

Original Research Article

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Efficiency of Inorganic and Organic Fertilizers on Soil Health and Yield of Black Gram (*Vigna mungo* L.)

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ABSTRACT

Keywords

Black gram, Vermicompost, Rhizobium and PSB.

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A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) in *kharif* 2016 to assess the effect of inorganic and organic fertilizers on yield, soil health and net returns of black gram. The experiment was laid out in randomized block design with four replications. The experiment comprised nine treatments combination were applied to the black gram. The results revealed that application of 40 kg P₂O₅ ha⁻¹ + 2.5t vermicompost ha⁻¹ + *Rhizobium* + PSB showed significantly better yield, soil health and net returns of black gram.

Introduction

India has made an impressive progress to achieve self sufficiency in food grain production and reached a growth rate which is sufficient to meet the requirement of increasing population. However, during last decades pulse production has remained stagnant around 13 to 15 million metric tons.

Our country is predominantly vegetarian and pulses are the main source of quality protein and essential amino acids. Due to low and unstable production and increasing population pressure, the per capita availability of pulse has become down from 69g in 1961 to about 47.2g per capita per day in 2014 against the minimum requirement of 80g per capita per day (MFED 2014-15).

This will result in malnutrition amongst larger section of population. Black gram is important pulse crop among the grain legumes grown in India. It contains 24 % protein, 60 % carbohydrate, 1.3 % fat and is richest in phosphoric acid among the pulses being five to ten times richer than in others. It is commonly known as “urd” or “urd bean”. Black gram plays an important role in maintaining and improving the soil fertility through its ability to fix atmospheric nitrogen in the soil through root nodules which possess *Rhizobium* bacteria.

In India, Black gram is grown on 7.23 million hectare area with a production of 2.89 million metric ton (DES 2016-17). Black gram is a

rained crop predominantly grown in *Kharif* in the state of Rajasthan. In Rajasthan, Black gram occupy 2.18 lac hectare area with a production of 1.25 lac ton. However, the productivity of black gram is low in Rajasthan (575 kg ha^{-1}) (DOA 2013). Farmers of south and south-eastern Rajasthan grow black gram without applications of fertilizers or use less than recommended dose of nutrients. This imbalanced nutrient supply adversely affects the seed yield of black gram, soil health, and even the profit to the farmers (Laddha *et al.*, 2006).

The supply of phosphorus to legumes is more important than of nitrogen because, nitrogen is being fixed by symbiosis with *Rhizobium* bacteria. The beneficial effects of phosphorus on nodulation, growth, yield and general behavior of legume crop have been well established because it plays an important role in root development. Phosphorus application to legumes plays a key role in the formation of energy rich phosphate bonds, phospholipids and for development of root system (Tisdale *et al.*, 1985). It also improves the crop quality and resistance to diseases.

Vermicompost has been emerging as an important source in supplementing chemical fertilizer in agriculture in view of sustainable development after Rio Conference, vermicompost is a bio fertilizer enriched with all beneficial soil microbes and also contains all the essential plant nutrients like N, P and K. Since vermicompost helps in enhancing the activity of microorganisms in soil which further increase solubility of nutrients and their consequent availability to plants is known to be altered by microorganism by reducing soil pH at microsites, chelating action of organic acids produced by them and intraphyl mobility in the fungal filaments (Parthasarathi *et al.*, 2008). Biofertilizers play a significant role in improving nutrient availability to crop plants. They are recognized as one of the components of

integrated plant nutrient supply system. Use of biofertilizers can have a greater importance in increasing fertilizer use efficiency. Indian soils are poor to medium status within available nitrogen and available phosphorus.

The seed of pulses is inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the microbiologically fixed nitrogen for the plant growth. The inoculation of seeds with suitable *Rhizobium* and pulse plants helps in improving fertility of soil and is a cost effective method of nitrogen fertilization in legumes. The productivity of leguminous crop in dry land could be improved by *Rhizobium* inoculation (Abdelgani *et al.*, 2003).

