Annals of Plant and Soil Research 25(4): 665-671 (2023)
https://doi.org/10.47815/apsr.2023.10320

Effect of integrated nutrient management on soil physico-chemical properties as affected by organic and inorganic sources in black gram (*Vigna mungo* L.) under South-Eastern plain of Rajasthan

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Received: September, 2023; Revised accepted: November, 2023

ABSTRACT

To investigated the effect of integrated nutrient management (INM) on soil physical and chemical properties under black gram in South Eastern plain of Rajasthan. 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) and three biofertilizers levels (Rhizobium, LMn16 and Rhizobium + LMn16) was applied to the variety MU-2 (Mukundra Urad 2). The results indicated that application of FYM and biofertilizers integration with higher fertility levels like 125% RDF significantly improved the soil physical chemical properties. The maximum organic carbon (0.46%), nitrogen (200 kg ha^{-1}), phosphorus (22.7 kg ha^{-1}), potassium (568 kg ha^{-1}) increased in soil higher fertility levels 125% RDF. Further analysis of data showed that the application of 5-ton ha^{-1} FYM significantly increases the organic carbon (0.48%), nitrogen content (197 kg ha^{-1}), phosphorus (21.2 kg ha^{-1}), potassium (553.6 kg ha^{-1}) and micronutrients Zn and Fe significantly increase over control plot. Similar, trend found in seed inoculation with Rhizobium + LMn16.

Keywords: Blackgram, FYM, INM, organic carbon, pH, *Rhizobium*

INTRODUCTION

The blackgram (*Vigna mungo* L.) is native to India, where it has been cultivated since prehistoric time and one of the best high quality pulses of country. It is a short-duration pulse crop is grown in many parts of country and can be grown on variety of soils ranging from sandy soils to heavy cotton soils. It is one of the second most important segments of Indian agriculture after cereals as they rich in protein and play vital role in human diet and it is perfect combination of all nutrient including 21-24% protein, 1.3% fat, 60% carbohydrates and rich source of calcium and iron. On other hand, nutrient mining was occurring in many soils due to lack of inexpensive fertilizer sources and where very less or no organic residues are reverted to the soils. Soils of Rajasthan are inherently poor in organic matter, fertility and water-holding capacity. In these soils, N, P and S deficiencies are principal yield-limiting factors for crop production (Shekhawat *et al.,* 2017). Beside many reason found low production of blackgram viz., low availability of quality of improved seed, growing of crop marginal and less fertile soil and moisture stress condition, lack of efficient management of nutrient management and growers dependent only chemical fertilizers which is major reason for land degradation and multi nutrient deficiencies mainly nitrogen, zinc, boron and sulphur (Swaminathan *et al.,* 2020). Hence, there is a scope for improving the production of black gram by adopting integrated nutrient management practises use of organic manures, inorganic manures and bio fertilizers (Danga *et al.,* 2022; Choudhary *et al.,* 2013). Among the various methods of fertilizer recommendations, the soil test based fertilizer recommendations is also appropriate practices to improve yield as well as soil nutrient status (Bhardwaj *et al.,* 2014; Sharma *et al.,* 2019). In India, effective nutrient management has played a major role in accomplishing the enormous increase in food grain production and maintain soil health (Khatana *et al.,* 2021). The present investigation was therefore initiated to work out the response of FYM, soil test based N, P, K along with bio fertilizers on soil properties and yield of blackgram.

