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Effect of Organic Manures and Inorganic Sources of Phosphorus on Soil Properties and Productivity of Black Gram (*Vigna mungo* L.)

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Abstract— *The present investigation entitled "Effect of Organic Manures and Inorganic Sources of Phosphorus on Soil Properties and Productivity of Black Gram (Vigna mungo L.)" was conducted at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, during the Kharif season of 2024. The study aimed to evaluate the effect of different organic manures and phosphorus sources on the growth, yield, and soil properties of black gram. The experiment comprised 16 treatment combinations with four levels of organic manures (FYM @ 5 t ha^{-1}, vermicompost @ 2.5 t ha^{-1}, FYM 5 t ha^{-1} + vermicompost 2.5 t ha^{-1}, and control) and four levels of phosphorus sources (100% RDP through SSP, 50% RDP through rock phosphate, 50% RDP through SSP + 50% RDP through rock phosphate, and control), arranged in a factorial randomized block design with three replications. Results revealed that the combined application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly enhanced growth and yield attributes, seed, haulm, and biological yield as well as soil organic carbon, water-holding capacity, available macronutrients, compared to other treatments. Soil pH and bulk density were significantly reduced under this treatment. Among phosphorus treatments, the application of 50% RDP through SSP + 50% RDP through rock phosphate recorded significantly higher yield attributes, yield, nutrient uptake, and soil biological activities.*

Keywords— ***Black gram, FYM, Vermicompost, Rock phosphate, Single super phosphate, Soil properties, Yield***

I. INTRODUCTION

The term "pulse" originates from the Latin word *puls* or *pultis*, meaning "thick soup." Belonging to the legume family (*Fabaceae*), pulses comprise more than 1,800 distinct species and form an integral part of sustainable agriculture due to their ability to fix atmospheric nitrogen and enrich soil fertility. India occupies a leading position globally in both the area and production of pulses, particularly during the Kharif and summer seasons. Pulses are cultivated on about 30.37 million hectares with an

average productivity of 888 kg ha^{-1} (Annual Report, 2020-21, Department of Agriculture & Farmers' Welfare). Black gram (*Vigna mungo* L.), commonly known as urdbean, is one of the most important pulse crops grown throughout India. It is valued for its high nutritional content and ability to improve soil health through biological nitrogen fixation. It is a rich source of easily digestible protein (25-28%), oil (1.0-1.5%), fiber (3.5-4.5%), ash (4.5-5.5%), and carbohydrates (62-65%) on a dry-weight basis. Its high lysine content makes it a perfect complement to rice-based diets for balanced human nutrition (Sharma *et al.,* 2011).

In India, black gram is cultivated on about 41.4 lakh hectares with a total production of 22.3 lakh tonnes and productivity of 538 kg ha^{-1} (IIPR, 2020-21). In Rajasthan, it ranks third after chickpea and mung bean, occupying 4.11 lakh hectares with production of 160.37 thousand tonnes and productivity of 390 kg ha^{-1} (IIPR, 2020-21). The major black gram-producing districts in Rajasthan include Ajmer, Tonk, Jhalawar, Banswara, Kota, and Udaipur. Despite its importance, the productivity of black gram remains low, primarily because it is grown under rainfed conditions with limited use of fertilizers and improved technologies. Low fertilizer use offers an opportunity to promote organic manures for better yield and soil health improvement (Singh *et al.,* 2015).

Organic agriculture is globally recognized for improving crop productivity and quality while maintaining environmental sustainability. It emphasizes the use of renewable organic resources such as farmyard manure (FYM), compost, and vermicompost. Presently, organic farming is practiced in over 190 countries, covering 74.9 million hectares with a market value exceeding US$120 billion. In India, about 4.33 million hectares are under organic cultivation, producing 3.49 million metric tonnes of certified organic produce (APEDA, 2021).

Among various organic amendments, vermicompost has emerged as an efficient nutrient source for sustainable crop production. It enhances soil structure, nutrient availability, microbial activity, and enzymatic functions (Das *et al.,* 2019). The bio-oxidative process of vermicomposting involves earthworms and microorganisms that accelerate organic matter decomposition, improving humus formation and nutrient solubility (Thakur *et al.,* 2021).

Phosphorus (P) is one of the major macronutrients essential for plant growth and metabolic functions such as energy transfer, root development, and photosynthesis. Its deficiency results in stunted growth and dark green leaves (Ghosh *et al.,* 2022). However, the availability of P in Indian soils is often limited due to fixation, especially in calcareous soils. Combining organic manures with inorganic phosphorus sources like single super phosphate (SSP) and rock phosphate enhances phosphorus use efficiency, soil microbial activity, and overall productivity.

