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Effect of integrated nutrient management on black gram (*Vigna mungo* (L.) growth, yield and subsequent soil fertility in middle gangetic plains of India

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Abstract
The field trial was conducted during the *Kharif* 2019 on the research farm of TCA Dholi at the Dr. Rajendra Prasad Central Agriculture University Pusa campus in Samastipur (Bihar). The test was conducted in Factorial RBD and to investigate Effect of Integrated Nutrient Management on black gram (*Vigna mungo* (L.) growth, yield and subsequent soil fertility in Middle Gangetic Plains of India. There was 8 treatment including 3 fertilizer levels (75, 100 and 125% RDF), 2 organic manure (control and FYM @ 5 tha^{-1}), 3 biofertilizer level (rhizobium, nutrient mobilizer, rhizobium+ nutrient mobilizer) and interaction with each other, treatments were randomly assigned in three replicates. The application of 125% RDF resulting higher plant height (33.67cm), more dry matter accumulation (5.56 g) and crop growth rate (6.73 g day^{-1}m^{-2}), Grain yield (10.78qt ha^{-1}) and gave higher gross return (65874 ₹ha^{-1}), net return (38883 ₹ha^{-1}) and BC ratio (1.44) as well as more soil NPK contain in F_3 treatment but statistically at par plant height (31.45cm), dry matter accumulation (5.06g) and crop growth rate (6.08), Grain yield (10.73qt ha^{-1}) and gross return (65702 ₹ha^{-1}), net return (39396 ₹ha^{-1}) and BC ratio (1.48) as well as soil NPK observed in F_2-100% RDF where addition of organic manure increase plant height (31.64cm), more dry matter accumulation (5.26 g) and crop growth rate (6.38 g day^{-1}m^{-2}), Grain yield (11.2 qt ha^{-1}) and gross return (68399 ₹ha^{-1}), net return (38007 ₹ha^{-1}) and BC ratio (1.24) as well as soil NPK in FYM treatment @ 5 tha^{-1} over control. In Biofertilizer observed higher plant height (32.32 cm), more dry matter accumulation (5.44g) and crop growth rate (6.56 gday^{-1} m^{-2}), Grain yield (10.26qt ha^{-1}) and gross return (62837 ₹ha^{-1}), net return (36508 ₹ha^{-1}) and BC ratio (1.36) and soil NPK in rhizobium + nutrient mobilizer treatment.

Keywords: Integrated nutrient management, growth, economics and soil fertility

Introduction
Pulses are given second importance after cereals and pulses crop are rich in protein, fibres, vitamins and minerals such as magnesium, iron, zinc and low in fat, making them a great addition to any diet that play very important role in the diet of humans specially in Indian people which are not able to supply their body protein due to being vegetarian. In the northern part of country black gram is grown in *kharif* or summer only while in eastern and southern part of India its grow in *rabi* season also and sometime grow as a green manuring crop. Black gram stands next to soybean in its dietary protein content and MP, UP and AP major black gram growing states in India.

Black gram consumed as peeled and un peeled form of "daal" with roti and boiled rice or other delicious food items can be prepared like idli, dosa, papad, bara, karhi, pudding, halva and imurthi (sweat), For animal purpose whole black gram plant used as a nutritive fodder. There are numerous reasons responsible for lower productivity of black gram. Among them, poor weed and fertilizer management are major factor contributing low yields of black gram. In the current intensive cropping system it is not easy to maintain productivity and protection of the environment for long. Unless we create a balance between the nutrients removal by crop from the soil and applied nutrients and this balance can be made possible by changing our present agricultural system in which our crop was committed to take nutrition from the different sources. The exact application of fertilizer and manure to the crop based on the soil testing, field trials and nutrient balances under the specific soil crop situation. Balance nutrition does not mean only added nutrient from outside but also include that nutrient which are present

