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Effect of different levels of phosphorous and biofertilizers on growth and yield attributes of the blackgram (*Vigna mungo* L.) in the Grid Region

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Abstract

A field experiment was conducted to determine the effect of different levels of Phosphorous and biofertilizers on the growth and yield attributes of blackgram (Vigna mungo L.). The soil of the experimental field was sandy loam in texture with low content of organic matter and accessible nitrogen, medium in available potash and phosphorous. The field experiment was carried out during Kharif 2021 to test three phosphorous Levels (45, 60, and 75 Kg ha^{-1}) and three biofertilizers (Rhizobium, PSB, and Azospirillum) with absolute control. Thus, a Randomized Block Design with 10 treatments and 3 Replications was employed. Other recommended agronomical practices administered in all the treatments were similar. The growth, yield attribute, and yield in the plots treated with 75 Kg P_2O_5 ha^{-1}+ Rhizobium were higher than other treatments but at par with 60 Kg P_2O_5 ha^{-1}+ Rhizobium. Therefore, according to economics 60 Kg, of P_2O_5 ha^{-1}+Rhizobium may be recommended as the best dose for the cultivation of blackgram in the Grid region.

Keywords: *Azospirillum*, Biofertilizers, Blackgram, Phosphorous levels, Phosphate solubilizing Bacteria, PSB, *Rhizobium*

Introduction

Pulses are known as the wizard of the health+, and their nomenclature pulse (P = People, U = Umbrella, L = Animals, S = Soil, E = Energy). Pulse crops provide superb energy and are symbiotic as an umbrella for people as dietary proteins, further pulse crops are a boon to livestock as it is a source of green nutritious fodder and feed for soil as these enrich the soil by working as a mini-nitrogen plant and green manure (Ajewole, 2002). Pulses belong to the Leguminosae family commonly known as Fabaceae. The word pulse refers exclusively to the dried seed. The term “pulse” is derived from the Latin word “puls,” meaning thick soup, potage, or broth (Keshavarz *et al.,* 2020). It is a solitary crop that is collected as a dry seed. Important pulse crops produced in India included gram (Chickpea), urd been (blackgram), Moong bean (green gram), Pigeon pea (red gram), and Masur (lentils). Pulses are typically utilized as dietary protein for vegetarians. Pulses contain approximately 21–25% protein; however, have a limiting amount of essential amino acids such as methionine, tryptophan, and cystine (Tiwari and Singh 2012). Pulse grains are an excellent source of protein, carbohydrates, dietary fibre, vitamins, minerals, and phytochemicals (Singh 2017). Pulses protein is high in Lysine holding an average of 65.7 mg g protein^{-1}. The total blackgram production in India was 2.89 million tonnes from an area of

3.56 million hectares. Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamil Nadu, Karnataka, Odisha, and Gujarat. Are important blackgram-producing states in India. In Madhya Pradesh, the total area was 9.32 lakh hectares with a total production of 515 million tonnes and productivity of 553 kg ha^{-1} (MoAFW 2017). Blackgram (*Vigna mungo* L.) belongs to the family "Leguminosae" and sub-family "Papilionaceous" and has the chromosome number 2n=24. Cultivated blackgram (also known as urd, urad, or mash; *Vigna mungo* var. *mungo* (L.) Hepper) is believed to have been domesticated in India from its wild progenitor, *Vigna mungo* var. *silvestris* Lukoki, Maréchal, and Otoul (Chandel *et al.,* 1984).

Phosphorous is an essential constituent of every living cell. Phosphorous is the most vital nutrient for plant growth and development. In Indian soils, the amount of phosphorus is low to medium. Phosphorus is referred to as the "kingpin" in Indian agriculture and also as the "energy currency" of plants (Dey *et al.,* 2017). Phosphorous comprises important components of ATP and it works as the energy unit of plants. At the moment of photosynthesis, ATP will develop, it contains phosphorous in its structure. Phosphorous also supports the appropriate growth of root and root nodules to increase nitrogen fixation and which helps to build crop quality and resistance to plant disease (Scheublin *et al.,* 2004). This procedure is from the commencement of seedling development up to the creation of grain and maturity. Phosphorous also supports the appropriate growth of root and root nodules to increase nitrogen fixation and which helps to build crop quality and resistance to plant disease. Phosphorous is the most vital nutrient for plant growth and development. In Indian soils, the amount of phosphorus is low to medium (Pattanayak *et al.,* 2009).