II. MATERIALS AND METHODS

The present investigation was carried out during *Kharif*, 2024 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The experimental site is located in the south-eastern region of Rajasthan, at an elevation of 581.13 meters above mean sea level, situated at latitude 24° 34′ 52.93″ N and longitude 73° 42′ 14.4″ E. The area falls within Agro-Climatic Zone IVA, classified as the Sub-Humid Southern Plain and Aravalli Hills of Rajasthan. The region experiences typical subtropical weather with moderate summer temperature and mild winters. The rainfall occurs with south-west monsoon with 698.3 mm mm of yearly average annual precipitation. The experimental soil was clay loam in texture. The 16 treatments combination which was carried out in factorial randomized block design are existing in table 1. The variety MU-2 was used for the experiment. The crop was sown on 7th July, 2024 with seed rate of 20kg and harvested on September 25, 2024. The critical difference for the comparison of treatments was worked out, wherever, the 'F' test was found significant at 5 per cent level of significance.

Table 1: Treatment details

Treatment	**:**	**Description**
Organic Manure		
O_0	:	Control
O_1	:	FYM @ 5 t ha^{-1}
O_2	:	Vermicompost @ 2.5 t ha^{-1}
O_3	:	FYM @ 5 t ha^{-1}+ vermicompost @ 2.5 t ha^{-1}
Inorganic sources of Phosphorus		
I_o	:	Control
I_1	:	100% RDP through SSP
I_2	:	100% RDP through Rock Phosphate
I_3	:	50% RDP through SSP + 50% RDP through Rock Phosphate

III. RESULTS

Plant height at 45 DAS and harvest

A perusal of data in (Table 2) showed that application of organic manures significantly increased the plant height at 45 DAS and harvest of black gram during experimentation. Maximum plant height at 45 DAS and harvest (21.36 cm and 35.31 cm, respectively) of black gram was recorded

with application of treatment O_3 (FYM @ 5 t ha^{-1}+ vermicompost @ 2.5 t ha^{-1}). It was found significantly superior over FYM @ 5 t ha^{-1} (O_1), Vermicompost @ 2.5 t ha^{-1} (O_2) and control (O_0). Further showed that application of vermicompost 2.5 t ha^{-1} and FYM @ 5 t ha^{-1} observed significantly higher plant height over control.

Table 2: Effect of organic manures and phosphorus level on plant height at 45 DAS and harvest and no. of nodules at 40 DAS of black gram

Treatments	Plant height 45 (cm)	Plant height harvest (cm)	No. of nodules at 40 DAS
O_0	16.20	24.57	17.10
O_1	17.14	28.31	19.70
O_2	18.12	31.21	20.69
O_3	21.36	35.31	25.71
SEm±	0.34	0.60	0.46
CD (0.05)	0.98	1.72	1.33
I_0	14.81	24.27	16.89
I_1	19.28	31.60	22.01
I_2	18.20	29.85	20.79
I_3	20.53	33.68	23.50
SEm±	0.34	0.60	0.46
CD (0.05)	0.98	1.72	1.33

A critical examination of data in (Table 2) revealed that different source of phosphorus fertilizers significantly varied the plant height of black gram during investigation. Plant height (20.53 and 33.68 cm at 45 DAS and harvest, respectively) was significantly higher with application of 100% RDF.

Number of nodules at 40 DAS

A perusal of data in (Table 2) showed that application of organic manures significantly increased the number of nodules at 40 DAS of black gram during experimentation. Highest number of nodules at 40 DAS (25.71) of black gram was recorded with application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}. It was found significantly superior over control. Further showed that application of vermicompost 2.5 t ha^{-1} (O_2) and FYM @ 5 t ha^{-1} (O_1) observed significantly higher number of nodules at 40 DAS (20.69 and 19.70, respectively) over control. The increase in number of nodules at 40 DAS due to application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} was to the magnitude of 50.35 per cent over control.

A critical examination of data in (Table 2) revealed that different source of phosphorus fertilizers significantly varied the number of nodules at 40 DAS of black gram during investigation. Number of nodules at 40 DAS of black gram (23.50) was significantly higher with application of 50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate. The per cent improvement in number of nodules at 40 DAS due to application of 50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate was 39.13 % compared to application of 100 % RDP through Single Super Phosphate, 100 % RDP through Rock Phosphate and control.

