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Effect of Integrated Nutrient Management on Quality, Yield, Nutrient Content and Uptake of Black Gram (*Vigna mungo* L.) in the South-eastern Plain of Rajasthan

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ABSTRACT

Background: To find out the suitable integrated nutrient management (INM) package for successful black gram production and to investigate the application of INM on growth, yield, quality and nutrient content of black gram (*Vigna mungo* L.).

Methods: A field experiment was conducted during *kharif* season of 2019-20, the experiment was laid out in randomized block design with factorial concept having three factors *viz*,, three fertility levels (75%, 100% and 125% RDF), two FYM level (control and 5 ton FYM ha^{-1}) and three biofertilizers level (*Rhizobium*, *LMn*16 and *Rhizobium* + *LMn*16) was applied to the variety MU-2 (Mukundra Urad 2).

Result: The results indicated that application of higher fertility level like 125% RDF significantly increased all the yield parameters, nutrient content and uptake. Similarly, all the yield parameters, nutrient content and uptake significantly increased under application of FYM (5 ton ha^{-1}) and bio fertilizer (*Rhizobium*+*LMn*16) over control plot and sole application of *Rhizobium* and *LMn*16 respectively.

Key words: Biofertilizer, Blackgram, INM, Plant height, *Rhizobium*, Yield.

INTRODUCTION

Black gram (*Vigna mungo* L.) is one of the most important pulse crops among the various grain legumes grown in India. As per Vavilov (1951), it is indigenous to India and belong to Leguminosae. It is highly nutritious containing higher amount of 22-24% protein, 1.3% fat and 60% carbohydrates on dry weight basis and it is rich source of calcium and iron. It is the most popular pulse and can be most appropriately referred to as the king of the pulses.

INM includes the intelligent use of organic, inorganic and on-line biological resources so as to sustain optimum yield, improve or maintain the soil physical and chemical properties and provide crop nutrition packages which are technically sound, economically attractive practically feasible and environmentally safe (Kachhave *et al.,* 2009; Desai *et al.,* 2020). INM is also important for marginal farmers who cannot meet the expense of supply crop nutrients from end-to-end costly chemical fertilizers. The biofertilizers have shown boosting results in sustaining the crop productivity and improving the soil fertility (Tomar *et al.,* 2015; Ghosh and Joseph, 2008).

Organic manures, on the other side are responsible to act as a good substrate for the growth of micro-organisms and sustain a favorable nutrients supply environment and improve soil fertility and productivity (Mannivanan *et al*., 2009). Uses of imbalanced or exorbitant supplements and long pull utilization of inorganic manures without natural augmentation harms the soil physical, chemical and organic properties directed to declining nutrient use efficiency bringing contrary effects on air (Aulakh and Adhya, 2005) and groundwater quality (Aulakh *et al.,* 2009) causing health hazards. In these region soils, N, P, S and Zn deficiencies are principal yield-limiting factors for crop production. Besides many reasons were found for low production of black gram *viz*., lack of improved cultural practices, cultivation on marginal and sub marginal lands of poor fertility, imbalanced use of fertilizers, lack of improved nutrient management technique, dependent only on chemical fertilizers are the major bottle necks responsible for poor yield of *Kharif* pulses including blackgram (Amruta *et al.,* 2016). These problems can be overcome to some extent by adopting the integrated nutrient management approach which helps to sustain the soil fertility as well as productivity by balanced fertilization and optimum integration of inorganic and organic source of nutrients (Govindan and Thirumurugan 2005).

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MATERIALS AND METHODS

The experiment was conducted in Field No.12 at Institutional Farm, Agricultural Research Station, Ummedganj, Kota (Rajasthan), which is situated at South-Eastern part of Rajasthan. The regions fall under Agro-climatic Zone V B (Humid South eastern Plains) of Rajasthan. This zone possesses typical sub-tropical conditions with maximum and minimum temperatures ranged between 23.46°C to 37.24°C and 17.5°C to 34.7°C during *Kharif,* 2019. The total amount of rainfall received during black gram crop growth in 2019 was 712 mm. The soil of experimental site was clay loam in texture, slightly saline in reaction. The experimental soil was medium in available nitrogen (173 kg ha^{-1}) and phosphorus (11 kg ha^{-1}) while high in potassium (478 kg ha^{-1}) and sufficient in DTPA extractable micronutrients with pH (7.8) and EC (0.60 dSm^{-1}). Source of nutrients applied were urea for nitrogen, DAP for phosphorus and K_2SO_4 for potassium. The FYM contained 0.5% N, 0.2% P and 0.5% K, which was applied as per treatments two weeks before sowing. The seeds were inoculated with *Rhizobium* and *LMn* 16 @ 400 g per 20 kg seed.