Suhag (2016) described that biofertilizers are compounds that contribute nutrients via the natural process of fixing atmospheric nitrogen, solubilizing phosphorous, and aid for plant development through the manufacture of growth-encouraging material. Examples: *Rhizobium*, PSB (Phosphate solubilizing bacteria), *Azospirillum*, etc., *Rhizobium* is a symbiotic bacterium that helps to fix atmospheric nitrogen in connection with the roots of legumes and higher plants. It is a genus of Gram-negative bacteria. The effect of this symbiosis is to create nodules (Delves *et al.,* 1986) on the plant root where it transforms air nitrogen into ammonia that may be utilized by the plant. Rhizobia are a group of soil bacteria that infect the roots of legume plants which leads to the creation of root nodules where they fix nitrogen gas (N_2) from the atmosphere transforming it into the beneficial form of nitrogen for plants. PSB (Phosphate solubilizing bacteria) biofertilizer assists plants by transforming an insoluble form of phosphorous into a soluble form and scavenging phosphate from soil layers (Rawat *et al.,* 2021). It aids in promoting the life cycle of micro-organisms in the soil which are capable of converting insoluble phosphorous and making it accessible for crops by secreting specific organic acids resulting in a decrease in soil pH. Different forms of organic acids, including citric acid, gluconic acid, lactic acid, succinic acid, propionic acid, and three more unknown organic acids were formed from the cultures of these isolates (Selvakumar 2012). And it also helps to prevent fungal illnesses by demonstrating anti-fungal activities. *Azospirillum* is a free-living Gram-negative bacterium that fixes atmospheric nitrogen for plant growth and development (Steenhoudt and Vanderleyden 2000). It is a non-photosynthetic bacterium that may thrive in aerobic, microaerobic, and anaerobic environments. It helps to synthesize phytohormones like Indole-3-acetic acid and is thought to boost biotic and abiotic stress tolerance capability thereby aiding in plant development.

Materials and methods

The experiment was carried out at the School of Agriculture, ITM University Gwalior, (M.P.) during the Kharif season of 2020-21. The experiment was conducted factorial randomized block design with ten treatments and three replications. In the experiment phosphorous was applied according to different levels and biofertilizers were applied as seed treatment as mentioned in the treatments, whereas nitrogen and potassium were applied as a recommended dose of fertilizer. The treatments under studied were Control, 45 Kg P_2O_5 ha^{-1} + *Rhizobium*, 45 Kg P_2O_5 ha^{-1} + PSB, 45 Kg P_2O_5 ha^{-1} + *Azospirillum*, 60 Kg P_2O_5 ha^{-1} + *Rhizobium*, 60 Kg P_2O_5 ha^{-1} + PSB, 60 Kg P_2O_5 ha^{-1} + *Azospirillum*, 75 Kg P_2O_5 ha^{-1} + *Rhizobium*, 75 Kg P_2O_5 ha^{-1} + PSB, 75 Kg P_2O_5 ha^{-1} + *Azospirillum*. The gross and net plot size was 4.5 m x 4.5 m and 3.5 m x 3.9 m^2, respectively. All other agronomic practices were practiced uniformly for all the treatments. Sowing is done by dibbling by using the seed rate is used 15-20 kg ha^{-1}. Spacing for sowing row to row 30 cm and plant to plant 10 cm. The recommended dose of fertilizer was 30:60:25 N:P:K kg ha^{-1} applied as per treatment and other cultural practices like gap filling, thinning and weeding done as per the schedule of days. Statistical analysis of the data was carried out by using Two Way ANOVA (Panse and Sukhantme 1967).