Materials and Methods

The experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) in *kharif* 2016 on sandy clay loam soil which is slightly alkaline in nature consisted of 9 treatments comprising chemical fertilizers, organic manure and biofertilizers, their combinations, *viz.*, $20 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, $20 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + 2.5 \text{ t vermicompost ha}^{-1}$, $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + 2.5 \text{ t vermicompost ha}^{-1}$, $20 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + \text{Rhizobium} + \text{PSB}$, $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + \text{Rhizobium} + \text{PSB}$, $20 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + 2.5 \text{ t vermicompost ha}^{-1} + \text{Rhizobium} + \text{PSB}$, $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} + 2.5 \text{ t vermicompost ha}^{-1} + \text{Rhizobium} + \text{PSB}$ and control. These treatments were evaluated under randomized block design (RBD) with four replications. Black gram cultivar (T - 9) was taken as test crop. Further, treatments were classified (excluding control) into four groups *viz.*, G₁ [T₂ and T₃ (chemical fertilizer)], G₂ [T₄ and T₅ (chemical fertilizer + organic manure)], G₃ [T₆ and T₇ (chemical fertilizer + biofertilizer)] and G₄ [T₈ and T₉ (chemical fertilizer + organic manure + biofertilizer)], respectively.

Results and Discussion

The results showed that balanced fertilization of black gram crop involving nutrient combination of phosphorus with vermicompost and biofertilizers most effectively enhanced various yield attributes & yield in black gram *viz.* number of pods plant⁻¹, number of seeds pod⁻¹, test weight, seed yield, straw yield, biological yield and harvest index were maximized when crop was fertilized with balanced and increased levels of nutrient combinations (Table 1). The highest yield attributes and yield parameters realized with application of balanced and higher level of plant nutrition in combination with biofertilizer and organic manure could be ascribed due to its profound influence on vegetative and reproductive growth of the crop. Hence, marked increase in yield attributes and yield parameters with balanced and higher level of fertilization seems to be due to exploitation of crop genetic potential for vegetative and reproductive growth.

The best result on seed yield (1246.66 kg ha⁻¹) was obtained with application of 40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₉) which was 91.46 percent higher over control (651.12 kg ha⁻¹). Group G₄ (chemical fertilizer + organic manure + biofertilizer) shows the best result (1189.67 kg ha⁻¹) in terms of seed yield, which was followed by (982.88 kg ha⁻¹) G₂ (chemical fertilizer + vermicompost), (911.18 kg ha⁻¹) G₃ (chemical fertilizer + biofertilizer) and (809.42 kg ha⁻¹) G₁ (chemical fertilizer), respectively. This indicates that black gram responds well to integrated nutrient management. The results of the present investigation indicating positive response of black gram crop to balanced fertilization are alike to findings of several researchers (Kumawat *et al.*, 2013; Jaga and Sharma, 2015; Kokani *et al.*, 2015; Amruta *et al.*, 2016; Mohammad *et al.*, 2017 and Singh *et al.*, 2017).

Application of integrated nutrient as 40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₉) increased yield components of black gram crop significantly over control and significantly at par with (1132.69 kg ha⁻¹) 20 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB (T₈) (Table 1).

The significant interactive effect as a consequence of biofertilizers, vermicompost and fertilizer application is attributed to the favorable nutritional status of the soil resulting into increased biomass production of the crop. This may also be attributed to favorable effect of vermicompost and biofertilizer on microbial and root proliferation on soil which caused solubilizing effect on native phosphorus and other nutrients. Integrative chemical fertilizers, organic manure and biofertilizers was, however, found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production by synergistic effect of vermicompost and biofertilizers on improving efficiency of optimum dose of Phosphorus. The results of the present study that Combined use of biofertilizer, organic manure and chemical fertilizer has been found to be providing higher productivity with those reported by Kokani *et al.*, (2015) and Mohammad *et al.*, (2017).

Data presented in table 1 show that significant increase in straw yield due to higher fertility levels and balanced fertilization (40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB) could be ascribed to their direct influence on dry matter production in leaf and stem at successive stages by virtue of increased photosynthetic efficiency. The profound influence of nutrient application on biological yield seems to be on account of its influence on vegetative (straw) and reproductive growth (seed).

