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Effect of Phosphorus and Potassium on Growth and Yield of Black Gram (*Phaseolus mungo* L.)

Kunwar Kunal Singh [a++*] and Victor Debbarma [a#]

[a] *Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagaraj-211007, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Zaid* season 2023 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The soil of the experimental field was sandy loam in texture, slightly alkaline in soil reaction (pH 8), low level of organic carbon (0.28%), available N (219 kg/ha), P (11.6 kg/ha) and K (217.2 kg/ha). The experiment was conducted in randomized block design consisting of 10 treatments with 3 different levels of phosphorus 40 kg/ha, 50 kg/ha, 60 kg/ha and different levels of potassium 25, 30 and 35 with three replications and the treatments were allocated randomly in each replication. On the topic "Effect of phosphorus and potassium on growth and yield of black gram (*Phaseolus mungo* L.)". The results showed that T_9 with the application of phosphorus (60 kg/ha) + potassium (35 kg/ha) recorded significantly higher plant height (43.81cm), higher plant nodules (40.11), higher plant dry weight (8 g), maximum crop growth rate (8.5 g/m^2/day), maximum number of pods/plant (36.61), higher seed yield (1115.62 t/ha) compared to other treatments. The

[++] *M.Sc. Scholar;*
[#] *Assistant Professor;*
**Corresponding author: E-mail: kunwarjee90@gmail.com;*

maximum gross returns (98297.69 INR/ha), maximum net returns (64701.09 INR/ha) and benefit ratio (1.93) was recorded in T_9 with the application of phosphorus (60kg/ha) + potassium (35 kg/ha) as compared to other treatments. Minimum parameters were recorded in treatment 10 control plot with RDF 20:40:20 kg/ha NPK.

Keywords: Black gram; phosphorus; potassium; growth; yield and economics.

1. INTRODUCTION

"Black gram (*Phaseolus mungo* L.) is one of the important pulse crop. All tropical and subtropical nations rely heavily on legumes as a food source, especially for grains and pulses. It is also known as urd bean, urad dal or urad. It is popular because of its nutritional quality having rich protein (22-24%), carbohydrates (56.6-59.6%), fat (1.2-1.4%), Minerals (3.2%), phosphorous (385 mg/100g) and it is rich source of calcium and potassium" (Aslam et al., 2010). It defers from other pulses in its peculiarity of attaining a somewhat mucilaginous pasty character, giving additional body to the mass due to long polymer chain of polysaccharide chain of carbohydrates. Due to cheaper protein source, it is designated as "poor man's meat" (Aslam *et al*., 2010) [1].

"About 70% of the world's black gram production comes from India. India is the world's largest producer as well as consumer of black gram. It produces about 11.99 million tonnes of Urad annually from about 9.85 million hectares of area, Uttar Pradesh black gram production 0.84 million tonnes in an area about 0.61 million hectares. Black gram area accounts for about 19 per cent of India's total pulse acreage which contributes 23 per cent of total pulse production. Madhya Pradesh, Maharashtra and Rajasthan are major black gram growing states area wise". (GOI 2021-22) [2]

"Application of phosphorus has been found very effective altogether soil types and called as vital element for increasing the yield. Aside from its essential role in growth and development of roots, phosphorus is important for growth of Rhizobium bacteria liable for biological N fixation to extend the efficiency of pulses as soil renovator and serves the twin purpose of accelerating yield of main also as succeeding crop. It also improves the standard of grain. It plays a vital role in energy storage and transfer. Phosphorus may be a constituent of nucleic acids (DNA and RNA) and majority of enzymes which are of great importance within the transformation of energy in carbohydrate metabolism and respiration of plants. Phosphorus stimulates the symbiotic organic process because in presence of phosphorus bacterial cell becomes mobile which is pre requisite for migration of bacterial cell to plant organ for nodulation" [3]. "Thus, it's going to be subjected to leaching if not haunted by plant roots. Improved potassium supply also enhances biological organic process and protein content of pulse grains" [4].

"Indian soil is deficient in potassium due to deficiency of potassium crop are less gum and protein content effect" Banti and Victor Debbarma, (2023).

"Potassium is one of the major essential plant nutrients is often required equal to or greater than other major nutrients like nitrogen, phosphorous. Even though it's not a part of any plant structure, it is found in the plant sap involved in many physiological and biochemical functions of plant growth. K is one of the three major dietary elements since plants need it in considerable amounts" (Golakiya and Patel, 1988; Leigh and Jones, 1984; Dev,1995). "Potassium application has been neglected in many countries, including India, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields" (Regmi *et al*., 2002; Panaullah et al., 2006). Keeping all the points in view the above fact, the experiment was conducted to find out the "Effect of Phosphorus and Potassium on Growth and Yield of black gram" is carried with following objectives.