Result and discussion

The effect of different levels of phosphorous and biofertilizers on the growth attributes of a blackgram at harvest have been presented in Table 1. The maximum plant height ($p<0.05$) recorded from the plot which was treated with 75 Kg P_2O_5 ha^{-1} (57.4 cm) was at par with 60 Kg P_2O_5 ha^{-1} (53.9 cm) and significantly superior to 45 Kg P_2O_5 ha^{-1}(48.7 cm). As far as the biofertilizers are concerned, significantly superior plant height ($p<0.05$) was recorded from the plot given *Rhizobium* (57.0 cm) and PSB (54.5 cm) compared to that given *Azospirillum* (48.5 cm). The inferior plant height was recorded in absolute control (39.5 cm) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The effectiveness of phosphorous on the number of leaves was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (22.5 $plant^{-1}$) and 60 Kg P_2O_5 ha^{-1} (21.0 $plant^{-1}$) compared to that with 45 Kg P_2O_5 ha^{-1} (19.2 $plant^{-1}$). *Rhizobium* (21.7 $plant^{-1}$) and PSB (21.6 $plant^{-1}$) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment (19.4 $plant^{-1}$) in the blackgram. The number of leaves $plant^{-1}$ was recorded lower in the absolute control (17.7 $plant^{-1}$). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. Regarding leaf area, 75 Kg P_2O_5 ha^{-1} (39.9) and 60 Kg P_2O_5 ha^{-1} (36.9) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (33.3). The maximum leaf area ($p<0.05$) was recorded from the plot treated with *Rhizobium* (39.6) and PSB (37.1) in comparison to the application of *Azospirillum* in the crop (33.3). A low leaf area was recorded in absolute control (29.8). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of regime of 75 Kg P_2O_5 ha^{-1} (5.99 $plant^{-1}$) and 60 Kg P_2O_5 ha^{-1} (5.37 $plant^{-1}$) on the number of branches was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (4.31 $plant^{-1}$). The regime of *Rhizobium* (5.74 $plant^{-1}$) and PSB (5.43 $plant^{-1}$) was better ($p<0.05$) than that of *Azospirillum* (4.49 $plant^{-1}$) on the number of branches. Absolute control (3.22 $plant^{-1}$) reported inferior results ($p<0.05$) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The effectiveness of phosphorous on the number of nodules was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (24.5 plant^{-1}) and 60 Kg P_2O_5 ha^{-1} (22.5 plant^{-1}) compared to that with 45 Kg P_2O_5 ha^{-1} (20.3 plant^{-1}). *Rhizobium* (24.4 plant^{-1}) and PSB (22.8 plant^{-1}) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment (20.2 plant^{-1}) in the blackgram. The number of nodules was recorded lower ($p<0.05$) in the absolute control (17.8 plant^{-1}). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. For nodules dry weight, 75 Kg P_2O_5 ha^{-1} (15.0 mg) and 60 Kg P_2O_5 ha^{-1} (14.6 mg) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (12.6 mg). The response to the effect of Biofertilizers on nodule dry weight, higher results ($p<0.05$) were recorded from the plots treated with *Rhizobium* (15.1 mg) and PSB (14.2 mg) in comparison to the application of *Azospirillum* in the crop (12.9 mg). A low leaf area ($p<0.05$) was recorded in absolute control (11.0 mg) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of administration of 75 Kg P_2O_5 ha^{-1} (430 g m^{-2}) and 60 Kg P_2O_5 ha^{-1} (386 g m^{-2}) on dry matter accumulation was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (340 g m^{-2}). The administration of *Rhizobium* (422 g m^{-2}) and PSB (390 g m^{-2}) was better ($p<0.05$) than that of *Azospirillum* (344 g m^{-2}) on dry matter accumulation. Absolute control (288 g m^{-2}) reported inferior results ($p<0.05$) in this respect. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect.