Seed yield (kg ha^{-1})

An examination of data in (Table 3) indicated that application of organic manures was significant influenced on seed yield of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly increased the seed yield (1035.1 kg ha^{-1}) of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) and vermicompost 2.5 t ha^{-1} (O_2) during the experimental years reported 768.3 kg ha^{-1} and 849.9 kg ha^{-1}, respectively both the treatments.

Table 3: Effect of organic manures and phosphorus level on seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and Harvest index (%) of black gram

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	HI (%)
O_0	666.98	1027.12	39.57
O_1	768.36	1250.90	38.12
O_2	849.96	1368.56	38.31
O_3	1035.10	1528.69	40.50
SEm±	16.19	19.62	0.44
CD (0.05)	46.76	56.66	NS
I_0	695.34	1047.33	40.00
I_1	889.21	1383.58	39.08
I_2	830.44	1288.48	39.16
I_3	905.40	1455.88	38.27
SEm±	16.19	19.62	0.44
CD (0.05)	46.76	56.66	NS

Among sources of phosphorus, source O_3 that was 50% RDP through SSP + 50% RDP through RP produced significantly highest seed yield (905.4 kg ha^{-1}) over the other sources. While minimum seed yield was reported in control (695.3 kg ha^{-1}). Remaining source (I_1) 100% RDP

through Single Super Phosphate and (T_2) 100% RDP through Rock Phosphate produced 889.2 kg ha^{-1} and 830.4 kg ha^{-1} respectively.

Haulm yield (kg ha^{-1})

An examination of data in (Table 3) indicated that application of vermicompost and FYM in different combinations was significant influenced on haulm yield of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly increased the haulm yield (1528.6 kg ha^{-1}) of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) and vermicompost 2.5 t ha^{-1} (O_2) during the experimental years reported 1250.9 kg ha^{-1} and 1368.6 kg ha^{-1}, respectively in both the treatments.

Among different sources of phosphorus, 50% RDP through SSP + 50% RDP through RP (1455.8 kg ha^{-1}) produced significantly highest haulm yield over the other sources. While minimum haulm yield was reported in control (1047.3 kg ha^{-1}). Remaining source (I_1) 100% RDP through Single Super Phosphate and (I_2) 100% RDP through Rock Phosphate produced 1383.5 and 1288.4 kg ha^{-1} respectively.

Harvest Index (%)

The data regarding harvest index presented in (Table 3) that application of different organic manures have non significantly effect on harvest index of black gram. The range for harvest index with respect organic manure treatments were 38.12 to 40.50 %.

The data regarding harvest index presented in Table 3. Among different sources of phosphorus, treatment I_0 (control) recorded highest harvest index (40.00 %) which was non significantly higher than other treatments. The range for harvest index with respect inorganic phosphorus source was 38.27 to 40.0 %.

Interactive effect of organic manures and phosphorus sources on seed yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) of black gram

An appraisal of data in (Table 4) showed that seed yield and haulm of black gram was influenced due to interactive effect of organic manures and phosphorus sources (% RDP). The significantly maximum seed yield (1198.6 kg ha^{-1}) and haulm yield (1849.8 kg ha^{-1}) of black gram was recorded in application of FYM @ 5 t ha^{-1}+ vermicompost @ 2.5 t ha^{-1} with 50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate as compared to rest of treatments.

Table 4: Interaction effect of organic manures and phosphorus sources on seed yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) of black gram

Treatments	Seed yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	I_0	I_1	I_2	I_3	I_0	I_1	I_2	I_3
O_0	573.6	748.7	667.18	678.3	829.6	1182.7	1012.6	1083.3
O_1	662.8	810.5	762.0	837.9	1046.0	1303.2	1240.0	1414.2
O_2	732.2	907.2	853.8	906.6	1170.3	1449.2	1378.6	1475.9
O_3	812.6	1090.3	1038.6	1198.6	1143.2	1599.1	1522.4	1849.8
SEm±	32.38				39.24			
CD (0.05)	93.51				113.33			

Bulk density (Mg m^{-3})

An examination of data in (Table 5) indicated that application of vermicompost and FYM in different combinations was significant influenced on bulk density of soil after harvesting of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly reduce the bulk density of soil (1.27 Mg m^{-3}) after harvesting of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) during the experimental years reported 1.30 Mg m^{-3}, while treatment vermicompost 2.5 t ha^{-1} (O_2) was reported 1.34 Mg m^{-3}. Data further, showed that the range for bulk density with respect organic manure treatments were 1.27 to 1.36 Mg m^{-3}. Maximum bulk density was reported in Control (1.36 Mg m^{-3}).