2. MATERIALS AND METHODS

The experiment was conducted during *Zaid* season 2023 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P). The topic titled "Effect of phosphorus and potassium on growth and yield of black gram (*Phaseolus mungo* L.)", to study the response of Phosphorus (40 kg/ha, 50 kg/ha, 60 kg/ha) with combination of Potassium (25, 30 and 35kg/ha). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.0), low in organic carbon (0.64 %), available Nitrogen (220 kg/ha), available P (37 kg/ha) and available K (240.7 kg/ha). There were 10 treatments, and replicated thrice and laid out in Randomized Block Design (RBD). The treatment combinations are T_1 : [Phosphorus (40 kg/ha) + Potassium (25 kg/ha)], T_2 : [Phosphorus (40kg/ha) + Potassium (30 kg/ha)], T_3 : [Phosphorus (40 kg/ha) + Potassium (35 kg/ha)], T_4 : [Phosphorus (50 kg/ha) + Potassium (25 kg/ha)], T_5 : [Phosphorus (50 kg/ha) + Potassium (30kg/ha)], T_6 : [Phosphorus (50 kg/ha) + Potassium (35kg/ha)], T_7 : [Phosphorus (60 kg/ha) + Potassium (25kg/ha)], T_8 : [Phosphorus (60 kg/ha) + Potassium (30kg/ha)], T_9 : [Phosphorus (60 kg/ha) + Potassium (35kg/ha)], T_{10} : [RDF 20:40:20 kg/ha NPK] (Control). The data recorded on different aspects of crop such as, growth parameters and yield attributes were subjected to statistical analysis by variance method Gomez and Gomez (1976).

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

At 60 DAS, significantly higher plant height (43.81 cm) was observed in the treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] over all the other treatments. However, the treatment 7 [Phosphorus (60 kg/ha) + Potassium (25 kg/ha)] and treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] which were found to be at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)]. might be due to phosphorus stimulates cell division which helps in increasing plant growth it also enhances the nodulation in root zone which is responsible for nitrogen fixation which might have helped in attaining higher plant height. Further, Potassium plays vital role in cell expansion and cell division helps in improving plant height. Similar results were also reported by Yadav et al [5] and Adsure et al. [6].

3.1.2 Nodules/plant

At 60 DAS, significantly higher nodules/plant (23.00) was observed in the treatment 9 [Phosphorus (60kg/ha) + Potassium (35 kg/ha)]. However, treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] were found to be statistically at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] might be due to phosphorus increased as phosphorus being a component of nucleic acids and various forms of proteins, which could have stimulated cell division, resulted with increased of nodules/plant. Further, potassium may have influenced the protein formation leading to increase in number of nodules in plant. Similar results were also reported by Niraj et al. (2013) and Abraham *et al*. [7].

3.1.3 Plant dry weight (g)

At 60 DAS, significantly higher plant dry weight (8.00 g/plant) was recorded with treatment 9 [(60 kg/ha) Phosphorus + (35 kg/ha). However, the treatment 7 [Phosphorus (60 kg/ha) + Potassium (25 kg/ha)] and treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] were found to be statistically at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] might be due to the cumulative effect of increasing in plant height and number of leaves which may have resulted in increasing the dry matter production of plant, phosphorus might enhance the activity of rhizome and increase the formation of root nodule and might be helps in fixing more of atmospheric nitrogen in root nodule. Further, might be due to potassium, the production of phytohormones like cytokine, potassium is essential for meristematic growth, which aids in enhancing plant growth particularly plant dry weight. Similar results were reported by Masih et al. [8] and Sahithi et al. [9].

3.1.4 Crop growth rate (g/m^2/day)

At 45-60 DAS, significantly higher Crop growth rate (8.50 g/m^2/day) was recorded with treatment 9 [Phosphorus (60 kg/ha) + Potassium(35 kg/ha)]. However, the treatment 4 [Phosphorus(50 kg/ha) + Potassium(25 kg/ha)], treatment 5 [Phosphorus (50 kg/ha)+ Potassium (30 kg/ha)], treatment 6 [Phosphorus (50 kg/ha) + Potassium (35 kg/ha)], treatment 7 [Phosphorus (60 kg/ha) + Potassium (25 kg/ha)] and treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] were found to be statistically at par with treatment 9 [Phosphorus(60 kg/ha) + Potassium(35 kg/ha)] might be due to phosphorus the physiological and metabolic processes of the plant, enabling it to develop more quickly by assimilating the available nutrients quickly and facilitating more photosynthesis, which in turn raises the crop growth rate. Similar result was reported by Nawhal et al. (2021).