already in the soil. Different sources are available now a days like fertilizer, cakes, dry blood and bone, farm yard manure, compost, vermicompost, biofertilizer (atmospheric nitrogen fixation, PSB), green manuring, etc. Manure and fertilizer are the material containing essential nutrients required for plant growth and development. In agriculture a major transformation started with the application of synthetic fertilizers to soil in the 1840 After that crops were dependent partially on chemical fertilizers and with the development of high yielding dwarf varieties (specially in rice and wheat) these dependence on inorganic fertilizer has been increased, even the green revolution was possible due to only with high yielding variety as well as fertilizers. But indiscriminate use of fertilizers is destroying our natural resources, due to which our production capacity is getting depleted for the future and we have stopped supporting natural resources for life. Therefore to save the natural resources by reducing the use of amount of chemical fertilizers and pesticides thereby maintaining the production capacity of our natural resources. Manures are organic materials containing small amount of plant nutrients and it's categories into two classes bulky and concentrate organic manures. Organic manure is also used extensively in India. In which amount of nutrients is found in very small, such manure are compost, FYM, decomposed agriculture residues and green manuring. Black gram is an important source of green manure crop when incorporated into soil to allow the release of nutrients from the green manure and making them available to the later growing crops. Incorporation of black gram leads to the several beneficial effects on soil like improvement in soil structure (i.e. by aggregation). Organic matters enhanced water infiltration, retention, soil aeration and reduce erosion. Biofertilizer is the products containing one or more carrier based living species of microorganism. The living micro-organism is capable to augment plant nutrient supplies in one way or other way. Integration of manures and Biofertilizer with inorganic fertilizer proved to be better for higher crop yield as well as maintain the soil health.

Material and Methods

The field experiment was done during 2019 at TCA Dholi which is research center of the RPCAU Pusa Samastipur Bihar. The experiment was conducted in Factorial RBD and to investigate Effect of Integrated Nutrient Management on black gram (*Vigna mungo* (L.) growth, yield and subsequent soil fertility in Middle Gangetic Plains of India. were 18 treatment combination such as 3 fertilizer levels (F_1 -75% RDF, F_2 -100% RDF and F_3 -125% RDF), 2 organic manure (M_1-control and M_2-FYM @ 5 tha^{-1}), 3 biofertilizer level (R_1-rhizobium, R_2-nutrient mobilizer, R_3-rhizobium + nutrient mobilizer) and interaction with each other, Treatments were randomly assigned in three replicates. The preparation of land with the help of tractor drawn cultivator and make suitable layout and sowing of crop in 30th July 2019 by manually and fallow all scientific methods and techniques. The soil of experimental site was slightly calcareous and moderate fertile. All observation related to crop growth takes on different growing stages of crop with five selected plant of each treatment while soil samples was collected after harvesting of black gram crop of experimental site and all soil samples analysis as per method given by Walkley and Black (1934) [10], in soil laboratory for different soil parameters. The result of observed data was analyzed with standardized principle of statistical ANOVA techniques described by Gomez and Gomez (1984) [3] at 5% level of significance.

Results and Discussion

The application of balanced nutrition with different sources results more vigorous growth, higher yield and economics of black gram (Fig Table 1) and their residual effect on soil (Table 2).