The data regarding bulk density presented in (Table 5) Among different phosphorus source combination reported that effect of phosphorus sources on bulk density of soil after harvesting of black gram having non significant effect. The range for bulk density with respect inorganic fertilizer treatments were 1.31 to 1.32 Mg m^{-3}.

Particle density (Mg m^{-3})

The data regarding particle density presented in (Table 5) Among different organic manures combination reported that effect of organic manures on particle density of soil after harvesting of black gram having non significant effect. The range for particle density with respect organic manures treatments were 2.63 to 2.64 Mg m^{-3}.

The data regarding particle density presented in (Table 5) Among different phosphorus source combination reported that effect of phosphorus sources on particle density of soil after harvesting of black gram having non significant effect. The range for particle density with respect inorganic fertilizer treatments were 2.63 to 2.64 Mg m^{-3}.

Water holding capacity (%)

An examination of data in (Table 5) indicated that application of organic manures have significant influenced on WHC of soil after harvesting of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly increase the WHC of soil (44.85 %) after harvesting of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) during the experimental years reported 44.14%, while treatment vermicompost 2.5 t ha^{-1} (O_2) was reported 42.78%. Minimum WHC was reported in Control (42.15%).

The data regarding WHC presented in (Table 5) Among different source of phosphorus, treatment I_3 (50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate) recorded highest WHC (43.68%) which was non significantly higher than other treatments. The range for WHC with respect inorganic fertilizer treatments were 43.34 to 43.68 %.

Soil pH

An examination of data in (Table 5) indicated that application of organic manures have significant influenced on pH of soil after harvesting of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly reduce the pH of soil (7.46) after harvesting of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) during the experimental years reported 7.59 while treatment vermicompost 2.5 t ha^{-1} (O_2) was reported 7.84. Maximum pH was reported in Control (7.97).

The data regarding soil pH presented in (Table 5) among different source of phosphorus, treatment I_3 (50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate) recorded lowest pH value of soil (7.67). Phosphorus source having non significantly effect on soil pH value. The range for pH of soil with respect inorganic fertilizer treatments were 7.67 to 7.75.

EC (dS m^{-1})

The data regarding EC presented in (Table 5) Among different organic manures combination, treatment O_3 (FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}) recorded highest EC (0.67 dS m^{-1}) which was non significantly higher than other treatments. The range for EC with respect organic manure treatments were 0.61 to 0.67 dS m^{-1}.

An examination of data in (Table 5) indicated that application of phosphorus through different source have significant influenced on EC of soil after harvesting of black gram. Application of I_3 (50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate) significantly increase the EC of soil (0.71 dS m^{-1}) after harvesting of black gram over remaining treatment. Application of 100% RDP through Single Super Phosphate (I_1) during the experimental years reported 0.61 dS m^{-1}, while treatment 100% RDP through Rock Phosphate (I_2) was reported 0.67 dS m^{-1} which was at par with treatment I_3.

Organic carbon (%)

An examination of data in (Table 5) indicated that application of organic manures have significant influenced on OC of soil after harvesting of black gram. Application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} significantly increase the OC of soil (0.55 %) after harvesting of black gram over remaining treatment. Application of FYM @ 5 t ha^{-1} (O_1) during the experimental years reported 0.62%, while treatment vermicompost 2.5 t ha^{-1} (O_2) was reported 0.65% which was at par with treatment O_3.

The data regarding soil organic carbon presented in (Table 5) among different source of phosphorus, treatment I_3 (50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate) recorded highest organic carbon of soil (0.54%). Phosphorus source having non significantly effect on soil organic carbon.

Available N, P, K (kg ha^{-1})

A perusal of data in (Table 6) showed that application of organic manures significantly increased the available nitrogen, phosphorus and potassium content of soil after harvesting of black gram during experimentation. Maximum available nitrogen, phosphorus and potassium content of soil (215.8 kg ha^{-1}, 22.16 kg ha^{-1} and 335.7 kg ha^{-1}, respectively) after harvesting of black gram was recorded with application of treatment O_3 (FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}). It was found at par with Vermicompost @ 2.5 t ha^{-1} (O_2). The increase in available nitrogen, phosphorus and potassium content of soil due to application of FYM @ 5 t ha^{-1}+ vermicompost @ 2.5 t ha^{-1} was to the magnitude of 21.64, 20.89 and 15.60 per cent over control, respectively. Minimum available nitrogen, phosphorus and potassium content of soil (177.4, 18.23 and

286.1 kg ha^{-1}, respectively) after harvesting of black gram was recorded in control.