3.1.5 Relative growth rate (g/g/day)

The data found that non- significant and highest relative growth rate (0.006 g/g/day) was recorded with 9 [phosphorus (60 kg/ha) + Potassium (35 kg/ha)] as compared to rest of the treatments (Table 1).

3.2 Yield Attributes and Yield

3.2.1 Number of pods/plant

Significant and maximum number of pods/plant (36.33) was recorded with the treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)]. However, treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] was found to be statistically at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] might be due to use of phosphorus increases symbiotic nitrogen fixation which may have increased the number of pods/plants. Further, balanced application of NPK which may have effect N and P fertilization in the presence of K, where, the crop's rate of photosynthetic and symbiotic activity might have increased, which may be stimulating stronger vegetative and reproductive growth particularly higher number of pods/ plant. Similar results were also reported by Parashar et al. [10] and Adsure et al. [6].

3.2.2 Number of seeds/pod

Significant and maximum number of seeds/pod (6.89) was recorded with the treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)]. However, the treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] was found to be statistically at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] might be due to phosphorus increase in vegetative development and reproductive attributes under proper phosphorus availability and improved soil physical properties. Further, potassium supports the development of strong cell walls and the cumulative effect in improvement of number of seeds/pod Similar results were also reported by Singh et al. [11] and Sahithi et al. [9].

3.2.3 Test weight (g)

Significant and higher test weight (37.69 g) was recorded with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)]. However, the treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] was found to be statistically at par with treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] might be due to phosphorus increased availability of nutrients in the soil has a big impact on the yield parameters, phosphorus might be boosted the plant photosynthesis, which may resulted in efficient assimilation and partitioning of photosynthates from sources to sink. Furthur, potassium supports the development of strong cell walls and the cumulative effect improvement in test weight. Similar result was also reported by Singh et al. (2020) and Sahithi et al. [9]

3.2.4 Seed yield (kg/ha)

Significant and higher Seed yield (1115.62 kg/ha) was recorded with the treatment application of treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)]. However, the treatment 8 [Phosphorus (60 kg/ha) + Potassium (30 kg/ha)] was found to be statistically at par with treatment 9 [Phosphorus(60 kg/ha) + Potassium(35 kg/ha)] might be due to phosphorus better nodulation and efficient functioning of nodule bacteria for fixation of N to be utilized by plants during grain development stage in the synthesis of protein as reflected in N uptake which in turn led to increase in seed yield. Further, potassium that could be because it improves the food environment of the rhizosphere and the plant system leading to increased nutrient translocation in various plants parts, which might directly responsible for seed yield. Similar results were reported by Singh et al [12] and Jat et al. (2019).

3.2.5 Harvest index (%)

Significant and higher harvest index (35.83 %) was recorded with treatment 7 [Phosphorus (60kg/ha) + Potassium (25kg/ha)]. However, the treatment 8 [Phosphorus (60 kg/ha) + Potassium (30kg/ha)] and treatment 9 [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)] were found to be statistically at par with treatment 7 [Phosphorus (60kg/ha) + Potassium (25 kg/ha)] phosphorus might be due to that photosynthates are being transported more effectively from source to sink. Further, application of potassium might be due to mineral nutrients, including potassium, which may be applied superficially when crop demand is at its high, are better absorbed and transported. Similar results were also reported by Singh *et al.* (2018) [11] and Rahimi et al. (2019) [13-17].

