Effect of phosphorus & bio-organics on quality and symbiotic efficiency of black gram (Vigna mungo L.)

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Abstract
A field 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, to assess the effect of phosphorus & bio-organics on yield, quality and symbiotic efficiency of black gram (T-9). The experiment was laid out in randomized block design with four replications. There were nine treatments combinations in the experiments. The results of study revealed that application of 40 kg P2O5 ha−1 + 2.5 t vermicompost ha−1 + Rhizobium + PSB showed significantly higher yield, quality and symbiotic efficiency of black gram.

Keywords: phosphorous, bio-organics, black gram, protein, leghaemoglobin

Introduction
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 possesses 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 rainfed 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) [5]. One of the important reason of low productivity is poor fertility of soil. The problem is compounded by the fact that the majority of farmers in rainfed areas are resource poor with low risk bearing capacity and they generally do not apply recommended dose of fertilizers, either through organic or inorganic sources. Hence, our research efforts should be aimed to remove the constraints which are responsible for its low productivity. Farmers of south and south-eastern Rajasthan grow black gram without applications of fertilizers or use less then 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) [12].

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) [18]. It also improves the crop quality and resistance to diseases. Phosphorus application to legumes not only benefits the particular crop but also improves the soil nitrogen content for the succeeding non-legume crops requiring lower doses of nitrogen application. It is also an essential constituent of majority of enzymes which are of great importance in the transformation of energy, carbohydrate metabolism, fat metabolism and also in respiration (catabolism of carbohydrates) in plants. It is closely related to cell division and development. Phosphorus stimulates seed setting, hastens maturity and enhanced protein content. It plays an important role in the nutrition of legumes and also improves biological nitrogen fixation and quality of grains (Kumar et al. 2009) [10]. It gives rapid and vigorous start to plants, strengthens straw and decreases lodging tendency.

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) [15].
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) [1].

**Material 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 kg P₂O₅ ha⁻¹ (T₂), 40 kg P₂O₅ ha⁻¹ (T₃), 20 kg P₂O₅ ha⁻¹ + 2.5 t vermicompost ha⁻¹ (T₄), 40 kg P₂O₅ ha⁻¹ + 2.5 t vermicompost ha⁻¹ (T₅), 20 kg P₂O₅ ha⁻¹ + *Rhizobium* + PSB (T₆), 40 kg P₂O₅ ha⁻¹ + *Rhizobium* + PSB (T₇), 20 kg P₂O₅ ha⁻¹ + 2.5 t vermicompost ha⁻¹ + *Rhizobium* + PSB (T₈), 40 kg P₂O₅ ha⁻¹ + 2.5 t vermicompost ha⁻¹ + *Rhizobium* + PSB (T₉) and control (T₁). 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 & T5 (chemical fertilizer)], G₂ [T₄ & T₅ (chemical fertilizer + organic manure)], G₃ [T₆ & T₇ (chemical fertilizer + biofertilizer)] and G₄ [T₈ & 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 yield in black gram viz. 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 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 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) G₃ (chemical fertilizer + vermicompost), (911.18 kg ha⁻¹) G₂ (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) [11, 6, 9, 2, 14, 17].

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 [19, 14].

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). The data presented in table 2 reveals that significant increase in protein content in seeds of black gram is due to the combined use of vermicompost & biofertilizers with chemical fertilizer (40 kg P₂O₅ ha⁻¹ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB). The protein content is maximum in T₉ treatment (22.63%) which was significantly higher over control (19.29%) and significantly at par with treatments T₇ & T₈. Group G₄ (chemical fertilizer + organic manure + biofertilizer) results in maximum protein content (22.30%) in seed of black gram which was highest among all the groups. The protein content of seeds is related to its nitrogen content, so when chemical fertilizer was used with combination of vermicompost & biofertilizer the nitrogen consumption of plant increases due to the nitrogen mineralization of vermicompost and biological nitrogen fixation by biofertilizer (*Rhizobium*), thereby increases the N content of seeds. Following are some researchs showing the result same as above, Kokani et al., 2015; Amruta et al., 2016; Mohammad et al., 2017 and Singh et al., 2017 [9, 2, 14, 17].

The total & effective number of nodules, fresh & dry weight of nodules and leghaemoglobin content of nodules is very much influenced by the different combination applications of chemical fertilizer with vermicompost & biofertilizer. The overall symbiotic efficiency is maximum when the soil is fortified with the treatment T₉ (40 kg P₂O₅ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB), it is significantly higher over control. Among the groups, the overall symbiotic efficiency was higher in G₄ which contain chemical fertilizer with organic manure & biofertilizer (Table 3).

Leghaemoglobin content of root nodules is highest (2.69 mg g⁻¹) in the treatment 40 kg P₂O₅ + Vermicompost 2.5 t ha⁻¹ + *Rhizobium* + PSB which is significantly higher than control.
(2.21 mg g⁻¹) and significantly at par with T₆, T₇ & T₈. Group G₁ results in maximum leghaemoglobin content (2.67 mg g⁻¹) in root nodules of black gram. Research findings showing the result which can be used to justify above result are done by Chakrabarti et al, 2007; Kachhave et al, 2009; Selvakumar et al, 2012; Lal and Khan, 2014 and Kannan et al, 2015 [3, 7, 16, 13, 9].

### Table 1: Effect of treatments and groups on yield and harvest index of black gram

<table>
<thead>
<tr>
<th>Treatments/Groups</th>
<th>Seed yield (kg ha⁻¹)</th>
<th>Straw yield (kg ha⁻¹)</th>
<th>Biological yield (kg ha⁻¹)</th>
<th>Harvest index</th>
</tr>
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<tbody>
<tr>
<td>T₁</td>
<td>651.12</td>
<td>900.67</td>
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<tr>
<td>T₂</td>
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<td>1064.16</td>
<td>1855.95</td>
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<tr>
<td>T₃</td>
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<td>1101.15</td>
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<td>1200.39</td>
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<tr>
<td>S Em±</td>
<td>26.30</td>
<td>52.30</td>
<td>46.34</td>
<td>1.41</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>76.76</td>
<td>152.65</td>
<td>135.26</td>
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### Table 2: Effect of treatments and groups on protein content (%) in seeds of black gram

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<tr>
<th>Treatments/Groups</th>
<th>Protein content (%)</th>
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<td>G₃</td>
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<td>G₄</td>
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<tr>
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### Table 3: Effect of treatments and groups on symbiotic efficiency of black gram

<table>
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<tr>
<th>Treatments/Groups</th>
<th>Total no. of root nodules plant⁻¹</th>
<th>Effective root nodules plant⁻¹</th>
<th>Fresh weight of root nodules (mg plant⁻¹)</th>
<th>Dry weight of root nodules (mg plant⁻¹)</th>
<th>Leghaemoglobin Content (mg g⁻¹)</th>
</tr>
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<tr>
<td>T₁</td>
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<td>62.92</td>
<td>47.91</td>
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<td>50.77</td>
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<tr>
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<td>30.00</td>
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<td>3.86</td>
<td>2.75</td>
<td>0.13</td>
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</table>

### References


3. Chakrabarti J, Chatterjee NC, Dutta S. Interactive effect of VAM and Rhizobium on nutrient uptake and growth of...