The experiment was carried out in three replications following randomized block design with factorial concept having eighteen treatments as follows *viz.,* T_1=75% RDF + Control +*Rhizobium*, T_2=75% RDF + Control +*LMn*16, T_3=75% RDF+ Control+*Rhizobium*+*LMn*16, T_4=75% RDF+ 5 ton FYM + *Rhizobium*, T_5=75% RDF+ 5 ton FYM +*LMn*16, T_6=75% RDF+ 5ton FYM +*Rhizobium* + *LMn*16, T_7=100% RDF+ Control +*Rhizobium*, T_8=100% RDF+ Control +*LMn*16, T_9=100% RDF+ Control +*Rhizobium* +*LMn*16, T_{10}=100% RDF+ 5 ton FYM +*Rhizobium*, T_{11}=100% RDF+ 5 ton FYM +*LMn*16, T_{12}=100% RDF+ 5 ton FYM +*Rhizobium* +*LMn*16, T_{13}=125% RDF+ Control + *Rhizobium*, T_{14}=125% RDF+ Control + *LMn*16, T_{15}=125% RDF+ Control +*Rhizobium* +*LMn*16, T_{16}=125% RDF+ 5 ton FYM + *Rhizobium*, T_{17}=125% RDF+ 5 ton FYM +*LMn*16, T_{18}=125% RDF+ 5 ton FYM +*Rhizobium* + *LMn*16. Data on growth and yield parameters like plant height, number of branches per plant, number of pods per plant, straw yield, biological yield and grain yield were recorded as per standard procedures. Plant samples (grain and straw) were collected after harvesting from each of the plots.

For analysis of plant nutrients in seed and straw after collection the plant samples were first washed with running regular water to wipe out totally recognizable soil particles followed by washing with 0.01 N HCl lastly with deionized water. From that point forward, plant samples were dried in a hot air oven at 65°C for 48 h until the steady weight was accomplished. In the wake of drying, the samples were ground to a fine powder for additional investigation. After wet digestion of plant sample with mixture of H_2SO_4 and H_2O_2 (Jackson, 1973) nitrogen was estimated in plant sample by modified Kjeldahl method (Snell and Snell 1949). Digestion of sample for phosphorus and potassium content was by tri acid mixture HNO_3: $HClO_4$:H_2SO_4 ratio of 10:4:1 as per procedure Vando molybdo phosphoric acid yellow colour method (Jackson 1973), Potassium was determined using flame photometer and cationic micronutrients viz., Fe, Mn, Zn and Cu were extracted by using DTPA extraction procedure (0.005 M diethylene triamine Penta acetic acid (DTPA) + 0.01 M $CaCl_2.2H_2O$ + 0.1 M triethanolamine or TEA) buffered at pH 7.3 as described by Lindsay and Norvell (1978). The data were statistically analyzed by adopting appropriate method of standard analysis of variance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Quality parameters

Data regarding to protein content and protein yield of black gram was exhibited in Table 1. The maximum protein content and protein yield were recorded under 125% RDF (20.9%, 188 kg ha^{-1}) followed by 100% RDF (20.5%, 163 kg ha^{-1}) and lowest under fertility level 75% RDF (20.3%, 141 kg ha^{-1}). The increasing nutrient content particularly nitrogen and phosphorus was attributed to biological nitrogen fixation and mineralization which ultimately increased the protein yield of the black gram (Kumawat *et al.,* 2015). Application of farm yard manure had no significant influence either on protein content or protein yield in blackgram (Table 1) (Patil *et al.,* 2010). Further it is evident from the data depicted in Table 1, that protein content was not statistically influenced by rhizobium treatments while protein yield was observed highest under application of *Rhizobium* + *LMn*16 followed by *Rhizobium* alone while, minimum protein yield was obtained with under treatment *LMn16* culture treated plot (Shekhawat *et al.,* 2017). The protein content of seed is directly related to the nitrogen content, so application of higher fertilization (125% RDF) with FYM and bio fertilizers significantly increased the nitrogen content and assimilation power of plants which is responsible for increasing the protein content as well as protein yield and improved the quality of black-gram variety under study. Similarly, results were reported by Shelvakumar *et al.,* 2012.