Table 5: Effect of organic manures and phosphorus level on bulk density, particle density, WHC, OC, soil pH and EC of soil after harvesting of black gram.

Treatments	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	WHC (%)	O.C. (%)	Soil pH	EC (dSm^{-1})
O_0	1.36	2.64	42.15	0.51	7.97	0.61
O_1	1.30	2.63	44.14	0.54	7.59	0.62
O_2	1.34	2.63	42.78	0.52	7.84	0.65
O_3	1.27	2.63	44.85	0.55	7.46	0.67
SEm±	0.003	0.004	0.13	0.006	0.02	0.02
CD (0.05)	0.01	NS	0.38	0.01	0.06	NS
I_0	1.32	2.64	43.34	0.53	7.75	0.56
I_1	1.32	2.63	43.41	0.53	7.73	0.61
I_2	1.32	2.63	43.48	0.53	7.71	0.67
I_3	1.31	2.63	43.68	0.53	7.67	0.71
SEm±	0.00	0.00	0.13	0.006	0.02	0.02
CD (0.05)	NS	NS	NS	NS	NS	0.05

Table 6: Effect of organic manures and phosphorus level on available nitrogen, phosphorus and potassium.

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
O_0	177.41	18.23	276.12
O_1	196.67	20.21	306.18
O_2	203.00	20.86	315.90
O_3	215.80	22.16	335.74
SEm±	3.44	0.35	5.28
CD (0.05)	9.94	1.00	15.25
I_0	178.60	18.36	278.12
I_1	207.20	21.28	322.41
I_2	195.64	20.09	304.41
I_3	211.44	21.72	329.00
SEm±	3.44	0.35	5.28
CD (0.05)	9.94	1.00	15.25

A critical examination of data in (Table 6) revealed that different source of phosphorus fertilizers significantly varied the available nitrogen, phosphorus and potassium content of soil after harvesting of black gram during investigation. Available nitrogen, phosphorus and potassium content of soil (211.4, 21.7 and 329 kg ha^{-1}, respectively) were significantly increased with application of 50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate. Minimum available nitrogen, phosphorus and potassium content of soil (178.6, 18.36 and 278.1kg ha^{-1}, respectively) after harvesting of black gram was recorded in control.

IV. DISCUSSION

The results of the present study revealed that the combined application of FYM (5 t ha^{-1}) and vermicompost (2.5 t ha^{-1}) significantly enhanced growth and yield attributes of black gram, including plant height, number of nodules, pods per plant, and test weight. The improvement in growth parameters may be attributed to the balanced and continuous supply of essential nutrients, which promoted vigorous vegetative growth and efficient nutrient uptake. Similar findings were reported by Prajapati *et al.* (2018), Kumar and Yadav (2018) and Soni *et al.* (2024).

The increased yield under organic manure treatments was likely due to enhanced availability of macro- and micronutrients throughout the growing period, corroborating the observations of Verma *et al.* (2017) and Tomar *et al.* (2021). Application of SSP and rock phosphate further improved phosphorus availability, root growth and water absorption, as supported by Deshpande *et al.* (2015) and Meena *et al.* (2016).

Organic manures also significantly improved soil physical and chemical properties. The FYM and vermicompost combination reduced soil pH and bulk density while

increasing organic carbon, porosity, and water-holding capacity. These results align with those of Tyagi and Singh (2019) and Rajkhowa *et al.* (2017). The mineralization of organic matter further enhanced nutrient availability, consistent with Lal *et al.* (2022) and Patel *et al.* (2016). Overall, the integrated use of organic manures and phosphorus fertilizers improved growth, yield and soil fertility, offering a sustainable and eco-friendly approach to black gram cultivation.

V. CONCLUSION

On the basis of one year experiment results have clearly showed an increasing response to organic manure and inorganic phosphorus sources (% RDP) in terms of increase yield, quality, nutrient content and uptake by black gram crop. The application of (O_3) FYM 5 t ha^{-1} + vermicompost 2.5 t ha^{-1} and (I_3) 50% RDP through Single Super Phosphate + 50% RDP through Rock Phosphate (Treatment- O_3I_3) improved overall picture of efficient nutrient utilization.

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