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MATERIALS AND METHODS

A field experiment was conducted at Research Farm, Agricultural Research Station, Ummedganj, Kota (Rajasthan) during *kharif* season 2019. The experiment was carried out by in three replicated (4.2 x 3.8 m sized plots) arrange in factorial randomized block design with eighteen treatments followings T_1= 75% RDF + Control +*Rhizobium*, T_2=75% RDF + Control +LMn16, T_3=75% RDF+ Control+ *Rhizobium* +LMn16, T_4=75% RDF+ 5 ton FYM + *Rhizobium*, T_5=75% RDF+ 5 ton FYM +LMn16, T_6=75% RDF+ 5ton FYM +*Rhizobium* +LMn16, T_7=100% RDF+ Control +*Rhizobium*, T_8=100% RDF+ Control +LMn16, T_9= 100% RDF+ Control +*Rhizobium* +LMn16, T_{10}=100% RDF+ 5 ton FYM +*Rhizobium*, T_{11}=100% RDF+ 5 ton FYM +LMn16, T_{12}=100% RDF+ 5 ton FYM +*Rhizobium* +LMn16, T_{13}=125% RDF+ Control + *Rhizobium*, T_{14}=125% RDF+ Control +LMn16, T_{15}=125% RDF+ Control +*Rhizobium* +LMn16, T_{16}=125% RDF+ 5 ton FYM +*Rhizobium*, T_{17}=125% RDF+ 5 ton FYM +LMn16, T_{18}=125% RDF+ 5 ton FYM +*Rhizobium* +LMn16. Black gram (Mukundra Urad 2) was selected as test crop and sown in July month. The recommended dose of fertilizer (RDF) different fertilizer using source of nutrients urea for nitrogen, DAP for phosphorus and K_2So_4 for potassium and sulphur. The farmyard manure contains 0.5% N, 0.2% P and 0.5% K, farmyard manure was applied as per treatments at two weeks before sowing. The seed were inoculated *Rhizobium* and LMn 16 @ 400 g per 20 kg seed. To estimate the fertility status of the soil, after harvesting of the crop the soil sample (0-15 cm depth) from each plot was taken. Immediately after collection soil sample brought to the laboratory and part of samples were stored in refrigerator at 4^0 C temperatures until analysed for the biological properties. The procured sample were naturally dried in shadow, grind and finally passed through 2 mm plastic sieve to avoid metallic contamination thereafter stored in polythene bags for analysis purpose. The initial soil sample analysis reveal that surface soil (0-15 cm) of experimental site was clay loam in texture (clay 37%, silt 46% and sand 13%), slightly saline in reaction (pH 8.3) with medium water holding capacity (48.5%) and CEC (23.2 C mol (P+) kg^{-1}). The experimental soil was low in oxidizable organic carbon (0.38%), available nitrogen (173 kg ha^{-1}), phosphorus (11 kg ha^{-1}) and high in potassium (478 kg ha^{-1}) while, sufficient in DTPA extractable micronutrients (Zn, Cu, Mn and Fe). The soil samples were assessed for pH, electric conductivity (EC) using digital pH meter and EC meters (Richards, 1954), organic carbon (Walkley and Black, 1934), available Nitrogen alkaline $KMNO_4$ method (Subbiah and Asija, 1956), Phosphorus (Olsen *et al.,* 1954), Potassium ammonium acetate method (Hanwey and Heidel, 1952) by flame photometer and DTPA extraction procedure for micronutrient Cu, Fe, Mn, Zn (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) using atomic absorption spectrometer. In physical properties analysis bulk density and particle density determined by (Piper, 1950), water holding capacity (WHC) was determined by the method of (Baruah and Barthakur, 1999) and cation exchange capacity (CEC) was analysed by ammonium saturation method of (Jacktion 1973) while, the total porosity is determined by the using standard formula. The data were statistically analysed by adopting appropriate method of standard analysis of variance (Gomez and Gomez 1984).

RESULT AND DISCUSSION

Effect of INM on physical properties of soil

Data presented for particle density and bulk density in (table 1) and showed that application of different fertility levels, farm yard manure and bio fertilizers didn't much affect these properties and found non-significant. Application of 5 ton FYM slightly decrease the bulk density and particle density because improve soil organic pools and soil aggregation while application of bio fertilizer slightly decreased both parameters due to secreted polysaccharide which act in the soil as cementing substances causing aggregates stability, contribution to create and maintain the soil structure and triggering better aeration (Kant *et al.,* 2017). The effect of bio fertilizers was observed significant variation in porosity of soil summarized in Table 1. The results revealed that the maximum porosity was recorded under inoculation of *Rhizobium* + LMn16 culture treatment (51.96%). This might

be due to improve organic carbon status in soil and action of microorganism produce polysaccharide that provide cementing action between soil particles and stabilize the soil aggregates cause decreases the bulk density and these in turn provide greater aeration and drainage (Yilmaz and Alagose, 2010).