Table 1. Effect of phosphorus and potassium on growth attributes of black gram

		At 60 DAS				
S. No.	**Treatments**	**Plant height (cm)**	**Number of nodules/plant**	**Dry weight (g)**	**CGR g/m^2/day**	**RGR(g/g/day)**
1.	Phosphorus 40kg/ha + Potassium 25kg/ha	37.30	18.56	5.23	5.14	0.04
2.	Phosphorus 40kg/ha + Potassium 30kg/ha	38.57	19.11	6.12	6.72	0.05
3.	Phosphorus 40kg/ha + Potassium 35kg/ha	39.00	19.11	6.13	6.33	0.04
4.	Phosphorus 50kg/ha+ Potassium 25kg/ha	38.58	19.33	6.46	6.98	0.04
5.	Phosphorus 50kg/ha + Potassium 30kg/ha	39.66	19.44	7.18	6.90	0.05
6.	Phosphorus 50kg/ha+ Potassium 35kg/ha	40.17	20.56	7.24	8.36	0.05
7.	Phosphorus 60kg/ha+ Potassium 25kg/ha	41.80	20.89	7.39	9.54	0.06
8.	Phosphorus 60kg/ha + Potassium 30kg/ha	41.92	22.22	7.48	7.62	0.04
9.	Phosphorus 60kg/ha + Potassium 35kg/ha	43.81	23.00	8.00	8.50	0.04
10.	Control	37.35	17.67	5.24	5.13	0.04
	SEm (±)	1.18	0.68	0.203	0.55	0.003
	CD (P=0.05)	2.02	2.04	0.61	1.66	0.01

Table 2. Effect of phosphorus and potassium on yield attributes of black gram

S. No.	**Treatments**	**No. of pods/plant**	**Seed/pod**	**Test weight (g)**	**Seed yield (kg/ha)**	**Harvest index (%)**
1.	Phosphorus 40 kg/ha + Potassium 25kg/ha	27.44	3.66	31.03	615.61	28.93
2.	Phosphorus 40 kg/ha + Potassium 30kg/ha	28.88	4.66	33.55	690.01	31.13
3.	Phosphorus 40 kg/ha + Potassium 35kg/ha	29.12	4.88	32.81	732.20	30.75
4.	Phosphorus 50 kg/ha+ Potassium 25kg/ha	30.41	5.00	31.52	809.01	31.27
5.	Phosphorus 50 kg/ha + Potassium 30kg/ha	31.88	5.33	34.87	870.28	32.22
6.	Phosphorus 50 kg/ha+ Potassium 35kg/ha	33.44	6.55	37.26	913.64	31.90
7.	Phosphorus 60 kg/ha+ Potassium 25kg/ha	34.51	5.67	35.04	974.28	35.83
8.	Phosphorus 60 kg/ha + Potassium 30kg/ha	35.14	5.76	35.94	1061.75	35.80
9.	Phosphorus 60kg/ha + Potassium 35kg/ha	36.61	6.89	37.69	1115.62	35.47
10.	Control	27.44	3.66	29.30	567.35	30.45
	SEm (±)	0.57	0.38	0.59	25.93	0.83
	CD (P=0.05)	1.72	1.15	1.76	77.04	2.50

Table 3. Effect of phosphorus and potassium on economics of Black gram

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	40 kg/ha Phosphorus + 25 kg/ha Potassium	32263.2	55294.16	23030.96	0.71
2.	40 kg/ha phosphorus + 30 kg/ha potassium	32430	61309.81	28879.81	0.89
3.	40 kg/ha Phosphorus + 35 kg/ha potassium	32596.6	65173.31	32576.71	1.00
4.	50 kg/ha phosphorus + 25 kg/ha Potassium	32763.2	71839.75	39076.55	1.19
5.	50 kg/ha phosphorus + 30 kg/ha Potassium	32930	76948.35	44018.35	1.34
6.	50 kg/ha Phosphorus + 35 kg/ha Potassium	33096.6	80900.53	47803.93	1.44
7.	60 kg/ha Phosphorus + 25 kg/ha Potassium	33263.2	84931.03	51667.83	1.55
8.	60 kg/ha Phosphorus + 30 kg/ha Potassium	33430	92547.68	59117.68	1.77
9.	60 kg/ha Phosphorus + 35 kg/ha Potassium	33596.6	98297.69	64701.09	1.93
10.	Control	32098	50569.20	18471.20	0.58

Selling price of grain/Kg – 80.00 INR; Selling price of straw/Kg – 4.00 INR

3.6 Economics

The data pertaining to the economics of different treatments presented in Table 3 showed that the maximum gross return (98297.69 INR/ha), net return (64701.09 INR /ha), and benefit-cost ratio (1.93) was obtained in the T_9 : [Phosphorus (60 kg/ha) + Potassium (35 kg/ha)], and the minimum gross return (50569.20 INR/ha), net return (18471.20 INR/ha), and lowest benefit-cost ratio (0.58) were recorded in treatment 10 (control).

4. CONCLUSION

It is concluded that in black gram treatment 9 with application of Phosphorus (60 kg/ha) and Potassium (35 kg/ha) recorded highest yield and benefit cost ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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