Effect of fertilizer

The significant effect of inorganic fertilizer was found on plant growth and development. Were maximum plant height (33.67 cm), Crop Growth rate (6.73 g day^{-1} m^{-2}), Plant dry matter (5.56 g plant^{-1}) and Grain yield (10.78qt ha^{-1}) observed in F_3-125% RDF. While statistical at par plant height (31.45 cm), Crop Growth rate (6.08, g day^{-1} m^{-2}), Plant dry matter (5.06 g plant^{-1}) and Grain yield (10.73qt ha^{-1}) to F_2-100% RDF and both were significantly superior over F_1-75% RDF. The sufficient availability of nutrients by fertilizers can help the better root development and vegetative growth of plants and making them dark green and enhancing protein synthesis and enhance pod settling and better regulate of all physiological activities of plants. These findings are in line with Mere *et al*. (2013) [5] and Meena *et al*. (2021) [4]. The availability of nutrients of soil affect by different treatments which found the maximum available N, P and K (192, 25.06, 122 kg ha^{-1} respectively) and 0.45% OC, 0.37 EC and 7.78 pH in F_3-125% RDF while statistically at par available N, P and K (185, 22.81, 113 kg ha^{-1}) and 0.44% OC, 0.37 EC, and 7.69 pH in F_2-100% RDF and low availability of N, P and K (177, 22.46 107 kg ha^{-1}) and 0.44% OC, 0.36 EC, and 7.67 pH in F_1-75% RDF. Inorganic fertilizers with higher nutrient content are very important nutrient sources for the plants and improves the availability of nutrients in significant growth stages that facilitate better crop growth, payoff greater transfer of nutrients and dry matter accumulation as well as left their residual effects on soil. The results were in line with the observations by Sharma *et al*. (2011). The cost of cultivation of black gram crop differed significantly from different treatments. The higher gross return (65874 ₹ ha^{-1}) was observed with the applications of 125% RDF, while the maximum net profit (39396 ₹ha^{-1}) and BC ratio (1.48) was found in 100% RDF treatment. Though the highest gross return in 125% RDF but the input cost under this treatment was comparatively higher than 100% RDF and thus reduced the net profit and overall the BC ratio with higher dose of fertilizer. The current results are agreed with the Saket *et al*. (2014) [6].

Effect of organic manure

Application of organic manure significantly improved the whole soil health in terms of increase soil buffering capacity, organic carbon, soil microorganism population and soil nutrient availability and ensure better plant growth were maximum plant height (31.64 cm) crop growth rate (6.38 g day^{-1} m^{-2}), plant dry matter accumulation (5.26) and Grain yield (11.2qt ha^{-1}) found in M_2 treatment (FYM @ 5 tha^{-1}) at 40 DAS as compared to M_1-comtrol. These findings are in consonance with Sharma *et al*. (2011). The significantly buildup soil fertility under different treatment were maximum available N, P and K (187, 26.01, 116 kg ha^{-1} respectively) and 0.45% OC, 0.36 EC, and 7.76 pH in M_2- treatment (FYM @ 5 tha^{-1}) compared to M_1 (Control) The positive effects of

FYM on growth could be supplementary effect of phyto-nutrient supply and enhanced fertility status of the soil (Datt *et al*., 2003) [1]. For the economics point of view application of FYM @5 tons ha^{-1} shown maximum gross return (68399 ₹ ha^{-1}), net profit (38007 ₹ ha^{-1}) and BC ratio (1.24) and these return were higher due to higher yield of grain and straw over no manure application treatment. Though the cost of FYM was high therefore the cost of cultivation with FYM recorded more than that of control (no manure) but overall the productivity was recorded significantly increase with FYM@ 5 tons ha^{-1} than control which ultimately fetched maximum returns. These facts in line with Singh *et al*. (2009) [5].

Effect of Biofertilizer

The application of Rhizobium + nutrient mobilizer (B_3-treatment) showed maximum plant height (32.32 cm) crop growth rate (6.56 g day^{-1} m^{-2}), plant dry matter accumulation (5.44), Grain yield (10.26qt ha^{-1}) and available N, P and K (186, 23.85 and 115 kg ha^{-1} respectively) and OC (0.44%), EC 0.36, and pH 7.72. Improvement in nutrient status of soil is due to direct release of nutrients nitrogen fixation by microbes solubilising of nutrients the reached nutrients and make available to soil- plant system. Organic acid are released by the organic manures which solubilise the fixed and unavailable form of nutrients specially P and K. this finding conformity with those of Gupta (2006) [2]. There was maximum gross return (62837 ₹ ha^{-1}), net profit (36508 ₹ ha^{-1}) and BC ratio (1.36) earned by the treatment B_3-rhizobium + nutrient mobilizer results of higher yield of black gram crop. However significantly low economic return were earned by the application of alone biofertilizer than mixed one. This results Approved by Thakur *et al*. (1999) [9].