Table 1: Effect of different levels of phosphorous and biofertilizers on growth attributes of blackgram at harvest

Treatments	Plant height (cm)	Leaf area (m^2)	No. of leaves (Plant^{-1})	No. of branches (Plant^{-1})	No. of Nodules (Plant^{-1})	Nodules dry weight (mg)	Dry matter accumulation (g m^{-2})
Phosphorous Levels (Kg ha^{-1}) [P]							
45	48.7	33.3	19.2	4.31	20.3	12.6	340
60	53.9	36.9	21.0	5.37	22.5	14.6	386
75	57.4	39.9	22.5	5.99	24.5	15.0	430
SEm±	1.5	1.2	0.6	0.16	0.8	0.4	15
CD (P=0.05)	4.4	3.5	1.7	0.46	2.0	1.2	44
Biofertilizers [B]							
Rhizobium	57.0	39.6	21.7	5.74	24.4	15.1	422
PSB	54.5	37.1	21.6	5.43	22.8	14.2	390
Azospirillum	48.5	33.3	19.4	4.49	20.2	12.9	344
SEm±	1.5	1.2	0.6	0.16	0.7	0.4	15
CD (P=0.05)	4.4	3.5	1.7	0.46	2.0	1.2	44
Control	39.5	29.8	17.7	3.22	17.8	11.0	288
P X B							
SEm±	2.6	2.1	1.0	0.27	1.2	0.72	26
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

The effect of different levels of phosphorous and biofertilizers on yield attributes and yield of blackgram at harvest have been presented in Table 2. The effectiveness of phosphorous on the number of pods was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (32. 9 $Plant^{-1}$) and 60 Kg P_2O_5 ha^{-1} (30.7 $Plant^{-1}$) compared to that with 45 Kg P_2O_5 ha^{-1} (26.0 $Plant^{-1}$). *Rhizobium* (32.7 $Plant^{-1}$) and PSB (30.5 $Plant^{-1}$) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment (26.5 $Plant^{-1}$) in the blackgram. The number of pods was recorded lower in the absolute control (19.7 $Plant^{-1}$). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of regime of 75 Kg P_2O_5 ha^{-1} (6.67 Pod^{-1}) and 60 Kg P_2O_5 ha^{-1} (6.30 Pod^{-1}) on the number of grains was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (5.26 Pod^{-1}). The regime of *Rhizobium* (6.69 Pod^{-1}) and PSB (6.41 Pod^{-1}) was better ($p<0.05$) than that of *Azospirillum* (5.13 Pod^{-1}) on the number of grains. Absolute control (2.55 Pod^{-1}) reported inferior results ($p<0.05$) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. For test weight (1000 seeds), 75 Kg P_2O_5 ha^{-1} (38.0 g) and 60 Kg P_2O_5 ha^{-1} (35.8 g) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (32.7 g). The response of the effect of Biofertilizers on test weight (1000 seeds) may be explained that the higher results ($p<0.05$) were recorded from the plots treated with *Rhizobium* (36.8 g) and PSB (36.6 g) in comparison to the application of *Azospirillum* in the crop (33.1 g). A low leaf area ($p<0.05$) was recorded in absolute control (29.8 g) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The maximum grain yield ($p<0.05$) recorded from the plot which was treated with 75 Kg P_2O_5 ha^{-1} (971 Kg ha^{-1}) which was at par with 60 Kg P_2O_5 ha^{-1} (962 Kg ha^{-1}) and significantly superior to 45 Kg P_2O_5 ha^{-1} (841 Kg ha^{-1}). As far as the biofertilizers are concerned, significantly superior grain yield ($p<0.05$) was recorded from the plot given *Rhizobium* (968 Kg ha^{-1}) and PSB (962 Kg ha^{-1}) compared to that given *Azospirillum* (843 Kg ha^{-1}). The inferior plant height was recorded in absolute control (514 Kg ha^{-1}) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of administration of 75 Kg P_2O_5 ha^{-1} (1191 Kg ha^{-1}) and 60 Kg P_2O_5 ha^{-1} (1123 Kg ha^{-1}) on stover yield was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (1013 Kg ha^{-1}). The administration of *Rhizobium* (1156 Kg ha^{-}) and PSB (1136 Kg ha^{-1}) was better ($p<0.05$) than that of *Azospirillum* (1036 Kg ha^{-1}) on stover yield. Absolute control (952 Kg ha^{-1}) reported inferior results ($p<0.05$) in this respect. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. Regarding biological yield, 75 Kg P_2O_5 ha^{-1} (2161 Kg ha^{-1}) and 60 Kg P_2O_5 ha^{-1} (2084 Kg ha^{-1}) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (1854 Kg ha^{-1}). The maximum biological yield ($p<0.05$) was recorded from the plot treated with *Rhizobium* (2124 Kg ha^{-1}) and PSB (2097 Kg ha^{-1}) in comparison to the application of *Azospirillum* in the crop (1879 Kg ha^{-1}). A low leaf area was recorded in absolute control (1466 Kg ha^{-1}). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The effectiveness of phosphorous on harvest index was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (44.9 %) and 60 Kg P_2O_5 ha^{-1} (46.1 %) compared to that with 45 Kg P_2O_5 ha^{-1} (45.3 %). *Rhizobium* (45.6 %) and PSB (45.9 %) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment

(44.9 %) in the blackgram. The harvest index was recorded lower ($p<0.05$) in the absolute control (35.0 %). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. Present findings confirmed the results of Kant *et al.,* (2016) who studied the effect of the use of various levels of phosphorus and different bio-fertilizers in combination.

The effect of different levels of phosphorous and biofertilizers on yield attributes and yield of blackgram at harvest have been presented in Table 2. The effectiveness of phosphorous on harvest index was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (44.9 %) and 60 Kg P_2O_5 ha^{-1} (46.1 %) compared to that with 45 Kg P_2O_5 ha^{-1} (45.3 %). *Rhizobium* (45.6 %) and PSB (45.9 %) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment (44.9 %) in the blackgram. The harvest index was recorded lower ($p<0.05$) in the absolute control (35.0 %). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The maximum grain yield ($p<0.05$) recorded from the plot which was treated with 75 Kg P_2O_5 ha^{-1} (971 Kg ha^{-1}) which was at par with 60 Kg P_2O_5 ha^{-1} (962 Kg ha^{-1}) and significantly superior to 45 Kg P_2O_5 ha^{-1} (841 Kg ha^{-1}). As far as the biofertilizers are concerned, significantly superior grain yield ($p<0.05$) was recorded from the plot given *Rhizobium* (968 Kg ha^{-1}) and PSB (962 Kg ha^{-1}) compared to that given *Azospirillum* (843 Kg ha^{-1}). The inferior plant height was recorded in absolute control (514 Kg ha^{-1}) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of regime of 75 Kg P_2O_5 ha^{-1} (6.67 Pod^{-1}) and 60 Kg P_2O_5 ha^{-1} (6.30 Pod^{-1}) on the number of grains was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (5.26 Pod^{-1}). The regime of *Rhizobium* (6.69 Pod^{-1}) and PSB (6.41 Pod^{-1}) was better ($p<0.05$) than that of *Azospirillum* (5.13 Pod^{-1}) on the number of grains. Absolute control (2.55 Pod^{-1}) reported inferior results ($p<0.05$) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The response of administration of 75 Kg P_2O_5 ha^{-1} (1191 Kg ha^{-1}) and 60 Kg P_2O_5 ha^{-1} (1123 Kg ha^{-1}) on stover yield was noted better ($p<0.05$) than that of 45 Kg P_2O_5 ha^{-1} (1013 Kg ha^{-1}). The administration of *Rhizobium* (1156 Kg ha^{-}) and PSB (1136 Kg ha^{-1}) was better ($p<0.05$) than that of *Azospirillum* (1036 Kg ha^{-1}) on stover yield. Absolute control (952 Kg ha^{-1}) reported inferior results ($p<0.05$) in this respect. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. Regarding biological yield, 75 Kg P_2O_5 ha^{-1} (2161 Kg ha^{-1}) and 60 Kg P_2O_5 ha^{-1} (2084 Kg ha^{-1}) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (1854 Kg ha^{-1}). The maximum biological yield ($p<0.05$) was recorded from the plot treated with *Rhizobium* (2124 Kg ha^{-1}) and PSB (2097 Kg ha^{-1}) in comparison to the application of *Azospirillum* in the crop (1879 Kg ha^{-1}). A low leaf area was recorded in absolute control (1466 Kg ha^{-1}). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. For test weight (1000 seeds), 75 Kg P_2O_5 ha^{-1} (38.0 g) and 60 Kg P_2O_5 ha^{-1} (35.8 g) applications reported better results ($p<0.05$) compared to 45 Kg P_2O_5 ha^{-1} (32.7 g). The response of the effect of Biofertilizers on test weight (1000 seeds), the higher results ($p<0.05$) were recorded from the plots treated with *Rhizobium* (36.8 g) and PSB (36.6 g) in comparison to the application of *Azospirillum* in the crop (33.1 g). A low leaf area ($p<0.05$) was recorded in absolute control (29.8 g) in this regard. The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. The effectiveness of phosphorous on the number of pods was observed more effective ($p<0.05$) in the plots treated with 75 Kg P_2O_5 ha^{-1} (32. 9 Plant^{-1}) and 60 Kg P_2O_5 ha^{-1} (30.7 Plant^{-1}) compared to that with 45 Kg P_2O_5 ha^{-1} (26.0 Plant^{-1}). *Rhizobium* (32.7 Plant^{-1}) and PSB (30.5 Plant^{-1}) were also recorded as superior ($p<0.05$) compared to the *Azospirillum* treatment (26.5 Plant^{-1}) in the blackgram. The number of pods was recorded lower in the absolute control (19.7 Plant^{-1}). The interaction between various phosphorus levels and biofertilizers remained nonsignificant ($p>0.05$) in this respect. Ananda *et al.,* (2014) reported that the application of phosphorus responded favorably up to 50 kg ha^{-1} for yield attributes, grain, and straw yield. The variation in this regard may be due to different soil fertility. In the present study, the soil fertility in terms of soil nitrogen, available phosphorus, and organic carbon was low. Present findings confirmed the results of Kant *et al.,* (2016) who studied the effect of the use of various levels of phosphorus and different bio-fertilizers in combination. The maximum value of yield attributes and seed yield of blackgram was obtained with the application of 75 kg P_2O_5 ha^{-1} (Kadam *et al.,* 2014).

