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Production potential, economics and soil fertility status of blackgram (*Phaseolus mungo*) as influenced by integrated nutrient supply system

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ABSTRACT

A fixed plot field experiment was conducted during two consecutive years (2010-12) at Farm Research, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, to find out the suitable integrated nutrient supply (INS) practice for improving the soil health, yield and profitability of blackgram in Eastern Indo Gangatic plain zone of India. The results indicated that significantly higher grain (948 and 971 kg ha^{-1}), stover (2433 and 2525 kg ha^{-1}), biological (3381and 3496 kg ha^{-1}) yields of blackgram were observed with the application of soil test based NPK+10 t FYM ha^{-1} + *Rhizobium* + 30 kg S ha^{-1} + 1 kg Mo ha^{-1} over rest of the treatments.With regards to soil fertility after crop harvest, soil test based application of NPK + 10 t FYM ha^{-1} + *Rhizobium* + 30 kg S ha^{-1}+ 1 kg Mo ha^{-1} resulted in the highest soil available N (223 and 228 kg ha^{-1}), P (21.17 and 22 kg ha^{-1}), K (244 and 247.60 kg ha^{-1}), S (19 and 19.78 kg ha^{-1}) and Mo (0.30 and 0.33 mg kg^{-1}) over other INM treatments. Similarly, soil test based application of NPK + 10 t FYM ha^{-1} + *Rhizobium* + 30 kg S ha^{-1}+ 1 kg Mo ha^{-1} recorded maximum gross returns (Rs.38584 and 50576 ha^{-1}), net returns (Rs.20624.52 and 32415.09 ha^{-1}) and benefit: cost ratio (2.15 and 2.78) over other nutritional treatments. Hence, study suggested that grower should follow soil test based application of NPK along with 10 t FYM ha^{-1} + *Rhizobium* + 30 kg S ha^{-1}+ 1 kg Mo ha^{-1} for fetching higher profitability from black gram cultivation in Eastern part of Indo Gangatic plains.

Key words: Available nutrients, Blackgram, Harvest index, INS, Yield.

INTRODUCTION

Black gram (*Phaseolus mungo*) is one of the important pulse crop, grown throughout the country. Among pulses, black gram area has increased from 1.87 m ha in 1971–72 to 3.48 Mha during 2015-16 with production level of 1.90 MT.

Black gram seeds are highly nutritious containing higher amount of protein (24-26%), which is almost three times that of cereals and are reported to be rich in potassium, phosphorus and calcium. The crop is resistant to adverse climatic conditions and improves soil fertility by fixing atmospheric nitrogen in the soil. Nutrient imbalance is one of the major abiotic constraints limiting productivity of pulses in general and black gram in particular. Balanced nutrition is crucial for achieving higher productivity. At the same time, in view of short supply of inorganic fertilizers, snowballing nutrients demand and price, there is gigantic need to exploit the alternate source of nutrients other than the conventional inorganic sources in an integrated fashion without excess reliance on one of them to sustain the pulses productivity. Pulses specially need adequate amount of P, Ca, Mg, S and Mo. Phosphorus is required for proper root growth and growth of rhizobia. Calcium and magnesium are required to stimulate growth and to increase the size of the nodules pod formation and grain setting. Sulphur is required for nodulation and protein synthesis. Furthmore, sulphur is also an indispensible element for legume growth and development (Yadav *et al.* 2017). Similarly, molybdenum plays a pivotal role in nitrogen fixation and assimilation and boron in reproduction processes in pulses (Thiyagarajan *et al.* 2003). INS (Integrated Nutrients Supply) an integrated nutrient supply system, supply the nutrients in synchronize manner as per the need of crops. Hence, there is a scope for improving the production potential of this crop by use of organic manures, inorganic manures and biofertilizers. Organic manures, on the other side, provide a good substrate for the growth of micro-organisms and maintain a favourable nutrient supply environment and improve soil physical properties (Kumpawat, 2010). The existing blanket recommendation for crops does not ensure efficient and economic use of fertilizers, as it does not take into account the fertility variations resulting in imbalanced use of fertilizer nutrients. Among the various methods of fertilizer recommendations, the soil test based fertilizer recommendations is also appropriate practices to improve

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yield as well as soil nutrient status (Gayathri *et al*. 2009). The present investigation was therefore, conducted to work out the response of FYM, soil test based NPK, Sulphur and Mo along with *Rhizobium* on yield, economics and soil fertility of blackgram in an Inceptisol.