A perusal of data presented in Table 1 indicated that total root nodule per plant and dry weight of nodule were significantly increased with increasing fertility levels 125% RDF (24.0, 44.4 mg) followed by 100% RDF (23.8, 42.8 mg), 75% RDF (21.3, 36.3 mg) respectively. Data revealed that the application of FYM @ 5 t ha^{-1} significantly increased the root nodule per plant and their dry weight (24.1, 43.8 mg) as compared to the control plot (22.0, 38.4 mg). The extent of increase in root nodule was noticed 9.3% higher over control. Similarly, the maximum nodule count and dry weight was observed in treatments receiving seed inoculation with *Rhizobium* + *LMn*16 (24.2, 46.7 mg) as compared to without combination of seed inoculation *LMn*16 (21.6, 35.7 mg) and *Rhizobium* (23.3, 41.1 mg) respectively. Due to application of higher fertility level with FYM and bio fertilizers vigorous plant growth which enhance the plant energy synthesis by the photosynthesis process increases store energy and synthesized the large quantity of food material that was responsible for source–sink relationship. Which, is ultimately

had positive effect on plant height, nodule count and their dry weight, resultant that the increased the grain yield straw yield and biological yield of black gram (Kumavat *et al.,* 2015; Kachhave *et al.,* 2009). Thus, it proved that in present investigation bio fertilizer and optimum quantity of fertilizers resulted in plant growth and quality parameters.

Yield

Data from Table 1 revealed that application of higher fertility level like 125% RDF significantly increased the grain yield (900 kg ha^{-1}), straw yield (3741 kg ha^{-1}) and biological yield (4640 kg ha^{-1}). Further data revealed that application of FYM @ 5 t ha^{-1} significantly increased the grain yield (830 kg ha^{-1}), straw yield (3518 kg ha^{-1}) and biological yield (4345 kg ha^{-1}) over control treatment. Inoculation of *Rhizobium* + *LMn*16 also resulted in significant increases in the grain yield (862 kg ha^{-1}) and biological yield (4432 kg ha^{-1}) over sole application of *Rhizobium* and *LMn*16. Probably increment in the growth parameters and yield of black gram *viz.*, biological yield, grain yield, straw yield and harvest index improvement might be due to accumulation of carbohydrate in plant and early and sufficient availability of plant growth regulator and chelating agent secretion leading to the better nutritional environment in the root zone of black gram (Kumpawat, 2010; Meena *et al.,* 2021).

Nutrient content of blackgram

The perusal of data of nitrogen in seed and straw of black gram mentioned in Table 2 indicated that nitrogen, phosphorus and potassium content in seed was found highest in 125% RDF (3.35, 0.45 and 1.07 %) respectively followed by 100% RDF and lowest in 75% RDF. Similar trend was observed in straw of blackgram (Table 2). The application of FYM @ 5t ha^{-1} registered highest nitrogen, phosphorus and potassium content in seed and straw compared to control plot. Among the biofertilizer, the highest nitrogen content in seed and straw were found in treatment receiving *Rhizobium* + *LMn*16 (3.31%, 1.69%) followed by *Rhizobium* (3.30%, 1.61%) and *LMn*16 (3.28%, 1.57%), respectively. Similarly, phosphorus and potassium in seed was noticed highest in application of *Rhizobium* + *LMn*16 (0.48%, 0.29%) followed by *Rhizobium* (0.46%, 0.28%) and in *LMn*16 (0.38%, 0.23%) respectively (Kumar and Jat, 2010; Yadav *et al.,* 2017). The results further indicated that maximum level of micronutrients like zinc was recorded in seed and straw with application of 125% RDF followed by 100% RDF, while minimum value of zinc content was observed in 75% RDF (Table 2). The maximum zinc content was recorded in seed treatment receiving of FYM @ 5t ha^{-1} (10.1, 15.1 mg, respectively) over the control (9.69, 13.5 mg in seed and straw respectively). In response of different biofertilizers, the maximum zinc content was observed treatment with the application of *Rhizobium* + *LMn*16 (9.37, 14.4 mg, respectively) followed by treatment under *Rhizobium* culture (9.87, 14.3 mg), *LMn*16 (9.82, 14.8 mg) respectively. Similarly, iron, copper and manganese content also increase in response to different treatment combinations (Table 2) (Husain *et al.,* 2011; Yadav *et al*., 2017). It observed that the favorable effect on soil as well as on plant was due to positive soil micro climate regime in soil and its effect on both plant and soil in terms of increase in the macro and micro nutrient concentration (Gosh and Das 2011; Swaminathan *et al.,* 2020).

Table 1: Effect of INM on quality and yield attributes of black gram.