Table 1: Effect of INM on physical properties of soil after harvest of black gram

Treatments	BD (Mg m^{-3})	PD (Mg m^{-3})	Porosity (%)	CEC (Cmol (P^{+}) kg^{-1})	WHC (%)
Fertility levels					
75 % RDF	1.26	2.57	51.00	25.47	47.69
100 % RDF	1.24	2.56	51.56	25.70	48.78
125 % RDF	1.25	2.56	51.17	25.69	48.66
SEm+	0.03	0.09	1.39	1.12	0.88
CD at 5%	NS	NS	NS	NS	NS
Farm yard manure					
Control	1.28	2.58	50.30	24.90	47.27
5 ton ha^{-1}	1.22	2.55	52.10	26.35	49.49
SEm+	0.03	0.08	1.13	0.91	0.72
CD at 5%	NS	NS	NS	NS	2.06
Bio fertilizers					
Rhizobium	1.26	2.62	51.90	25.85	48.23
LMn 16	1.24	2.54	51.18	25.13	47.93
Rhizobium + LMn16	1.22	2.54	51.96	25.89	48.98
SEm+	0.02	0.09	1.32	1.12	0.88
CD at 5%	NS	NS	NS	NS	NS

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

Further result indicated that the application of higher fertility dose significantly increases the cation exchange capacity (CEC) of soil. The maximum CEC observed in the application of 125% RDF (27.14) C mol kg^{-1} followed by 100% RDF (25.13) and 75% RDF (23.81) C mol kg^{-1} (Table 1). The treatments receiving 5 ton farm yard manure showed maximum CEC (27.5) as compare to control plot (23.15) C mol kg^{-1}. Generally, soil organic carbon is directly responsible for 25-90% of the total CEC of surface horizon of soil (Yilmaz and Alagose, 2010). The seed treated with *Rhizobium* + LMn16 strain of bio fertilizer showed highest CEC (27.57) as compare to the sole application of *Rhizobium* (23.89) and LMn16 (24.62) C mol kg^{-1}. It means prove that the application of mix both strain can cause significant variation, this may be due to rises the microbial population in soil resultant fast decomposition of organic matter, releases the chelating agent and polysaccharides which affect the soil chemical and physical properties (Senthivalavan and Ravichandran, 2020). It is evident from the data water holding capacity (WHC) after harvesting of crop presented in table 1 significantly increase application of higher fertility doses varied from 49.2%, 52.9% and 53.2% under the treatment 75% RDF, 100% RDF and 125% RDF respectively. The treatment receiving the FYM the water holding capacity was increases significantly. The WHC varied 48.6% & 50% under the control and FYM treated plot respectively. The seed inoculated with *Rhizobium* + LMn16 observed maximum WHC (53.4%) followed by LMn16 (51.1%) whereas, minimum WHC recorded in *Rhizobium* (50.7%). It might be due to keep soil environments rich all kind of micro and macronutrients via nutrient mineralization and solubilisation, release of plant growth regulating substance, production of antibiotics and decomposition of organic matter in the soil resulted that stimulate microbial activity and improve soil structure ultimately improve water use efficiency (Bhardwaj *et al.,* 2014; Mannivanan *et al.,* 2009).

