Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 3419-3422
Received: 19-01-2018
Accepted: 20-02-2018

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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 asses 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 P_2O_5 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 is 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 hactare 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 hactare 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 adversly 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 solubiltiy of nutrients and their consequent availability to plants is known to be altered by microrganism 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 P_2O_5 ha^{-1} (T_2), 40 kg P_2O_5 ha^{-1} (T_3), 20 kg P_2O_5 ha^{-1} + 2.5 t vermicompost ha^{-1} (T_4), 40 kg P_2O_5 ha^{-1} + 2.5 t vermicompost ha^{-1} (T_5), 20 kg P_2O_5 ha^{-1} + *Rhizobium* + PSB (T_6), 40 kg P_2O_5 ha^{-1} + *Rhizobium* + PSB (T_7), 20 kg P_2O_5 ha^{-1} + 2.5 t vermicompost ha^{-1} + *Rhizobium* + PSB (T_8), 40 kg P_2O_5 ha^{-1} + 2.5 t vermicompost ha^{-1} + *Rhizobium* + PSB (T_9) and control (T_1). 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*, G_1 [T2 & T_3 (chemical fertilizer)], G_2 [T_4 & T_5 (chemical fertilizer + organic manure)], G_3 [T_6 & T_7 (chemical fertilizer + biofertilizer)] and G_4 [T_8 & T_9 (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 P_2O_5 ha^{-1} + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (T_9) which was 91.46 percent higher over control (651.12 kg ha^{-1}). Group G_4 (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}) G_2 (chemical fertilizer + vermicompost), (911.18 kg ha^{-1}) G_3 (chemical fertilizer + biofertilizer) and (809.42 kg ha^{-1}) G_1 (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 P_2O_5 ha^{-1} + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (T_9) increased yield components of black gram crop significantly over control and significantly at par with (1132.69 kg ha^{-1}) 20 kg P_2O_5 ha^{-1} + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (T_8) (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 biofrtilizers 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 [9, 14].

Data presented in table 1 show that significant increase in straw yield due to higher fertility levels and balanced fertilization (40 kg P_2O_5 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 P_2O_5 ha^{-1} + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB). The protein content is maximum in T_9 treatment (22.63%) which was significantly higher over control (19.29%) and significantly at par with treatments T_7 & T_8. Group G_4 (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 nudules 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 T_9 (40 kg P_2O_5 + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB), it is significantly higher over control. Among the groups, the overall symbiotic efficiency was higher in G_4 which contain chemical fertilizer with organic maure & biofertilizer (Table 3).

Leghaemoglobin content of root nodules is highest (2.69 mg g^{-1}) in the treatment 40 kg P_2O_5 + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB which is significantly higher than control

(2.21 mg g^{-1}) and significantly at par with T_6, T_7 & T_8. Group G_4 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, 8].

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

Treatments/Groups	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
T_1	651.12	900.67	1551.79	41.98
T_2	791.79	1064.16	1855.95	42.67
T_3	827.04	1101.15	1928.19	42.90
T_4	930.25	1200.39	2130.64	43.71
T_5	1035.50	1259.21	2294.71	45.16
T_6	854.69	1172.22	2026.91	42.13
T_7	967.67	1227.58	2195.25	44.21
T_8	1132.69	1428.86	2561.56	44.31
T_9	1246.66	1442.16	2688.81	46.44
G_1	809.42	1082.66	1892.07	42.78
G_2	982.88	1229.80	2212.68	44.43
G_3	911.18	1199.90	2111.08	43.17
G_4	1189.67	1435.51	2625.18	45.38
S Em±	26.30	52.30	46.34	1.41
CD (P=0.05)	76.76	152.65	135.26	4.10

Table 2: Effect of treatments and groups on protein content (%) in seeds of black gram

Treatments/Groups	Protein content (%)
T_1	19.29
T_2	20.106
T_3	20.263
T_4	20.531
T_5	20.688
T_6	21.219
T_7	21.844
T_8	21.981
T_9	22.625
G_1	20.18
G_2	20.61
G_3	21.53
G_4	22.30
SEm±	0.268
CD (P=0.05)	0.783

Table 3: Effect of treatments and groups on symbiotic efficiency of black gram

Treatments/Groups	Total no. of root nodules $plant^{-1}$	Effective root nodules $plant^{-1}$	Fresh weight of root nodules (mg $plant^{-1}$)	Dry weight of root nodules (mg $plant^{-1}$)	Leghaemoglobin Content (mg g^{-1})
T_1	35.25	23.05	62.92	47.91	2.21
T_2	39.50	25.75	70.00	50.77	2.36
T_3	41.50	27.79	72.22	52.87	2.42
T_4	43.00	29.25	74.20	53.85	2.49
T_5	44.75	30.00	76.10	56.35	2.54
T_6	47.50	31.75	77.17	57.30	2.59
T_7	48.25	32.25	79.00	58.82	2.63
T_8	49.50	33.00	80.00	60.37	2.65
T_9	49.75	33.75	82.10	61.75	2.69
G_1	40.50	26.77	71.11	51.82	2.39
G_2	43.88	29.63	75.15	55.10	2.52
G_3	47.88	32.00	78.09	58.06	2.61
G_4	49.63	33.38	81.05	61.06	2.67
SEm±	1.28	0.81	1.32	0.94	0.04
CD (P=0.05)	3.75	2.37	3.86	2.75	0.13

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