Table.2: Effect of different levels of phosphorous and biofertilizers on yield attributes and yield of blackgram at harvest

Treatments	Pods (Plant^{-1})	Grains (Pod^{-1})	Test weight (g 1000 seeds^{-1})	Grain yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)
Phosphorous Levels (Kg ha^{-1}) [P]							
45	26.0	5.26	32.7	841	1013	1854	45.3
60	30.7	6.30	35.8	962	1123	2084	46.1
75	32. 9	6.67	38.0	971	1191	2161	44.9
SEm±	0.9	0.21	1.0	23	31. 7	17	0.4
CD (P=0.05)	2.7	0.64	3.0	68	94.1	50	1.1
Biofertilizers [B]							
Rhizobium	32.7	6.69	36.8	968	1156	2124	45.6
PSB	30.5	6.41	36.6	962	1136	2097	45.9
Azospirillum	26.5	5.13	33.1	843	1036	1879	44.9
SEm±	0.9	0.21	1.0	23	32	17	0.4
CD (P=0.05)	2.7	0.64	3.0	68	94	50	1.1
Control	19.7	2.55	29.8	514	952	1466	35.0
P X B							
SEm±	1.6	0.37	1.7	40	55	30	0.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

The effect of different levels of phosphorous and biofertilizers on the economics of blackgram has been presented in Table 3. The highest cost of cultivation was recorded in the groups treated with *Rhizobium* + P_2O_5 75 Kg ha^{-1} (INR 32940 ha^{-1}) followed by PSB + P_2O_5 75 Kg ha^{-1} (INR 32910 ha^{-1}) and T10-*Azospirillum* + P_2O_5 75 Kg ha^{-1} (INR 32888 ha^{-1}), whereas lowest in the absolute control group (INR 29931 ha^{-1}). The reason may perhaps be because of the cost of phosphorus fertilizer and the biofertilizer involved in respective treatments. The gross return was recorded in the groups administered *Rhizobium* + P_2O_5 75 Kg ha^{-1} (INR 107397 ha^{-1}) followed by PSB + P_2O_5 75 Kg ha^{-1} (INR 105832 ha^{-1}) and *Rhizobium* + P_2O_5 60 Kgha^{-1} (INR 104894 ha^{-1}), whereas lowest in the absolute control group (INR 57669 ha^{-1}). The reason may perhaps be because of the grain and stover yield obtained in the respective treatments. The net return was recorded in the groups administered *Rhizobium* + P_2O_5 75 Kg ha^{-1} (INR 74457 ha^{-1}) followed by PSB + P_2O_5 75 Kg ha^{-1} (INR 72922 ha^{-1}) and *Rhizobium* + P_2O_5 60 Kgha^{-1} (INR 72535 ha^{-1}), whereas lowest in the absolute control group (INR 27738 ha^{-1}). The reason may perhaps be because of the difference in gross return and cost of cultivation in the respective treatments. The benefit-to-cost ratio (B-C ratio) was recorded in the groups administered *Rhizobium* + P_2O_5 75 Kg ha^{-1} (INR 2.26 INR^{-1}) followed by *Rhizobium* + P_2O_5 