Effect of INM on chemical properties of soil

Data presented in Table 2 was revealed that the effect of the application of higher fertility dose slightly increase the pH and EC (dSm^{-1}) due to increases the fertilizer doses resultant increases salt content that fluctuate the soil pH

Table 2: Effect of INM on chemical properties of soil after harvest of black gram

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Fertility levels						
75 % RDF	7.64	0.53	0.45	194.3	20.0	548.0
100 % RDF	7.65	0.56	0.46	199.4	22.7	568.5
125 % RDF	0.09	0.022	0.01	194.3	20.0	548.0
SEm+	NS	NS	NS	2.12	0.16	4.93
CD at 5%	7.64	0.53	0.45	6.1	0.45	14.18
Farm yard manure						
Control	7.68	0.54	0.43	192.0	19.4	522.0
5 ton ha^{-1}	7.56	0.56	0.48	197.8	21.2	553.6
SEm+	0.08	0.02	0.01	1.73	0.13	4.03
CD at 5%	NS	NS	0.02	5.10	0.37	11.59
Bio fertilizers						
Rhizobium	7.62	0.54	0.46	194.4	20.0	530.0
LMn 16	7.63	0.52	0.44	193.6	20.2	527.4
Rhizobium + *LMn16*	7.62	0.56	0.47	197.2	20.8	556.5
SEm+	0.09	0.02	0.01	2.12	0.16	4.93
CD at 5%	NS	NS	NS	NS	0.45	14.20

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

and EC (Sherawat *et al.,* 2018). The application of bio fertilizer causes marginally change in pH and EC (Sharma *et al.,* 2019). The application of higher fertility level was increased the organic carbon of soil. The highest organic carbon was recorded with application of 125% RDF (0.46%) followed by 100% RDF (0.45%) whereas the minimum organic carbon was recorded with 75% RDF (0.44%) treatment (Shekhawat *et al.,* 2017). Data of soil organic carbon content exhibited in table 1 revealed that the application of 5 ton FYM ha^{-1} highest organic carbon noticed from FYM treated plot (0.48%) in comparison to control plot (0.43%). The maximum organic carbon was obtained from *Rhizobium* + LMn16 (0.47%) followed by *Rhizobium* (0.46%) and lowest organic carbon under seed inoculation with LMn16 (0.44%). This might be due to application of organic and inorganic fertilizers increase the stable fraction of organic matter provides evidence of an increase on the soil OC stability (Mousum *et al.,* 2023). In turn, the contribution of organic matter fraction that is more resistant to decomposition is crucial for increasing soil carbon (Debuska *et al.,* 2016; Meena and Ram 2016).

The maximum available nitrogen was recorded in 125% RDF (200 kg ha^{-1}) followed by 100% RDF (194 kg ha^{-1}) and lowest available nitrogen under 75% RDF (191 kg ha^{-1}). The maximum available nitrogen was found in application of 5 ton FYM ha^{-1} (198 kg ha^{-1}) over control (192 kg ha^{-1}) (Kumawat *et al.,* 2015 and Dhakal *et al.,* 2016). The treatment receiving seed inoculation with *Rhizobium* + LMn16 (197 kg ha^{-1}) found maximum nitrogen content followed by *Rhizobium* treatment (194 kg ha^{-1}) and minimum value of available nitrogen recovered from seed treatment (193 kg ha^{-1}). However, the maximum available nitrogen content was obtained under application of *Rhizobium* + LMn16 was statistically at par with *Rhizobium*. The data showed that the application of fertilizer, FYM and biofertilizers similar trend found in phosphorus and potassium content in soil (Khatana *et al.,* 2021). It observed that the favourable effect on soil as well as on plant due to positive soil micro climate regime in soil and effect looks on both plant and soil in terms of increase the macro and micro nutrient concentration in plant and soil. This might due to improved nutritional environment in the rhizosphere and faster rate of mobilization of applied and native nutrient leading to the dissolution of bound nutrients (Shekhawat *et al.,* 2017; Choudhary *et al.,* 2019).