Table.1 Effect of treatments and groups on yield attributes, yield and harvest index of black gram

Treatments / Groups	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	Test weight (gm)	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index
T ₁	29.65	4.85	41.81	651.12	900.67	1551.79	41.98
T ₂	33.05	5.40	45.19	791.79	1064.16	1855.95	42.67
T ₃	34.15	5.65	45.31	827.04	1101.15	1928.19	42.90
T ₄	35.40	6.20	45.61	930.25	1200.39	2130.64	43.71
T ₅	36.15	6.40	45.70	1035.50	1259.21	2294.71	45.16
T ₆	34.20	5.95	45.49	854.69	1172.22	2026.91	42.13
T ₇	35.25	6.10	45.50	967.67	1227.58	2195.25	44.21
T ₈	38.35	6.80	46.09	1132.69	1428.86	2561.56	44.31
T ₉	39.40	6.95	46.33	1246.66	1442.16	2688.81	46.44
G ₁	33.60	5.53	45.25	809.42	1082.66	1892.07	42.78
G ₂	35.78	6.30	45.66	982.88	1229.80	2212.68	44.43
G ₃	34.72	6.03	45.49	911.18	1199.90	2111.08	43.17
G ₄	38.88	6.88	46.21	1189.67	1435.51	2625.18	45.38
SEm±	1.06	0.17	0.79	26.30	52.30	46.34	1.41
CD (P=0.05)	3.10	0.49	2.30	76.76	152.65	135.26	4.10

Table.2 Effect of treatments and groups on physio-chemical properties of soil after crop harvest

Treatments / Groups	Bulk Density (Mg m ⁻³)	Particle Density (Mg m ⁻³)	pH	EC (dS m ⁻¹)	O.C (%)
T ₁	1.35	2.65	8.14	0.81	0.58
T ₂	1.35	2.64	8.15	0.82	0.61
T ₃	1.34	2.65	8.15	0.83	0.62
T ₄	1.32	2.63	8.16	0.82	0.67
T ₅	1.31	2.65	8.16	0.83	0.68
T ₆	1.34	2.64	8.16	0.83	0.64
T ₇	1.34	2.64	8.17	0.83	0.66
T ₈	1.30	2.64	8.18	0.83	0.70
T ₉	1.29	2.64	8.17	0.83	0.73
G ₁	1.35	2.65	8.15	0.83	0.62
G ₂	1.32	2.64	8.16	0.83	0.68
G ₃	1.34	2.64	8.17	0.83	0.65
G ₄	1.30	2.64	8.18	0.83	0.72
SEm±	0.02	0.03	0.13	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	0.03

Table.3 Effect of treatments and groups on net returns of black gram

Treatments / Groups	Net Returns (Rs. ha ⁻¹)
T ₁	20878.19
T ₂	28002.43
T ₃	29687.13
T ₄	24982.40
T ₅	29937.16
T ₆	31364.76
T ₇	36648.32
T ₈	35286.41
T ₉	40382.89
G ₁	28844.78
G ₂	27459.78
G ₃	34006.54
G ₄	37834.65
SEm±	1080.19
CD (P=0.05)	3152.84

The data presented in table 2 reveals that no significant variation was observed in pH, EC, bulk density and particle density of soil after harvest of black gram crop due to application of various nutrients during the year of investigation. However, use of vermicompost decreases the bulk density and particle density of the soil but not significantly.

Combined application of phosphorus through chemical fertilizer with vermicompost and biofertilizers significantly increased organic carbon in soil at harvest of black gram crop over control (Table 2). Organic carbon content is highest (0.73 %) in T₉ (40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB) which is significantly higher over control (0.58 %).

The favorable effects of phosphorus with vermicompost and biofertilizers, on soil properties may also be due to increased microbial activities which in turn release organic acids to bring down to soil pH to a range where the activities of plant nutrients are maximum. The increase in microbial

activity due to the addition of organic manure and biofertilizer, which enhance activity of enzymes that play a key role in transformation, recycling and availability of plant nutrients in soil. Thus, improvement in nutritional status of plant might have resulted in greater synthesis of amino acids and protein and other growth promoting substances. Similar results were reported by Kumawat *et al.*, (2013), Kokani *et al.*, (2015), Nagar *et al.*, (2016), Mohammad *et al.*, (2017) and Jangir *et al.*, (2017).

The data presented in table 3 showed that application of integrated nutrient management (40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB) gave highest net returns (Rs. 40382.89 ha⁻¹) as compared to control (Rs. 20878.19 ha⁻¹) and other treatments. It is obvious that net returns increased with increased in seed and straw yield in black gram crop. The integrated nutrient management *viz.*, G₄ (chemical fertilizer + organic manure + biofertilizer) increased the expenditure on chemical fertilizer with organic manure and biofertilizers over the

control and other treatments, but generated additional produce excluding the extra cost of treatment resulting in a better net returns. The higher net returns in integrated nutrient management have also been stated by Kumawat *et al.*, (2013), Jaga and Sharma (2015) and Sipai *et al.*, (2016).

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