60 Kg ha^{-1} (INR 2.24 INR^{-1}) and PSB + P_2O_5 60 Kg ha^{-1} (INR 2.23 INR^{-1}), whereas lowest in the absolute Control group (INR 0.92 INR^{-1}). The reason may perhaps be because of the difference in gross return and cost of cultivation in the respective treatments. Present findings verified the results of Kumar *et al.,* (2021) who reported that the application of P_2O_5 at 60 kg ha^{-1} resulted in a significant increase in all the economical attributes over 30 kg P_2O_5 kg ha^{-1}. The interaction effect of fertility levels and biofertilizers significantly influenced the yield and economics of blackgram maximum being with 100% RDF and Rhizobium +PSB combination (Jangir *et al.,* 2016).

Table 3: Effect of different levels of phosphorous and biofertilizers on the economics of blackgram at harvest.

Treatments	Cost of Cultivation (INR ha^{-1})	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B-C Ratio
Control	29931	57669	27738	0.92
Rhizobium +P_2O_5 45 Kgha^{-1}	31769	90720	58951	1.85
PSB+ P_2O_5 45 Kgha^{-1}	31739	90114	58375	1.83
Azospirillum + P_2O_5 45 Kgha^{-1}	31717	82627	50911	1.60
Rhizobium + P_2O_5 60 Kgha^{-1}	32359	104894	72535	2.24
PSB + P_2O_5 60 Kgha^{-1}	32329	104580	72251	2.23
Azospirillum + P_2O_5 60 Kgha^{-1}	32307	90604	58297	1.80
Rhizobium + P_2O_5 75 Kgha^{-1}	32940	107397	74457	2.26
PSB + P_2O_5 75 Kgha^{-1}	32910	105832	72922	2.21
T10-*Azospirillum* + P_2O_5 75 Kgha^{-1}	32888	91688	58800	1.78

Conclusion

Based on the results of the present investigation it can be suggested that the application of 60 kg of P_2O_5 ha^{-1} and *Rhizobium* as seed treatment will significantly influence the growth contributing characters viz., plant height, number of branches, leaf area, number of nodules, dry matter accumulations. The highest yield and yield attributing characters viz., number of pods, number of seeds, test weight, grain yield stover yield, and biological yield were recorded with the application of 60 kg of P_2O_5 ha^{-1} and *Rhizobium* as a seed treatment. Cost of cultivation, Gross monetary returns, net monetary returns, and B: C ratio were maximum with the application of 60 kg of

P_2O_5 ha^{-1} and *Rhizobium* as a seed treatment.

References

Ajewole K. 2002. Investigation into the lesser known Pulse - *Canavalia ensiformis*: Chemical composition and Fatty acid profile. The Journal of Food Technology in Africa. 7(3): 82-84.