The treatment receiving of 125% RDF, 100% RDF and 75% RDF zinc content varies from (0.66, 0.90 and 0.77 mg) respectively. In among these fertility levels 100% RDF level was found maximum quantity of available zinc. Application of farm yard manure results showed

Table 3: Effect of INM on micronutrients of soil after harvest of black gram

Treatments	Avail. Zn (mg kg^{-1})	Avail. Fe (mg kg^{-1})	Avail. Mn (mg kg^{-1})	Avail. Cu (mg kg^{-1})
Fertility levels	504.4	0.67	3.90	5.88
75 % RDF	548.0	0.87	4.08	5.61
100 % RDF	568.5	0.74	3.70	5.52
125 % RDF	4.93	0.04	0.03	0.05
SEm+	14.18	0.12	0.08	0.13
CD at 5%	504.4	0.67	3.90	5.88
		Farm yard manure		
Control	0.75	3.88	6.00	0.64
5 ton ha^{-1}	0.77	3.90	5.34	0.49
SEm+	0.03	0.02	0.04	0.01
CD at 5%	NS	NS	0.11	0.02
Bio fertilizers				
Rhizobium	0.76	3.52	5.50	0.55
LMn 16	0.71	4.09	6.45	0.59
Rhizobium + *LMn16*	0.81	4.05	5.07	0.55
SEm+	0.04	0.03	0.05	0.01
CD at 5%	NS	0.08	0.13	0.02

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

that available zinc was varied from 0.70 to 0.82 mg kg^{-1} under the control plot and application of 5 ton FYM ha^{-1}, respectively (Choudhary *et al.,* 2013). The maximum available zinc was observed in seed treated with combination of two different bio fertilizers like *Rhizobium* + LMn16 (0.80 mg kg^{-1}) followed by sole inoculation *Rhizobium* (0.76 mg kg^{-1}) and LMn16 (0.74 mg kg^{-1}). Further, indicated that the available iron of soil was found maximum in application of 100% RDF (4.1 mg kg^{-1}) followed by 75% RDF (3.90 mg kg^{-1}) and lowest in 125% RDF (3.7 mg kg^{-1}. The data revealed that the application of FYM was slightly increased the available iron. The iron content was varied 3.8 mg kg^{-1} (control) to 3.9 mg kg^{-1} (FYM treated plot).

The maximum available iron was recorded in seed treated with application of LMn16 followed by the combination of bio fertilizer like *Rhizobium* + LMn16 (4.0 mg kg^{-1}). The data revealed (table 2) the maximum available manganese was found in application of 75% RDF (5.88 mg kg^{-1}) over 100% RDF and 125% RDF (5.61 and 5.52 mg kg^{-1}) respectively. The data revealed that effect of bio fertilizers was significantly increased the available manganese under inoculation of LMn16 treatment (6.45 mg kg^{-1}) followed by *Rhizobium* (5.1 mg kg^{-1}) and least in combination of (*Rhizobium* + LMn16) of bio fertilizers (5.1 mg kg^{-1}). Similar, trend found in copper content in soil. The micronutrient availability was augmented by treatment receiving 75% RDF, 5 ton FYM and seed inoculant with LMn 16 found better in comparison to other treatment levels. This might be due to the improved soil physical and chemical property and release the chelating agent which, make native nutrient as well as applied nutrients more soluble and convert unavailable to available form of nutrient and ultimately increases of micronutrients concentration in soil (Debska *et al.,* 2016 and Ashutosh *et al.,* 2012).

CONCLUSION

On the basis of one year field experimentation was conducted. It can be concluded that agro climatic condition of zone V (Humid South Eastern Plain) of Rajasthan, 125% RDF + 5 ton FYM + biofertilizer could be better option for realizing higher productivity, maintaining soil health, increasing nutrient content and net return of black gram which ultimately improved the soil productivity and fertility status of soil through judicious integration of organic and inorganic fertilizers.

ACKNOWLEDGMENTS

First author thankful to Research Farm, Agricultural Research Station, Ummedganj, Kota (Rajasthan) and Department of Soil Science and Agricultural Chemistry, Agriculture University, Kota for providing all the necessary facilities required for the field experiments and laboratory work.

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