2:PSB+KSB	64575	147179	82604	2.27
T3:100%RDF P&K	68185	178668	110483	2.62
T4:100%RDF P&K+PSB	68585	180046	111461	2.62
T5:100%RDF P&K+KSB	68585	179473	110888	2.61
T6:100%RDF+PSB+KSB	68985	206512	137527	2.99
T7:100%P+75%K+KSB	68360	175285	106925	2.56
T8:75%P+100%K+PSB	68607	174911	106304	2.54
T9:75%P&K+PSB+KSB	68504	166853	98349	2.43

References

Agricultural Statistics at a Glance, 2021.

Azad VB, Bali BS and Saha AAS. Effect of phosphorus levels and biofertilizers on yield, P-uptake and economics of wheat (*Triticum aestivum).* Environment and Ecology. 2010;28: 1B, 534-537.

DES, 2020-21.

Ghetiya KP, Bhalu VB, Mathukia RK, Hadavani JK Kaman MD. Effect of phosphate and potash solubilizing bacteria on growth andyield of popcorn (*Zea mays* L. Var. Everta). International Journal of Pureand Applied Biosciences. 2017; 6(5): 167-174

Hamayun M, Khan SA, Khan AL, and Shinwari. Effect of foliar and soil application of nitrogen, phosphorus and potassium on yield components of lentil. Pakistan Journal of Botany. 2011; 43(1): 391-396.

Han HS and Lee KD. Effect of co-inoculation with phosphate and potassium solubilizing bacteria on mineral uptake and growth of pepper and cucumber. Plant Soil and Environment. 2006; 52(3): 130.

Nadeem M, Ali Asgar and Ejaj, M. Effect of different levels of potash on growth and yield of mungbean varieties. Journal of Agriculture Research. 2003; 44 (2): 121-126.

Navsare RI, Mane SS and Supekar SJ. Effect of potassium and zinc solubilizing microorganism on growth, yield and quality of mungbean. International Journal of Chemical Studies. 2016; 6(1): 1996-2000.

Pasricha NS and Bahl GS. Fertiliser News. 1996; 41: 27-37.

Rajan SSS, Watkinson JH and Sinclair AG. Phosphate rock for direct application to soils. Advances in Agronomy. 1996; **57**: 77–159.

Ravindra S and Agrawal S K. Effect of organic manuring and nitrogen fertilization on productivity and economics of wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2004; 49 (1): 49-52.

Reddy TY and Reddy Sankara GH. Principles of Agronomy. Kalyani Publication. 2010; 191-241.

Singh BN and Ali M. Fertiliser News. 1994; 39: 43-45.

Tilak KVBR and Annapurna K. Effect of PSB in different crop. India National Academic Science. 1993; 59: 315-324.

Vaisya VK, Gayendregdkar, GR and Penday RL. Effect of *Rhizobium* inoculation on nodulation and grain yield of mungbean. Indian Journal of Microbiology. 1983; 23: 228-230.

Vimla B and Natarajan S. Effect of nitrogen, phosphorus and bio- fertilizers on pod characters, yield and quality in pea (*Pisum sativum* L. spp. hortense). South Indian Horticulture. 2000; 48: 60-63.