Ananda J M, Chavan M G, Rajemahadik V A and Singh J K. 2014. Response of Summer Blackgram (*Vigna mungo*) Varieties to Phosphorus Levels under Lateritic Soils of Konkan. International Journal of Scientific Engineering and Technology. 3(3): 259-262.

Chandel K P S, Lester R N and Starling R J. 1984. The wild ancestors of urd and mung beans (*Vigna mungo* (L.) Hepper and V. radiata (L.) Wilczek). Botanical Journal of the Linnean Society. 89: 85–96.

Delves A C, Mathews A, Day D A, Carter A S, Carroll B J and Gresshoff P M. 1986. Regulation of the Soybean-Rhizobium Nodule Symbiosis by Shoot and Root Factors. Plant Physiology. 82(2): 588–590.

Dey P, Santhi R, Maragatham S and Sellamuthu K M. 2017. Status of Phosphorus and Potassium in the Indian Soils vis-à-vis World Soils. Indian Journal of Fertilisers. 13(4): 44-59.

Jangir C K, Singh D and Kumar S. 2016. Yield and economic response of biofertilizer and fertility levels on black gram (*Vigna mungo* L.). Progressive Research. 11: 5252-5254.

Kadam S R, Kalegore N K and Patil, S R. 2014. Influence of phosphorus, vermicompost and PSB on yield attributes, seed yield and quality of black gram. Advance Research Journal of Crop Improvement. 5(1): 7-10.

Kant S, Kumar A, Kumar S, Kumar V, Pal Y and Shukla A K. 2016. Effect of Rhizobium, PSB and P-levels on Growth, Yield Attributes and Yield of Urdbean (*Vigna mungo* L.) Journal of Pure and Applied Microbiology. 10(4): 3093-3098.

Keshavarz R, Didinger C, Duncan A and Thompson H. 2020. Pulse Crops and their Key Role as Staple Foods in Healthful Eating Patterns. Colorado State University Extension.

Kumar S, Tomar S and Tomar, T S. 2021. Integrated phosphorus management in black gram (*Vigna mungo*) in western Uttar Pradesh during summer season [2016]. Annals of Agricultural Research. Retrieved from https://agris.fao.org/agris-search/search.do?recordID=IN2022000306.

MoAFW, 2017. Annual Report 2016-17. Ministry of Agriculture and Farmer's welfare.

Panse VG, Sukhantme PV, Statistical methods for agricultural workers. Published by ICAR, New Delhi, 1967.

Pattanayak S K, Sureshkumar P and Tarafdar J C. 2009. New Vista in Phosphorus Research. Journal of the Indian Society of Soil Science. 57(4): 536-545.

Rawat P, Das S, Shankhdhar D and Shankhdhar S C. 2021. Phosphate-Solubilizing Microorganisms:

Mechanism and Their Role in Phosphate Solubilization and Uptake. J Soil Sci Plant Nutr 21: 49–68.

Scheublin T R, Ridgway K P, Young, J P W and van der Heijden M G A. 2004. Nonlegumes, Legumes, and Root Nodules Harbor Different Arbuscular Mycorrhizal Fungal Communities. Applied and Environmental Microbiology: 70(10): 6240–6246.

Selvakumar G, Reetha S and Thamizhiniyan P. 2012. Response of Biofertilizers on Growth, Yield Attributes and Associated Protein Profiling Changes of Blackgram (*Vigna mungo* L. Hepper). World Appl. Sci. 16(10): 1368-1374.

Singh N. 2017. Pulses: an overview. Journal of Food Science and Technology. 54: 853–857.

Steenhoudt O and Vanderleyden J. 2000. Azospirillum, a free-living nitrogen-fixing bacterium closely associated with grasses: genetic, biochemical and ecological aspects. FEMS Microbiology Reviews. 24(4): 487–506.

Suhag M. 2016. Potential of Biofertilizers to Replace Chemical Fertilizers. International Advanced Research Journal in Science, Engineering and Technology. 3(5): 163-167.

Tiwari B K and Singh N. 2012. Pulse Chemistry and Technology. Royal Society of Chemistry.