Table 1: Effect of fertilizer, organic manure and Biofertilizer on growth parameters, yield and economics of black gram

Treatment Unit	Plant height* (cm)	Dry matter* g/plant	CGR** $g/m^2/day$	Grain yield qt/ha	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
Fertilizer dose							
F_1 (75% RDF)	26.5	4.51	5.22	6.94	42815	17197	0.67
F_2 (100% RDF)	31.45	5.06	6.08	10.73	65702	39396	1.48
F_3 (125% RDF)	33.67	5.56	6.73	10.78	65874	38883	1.44
S.E(m)±	0.77	0.14	0.25	0.29	1736	1736	0.06
CD.(P=0.05)	2.23	0.40	0.71	0.85	4993	4993	0.17
Farm yard manure(tha^{-1})							
M_1 (Control)	28.96	4.85	5.64	**7.77**	47862	25642	1.14
M_2 (FYM @ 5 tha^{-1})	31.64	5.26	6.38	11.2	68399	38007	1.24
S.E(m)±	0.63	0.11	0.20	0.24	1418	1418	0.05
CD.(P=0.05)	1.82	0.33	0.58	0.69	4077	4077	NS
Biofertilizers							
B_1 (Rhizobium)	29.35	4.84	5.74	9.17	56150	29871	1.12
B_2 (Nutrient Mobilizer)	29.23	4.83	5.75	9.03	55404	29095	1.09
B_3 (Rhizobium + B_2)	32.32	5.44	6.56	10.26	62837	1.36	36508
S.E(m)±	0.77	0.14	0.25	0.29	1736	1736	0.06
CD.(P=0.05)	2.23	0.40	0.71	0.85	4993	4993	0.17

** Crop growth rate, * plant height, Dry matter production and CGR at 40 DAS

Table 2: Effect of fertilizer, organic manure and Biofertilizers on subsequent fertility of black gram growing soil

Treatment	N (Kg ha^{-1})	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha^{-1})	OC (%)	EC dSm^{-1}	pH
Fertilizer dose						
F_1 (75% RDF)	177	22.46	107	0.44	0.36	7.67
F_2 (100% RDF)	185	22.81	113	0.44	0.37	7.69
F_3 (125% RDF)	192	25.06	122	0.45	0.37	7.78
S.E(m)±	1.52	0.30	0.53	0.012	0.003	0.04
CD.(P=0.05)	4.36	0.86	1.52	NS	NS	NS
Farm yard manure (tha^{-1})						
M_1 (Control)	182	20.87	112	0.43	0.37	7.67
M_2 (FYM @ 5 tha^{-1})	187	26.01	116	0.45	0.36	7.76
S.E(m)±	1.24	0.24	0.43	0.010	0.002	0.03
CD.(P=0.05)	3.56	0.70	1.24	NS	NS	NS
Biofertilizers						
B_1 (Rhizobium)	184	22.97	113	0.43	0.37	7.72
B_2 (Nutrient Mobilizer)	183	23.50	114	0.44	0.36	7.70
B_3 (Rhizobium + B_2)	186	23.85	115	0.44	0.36	7.72
S.E(m)±	1.52	0.30	0.53	0.012	0.003	0.04
CD.(P=0.05)	NS	NS	NS	NS	NS	NS

Conclusion

Application of NPK @ 125% RDF (25:56:25 kg ha^{-1}) + FYM @ 5 tons ha^{-1} + Rhizobium + nutrient mobilizer treatment gave maximum Growth attributes, Yield and fertility of soil and economic returns of blackgram but statistically at par Growth attributes, Yield and fertility of soil and economic returns found at 100% RDF (20:45:20 kg ha^{-1}) + FYM @ 5 tons ha^{-1} + Rhizobium + nutrient mobilizer treatment. These results show the integration of different nutrient sources increase resources sustainability and reasonable crop production.

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