Treatment	Protein content (%)	Protein yield (kg ha^{-1})	No of nodule count plant^{-1} at 40 DAS	Nodule dry weight plant^{-1} (mg)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Fertility levels							
75% RDF	20.3	143.3	21.3	36.3	690	3240	3925
100% RDF	20.5	163.6	23.1	42.8	800	3347	4140
125% RDF	21.0	188.3	24.1	44.4	900	3741	4640
SEm±	0.50	5.57	0.54	0.73	14.70	65.0	74.2
CD at 5%	NS	16.01	1.54	2.10	42.26	186.9	215
FYM							
Control	20.4	160.1	21.0	38.4	755	3367	4122
5 ton ha^{-1}	20.7	171.0	24.0	43.8	830	3518	4345
SEm±	0.41	4.55	0.44	0.59	12.01	53.1	60.6
CD at 5%	NS	NS	1.26	1.70	34.5	152.6	174.1
Biofertilizer							
Rhizobium	20.5	162.3	23.0	41.1	773	3414	4186
LMn16	20.5	155.3	21.6	35.7	738	3345	4083
Rhizobium + LMn 16	20.7	177.6	24.2	46.7	862	3570	4432
SEm±	0.50	5.57	0.53	0.73	14.7	65.0	74.2
CD at 5%	NS	16.01	1.54	2.09	42.2	186.9	213.3

RDF - Recommended dose fertilizer, FYM- Farmyard manure, *LMn*16- Biofertilizer release from PAU Ludhiana. Significant at 5% level.

Table 2: Effect of INM on macro and micro nutrient of black gram seed and straw.

Treatments	Seed			Straw			Seed				Straw			
	N	P	K	N	P	K	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
	(%)						(mgkg^{-1})							
Fertility levels														
75% RDF	3.25	0.41	0.90	1.50	0.25	1.40	9.0	29.2	22.7	12.3	13.2	116.7	13.1	7.2
100% RDF	3.28	0.44	0.97	1.66	0.27	1.47	9.8	33.0	25.3	12.6	14.1	125.0	16.1	8.2
125% RDF	3.35	0.45	1.07	1.7	0.30	1.53	10.9	38.5	26.1	13.5	15.6	148.5	17.5	9.0
SEm±	0.08	0.01	0.01	0.01	0.00	0.01	0.06	0.21	0.11	0.08	0.11	0.86	0.12	0.06
CD at 5%	NS	0.01	0.03	0.03	0.01	0.03	0.16	0.60	0.33	0.24	0.32	2.49	0.36	0.17
FYM														
Control	3.28	0.40	0.90	1.56	0.23	1.40	9.0	32.0	24.2	12.6	13.0	123.0	15.3	8.0
5 ton ha^{-1}	3.32	0.45	1.0	1.66	0.28	1.50	10.1	34.7	25.2	13.0	15.0	137.2	15.8	8.4
SEm±	0.06	0.00	0.01	0.01	0.00	0.01	0.05	0.17	0.09	0.07	0.09	0.70	0.10	0.05
CD at 5%	NS	0.01	0.02	0.03	0.01	0.02	0.13	0.50	0.26	0.19	0.26	2.02	0.30	0.14
Biofertilizers														
Rhizobium	3.30	0.46	0.97	1.61	0.29	1.49	9.9	33.6	24.7	12.8	14.3	130.6	15.6	8.2
LMn 16	3.27	0.38	0.95	1.58	0.23	1.40	9.8	33.4	24.5	12.7	14.2	128.4	15.3	8.2
Rhizobium+LMn16	3.31	0.50	1.0	1.70	0.30	1.52	9.9	33.7	24.8	12.9	14.3	131.2	15.7	8.3
SEm±	0.08	0.001	0.01	0.01	0.001	0.01	0.1	0.2	0.1	0.1	0.1	0.9	0.1	0.1
CD at 5%	NS	0.01	0.03	0.03	0.01	0.03	NS	NS	NS	NS	NS	NS	NS	NS

RDF – Recommended dose fertilizer, FYM- Farmyard manure, *LMn*16- Biofertilizer release from PAU Ludhiana, Significant at 5% level.

Table 3: Effect of INM on uptake of macro and micro nutrient of black gram seed and straw.

Treatments	Seed			Straw			Seed				Straw			
	N	P	K	N	P	K	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
	(kg ha^{-1})						(g kg^{-1})							
Fertility levels														
75 % RDF	22.26	2.69	6.00	5.61	7.74	45.16	6.11	20.04	15.56	8.35	42.67	378.53	42.32	23.06
100 % RDF	25.82	3.54	7.67	6.02	9.09	49.17	7.80	25.94	20.33	10.02	47.03	416.75	53.11	27.52
125 % RDF	30.12	4.52	9.61	6.09	11.35	57.42	9.76	34.45	23.49	12.16	58.31	555.59	65.30	35.26
SEm±	0.88	0.08	0.17	0.17	0.21	1.14	0.13	0.54	0.42	0.24	1.18	9.50	1.12	0.66
CD at 5%	2.54	0.23	0.49	NS	0.60	3.28	0.38	1.55	1.20	0.68	3.39	27.29	3.21	1.89
FYM														
Control	24.78	3.34	7.28	5.73	8.94	48.21	7.34	24.38	18.43	9.48	45.62	416.19	51.61	27.38
5 ton ha^{-1}	27.35	3.83	8.24	6.09	9.86	52.96	8.44	29.24	21.15	10.88	53.05	484.39	55.54	29.85
SEm±	0.72	0.06	0.14	0.14	0.17	0.93	0.11	0.44	0.34	0.19	0.96	7.75	0.91	0.54
CD at 5%	2.07	0.19	0.40	NS	0.49	2.67	0.31	1.27	0.98	0.56	2.77	22.28	2.62	1.54
Biofertilizers														
Rhizobium	25.59	3.66	7.58	5.89	9.78	50.90	7.67	26.32	19.02	9.91	48.86	446.25	53.72	28.34
LMn 16	24.20	2.86	7.06	5.90	7.82	46.74	7.34	24.65	18.45	9.41	47.69	431.76	51.83	27.62
Rhizobium + *LMn16*	28.41	4.24	8.64	5.94	10.59	54.12	8.65	29.47	21.91	11.22	51.45	472.86	55.17	29.88
SEm±	0.88	0.08	0.17	0.17	0.21	1.14	0.13	0.54	0.42	0.24	1.18	9.50	1.12	0.66
CD at 5%	2.54	0.23	0.49	NS	0.60	3.28	0.38	1.55	1.20	0.68	NS	27.29	NS	NS

RDF - Recommended dose fertilizer, FYM – Farmyard manure, *LMn* 16- Biofertilizer release from PAU Ludhiana, Significant at 5 % level.

Nutrient uptake

Nutrient uptake of macro and micro nutrients by seed and straw in blackgram significantly increased with different fertility doses. The highest nitrogen, phosphorus and potassium uptake was found in seed of black gram with application of 125 % RDF (30, 4.5 and 9.6 kg ha^{-1}) respectively compared to lower doses tested. Similarly, treatments receiving FYM resulted in found highest uptake by seed nitrogen, phosphorus and potassium (27.35, 3.83 and 8.24 kg ha^{-1}) respectively as compare to control plot. Highest nitrogen, phosphorus and potassium uptake in seed were noticed in treatment receiving *Rhizobium* + *LMn*16 (28.41, 4.24 and 8.64 kg ha^{-1} respectively) as compared to sole application of *Rhizobium* and *LMn*16. Similar, trend was noticed in case of straw uptake in relation to different treatment combinations (Table 3). Application of higher fertilizer doses, FYM @ 5 t $ha^{-1}$and biofertilizer (*Rhizobium* + *LMn*16) resulted in uptake of micronutrients (Zn, Cu, Mn and Fe) by seed and straw of black gram. Similar results were reported by (Dekhane *et al.,* 2011; Gosh and Das, 2011). Organic manure and bio fertilizers with inorganic fertilizers increased the absorption power of the soil for cations and anions particularly nitrogen, potassium and some micronutrients. These ions are released gradually during entire growth period of the crops which might have increased concentration and uptake of nutrients (Desai *et al.,* 2020). Farm yard manure and biofertilizers along with optimum dose of fertilizer helps in improving quality of soil and efficient supply of nutrient. Which ultimately increase the sustainability of crops with the zero adverse impact on agro eco system by enhancing the availability of applied as well as native soil nutrient (Amruta *et al.,* 2016). It helps in providing balanced nutrition to crop and minimizes the antagonistic effects resulting from hidden deficiencies (Kumar and Jat, 2010; Kudi and Shingh, 2016).

CONCLUSION

The study concluded that the variation in the availability of plant macro and micronutrients, plant growth and yield of black gram in response to inorganic to organic fertilization varied quantitatively based on the nature. In INM application of organic nutrient sources particularly FYM and biofertilizers integrating with optimal doses of chemical fertilizers substantially enhances the growth, yield, nutrient content and uptake of black gram and improve sustainability under south eastern plains of Rajasthan. This experiment outcomes high light significance of soil application of higher fertilizer doses, farm yard manure and biofertilizers for increasing the productivity with improved quality of blackgram.

Conflict of interest: None.

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