MATERIALS AND METHODS

The experiment was conducted during two consecutive *kharif* seasons of 2010 and 2011 at Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, situated in the south eastern part of Varanasi city at 25° 18' N latitude, 83° 30' E longitudes and at an altitude of 125.93 meters above mean sea level. The soil of Varanasi region formed under alluvium deposited by river Ganges, have predominance of Illite, Quartz and Feldspar minerals. Most of the soils of Varanasi division have been classified in the soil order of Inceptisol (Udic, Ustochrept). Varanasi has a sub-tropical climate with extremes of hot in summer and cold in winter. The average temperature ranges from 18°C to 32°C and the normal annual rainfall of the region is about 1113 mm.The initial soil was sandy clay loam in texture, pale olive in colour, low in organic carbon (0.42g kg^{-1}), available nitrogen (191.4 kg ha^{-1}) and sulphur (12.5 kg ha^{-1}), medium in available phosphorous (16.30 kg ha^{-1}), available potassium (212.8 kg ha^{-1}) and available molybdenum (0.09 mg kg^{-1}) with pH (7.56) and electrical conductivity (EC) 0.26 dS m^{-1}. The soil samples were tested with pH, electrical conductivity, organic carbon content, available N, P, K, S and Mo as per methods given by (Jackson, 1973), Walkley and Black (1934), Subbaiah and Asija (1956), Olsen *et al*. (1954), Chesnin and Yien (1951) and Soltanpour *et al.* (1982). The experiment was carried out in randomized block design with nine treatments *viz*., T_1-Control, T_2-100% RDF, T_3-100%RDF+5t FYM ha^{-1}, T_4-50%RDF +10t FYM ha^{-1}, T_5-50%RDF+10t FYM ha^{-1}+Rh, T_6-50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}, T_7- 50% RDF +10t FYM ha^{-1}+Rhizobium (Rh)+30kg S ha^{-1}+1kg Mo ha^{-1}, T_8 - STB+5t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}, T9-STB+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1} in three replications. Full dose of phosphorous in the form of diammonium phosphate (DAP) @ 40 kg ha^{-1}, nitrogen through urea @ 20 kg ha^{-1} and potassium through muriate of potash @ 20 kg ha^{-1} were applied as per treatment as basal.

Table1: Effect of integrated nutrient supply (INS) on grain, stover and total biomass yields of blackgram.

Treatment	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Total Biological yield (kg ha^{-1})		Harvest index (%)	
	2010	2011	2010	2011	2010	2011	2010	2011
Control	467	465	1753	1820	2219	2286	21.10	20.44
100% RDF	633	640	2166	2250	2799	2890	22.61	22.15
100%RDF+5t FYM ha^{-1}	720	733	2183	2350	2903	3083	24.79	23.78
50%RDF +10t FYM ha^{-1}	731	748	2166	2233	2898	2981	25.24	25.08
50%RDF+10t FYM ha^{-1}+Rh	737	757	2200	2267	2937	3024	25.10	25.07
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}	782	807	2233	2317	3015	3123	25.93	25.84
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+1kg Mo ha^{-1}	812	842	2267	2342	3078	3184	26.38	26.45
STB+5t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	880	903	2400	2433	3280	3337	26.85	27.09
STB+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	948	971	2433	2525	3381	3496	28.08	27.80
SEm ±	12.43	6.55	57	55	58	61	0.579	0.39
CD (P = 0.05)	37.28	19.63	171	170	174	182	1.734	1.17

RDF = Recommended dose of fertilizers, STB = Soil test based NPK fertilizers, Rh = Rhizobium, FYM = Farmyard manure.

Table 2: Effect of integrated nutrient supply (INS) on gross returns, net returns and B:C ratio.

Treatment	Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B:C ratio	
	2010	2011	2010	2011	2010	2011
Control	20659	26364	7773	13276	1.60	2.01
100% RDF	27389	35381	13375	21165	1.95	2.49
100%RDF+5t FYM ha^{-1}	30299	39744	14885	24128	1.97	2.55
50%RDF +10t FYM ha^{-1}	30634	39966	14384	23515	1.89	2.43
50%RDF+10t FYM ha^{-1}+Rh	30921	40484	14671	24033	1.90	2.46
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}	32495	42795	16053	26152	1.98	2.57
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+1kg Mo ha^{-1}	33585	44402	16471	27087	1.96	2.56
STB+5t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	36240	47360	19680	30599	2.19	2.83
STB+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	38584	50576	20624	32415	2.15	2.78
SEm ±	440	424	440	424	0.029	.028
CD (P = 0.05)	1319	1273	1319	1272	0.086	.082

RDF = Recommended dose of fertilizers, STB = Soil test based NPK fertilizers, Rh = Rhizobium, FYM = Farmyard manure.

In some of the treatments, NPK were applied on the basis of soil test based as basal application. Sulphur was added in the form of gypsum @ 30 kg S ha^{-1} and Molybdenum @ 1 kg Mo ha^{-1} through ammonium molybdate.The seeds were inoculated with *Rhizobium*, @ 200g/10kg seed. The farmyard manure contained 0.50% N and 0.25% P, 0.50% K (on oven dry basis). Farmyard manure was applied as per treatment at three weeks before sowing. The crop was sown in first fortnight of July using genotype Shekhar-2. The requisite plot wise fertilizers were prepared and applied before sowing. Each treatment was accommodated in 5.0x4.0 m^2 plot with row to row distance 30 cm and plant to plant 15 cm. Data on grain yield, stover yield,biological yield and harvest index were recorded as per the standard procedures. Economic return was calculated on present market price of output and inputs to check profitability of integrated nutrient management in blackgram.The data of both years were statistically analyzed by adopting appropriate method of standard analysis of variance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect of INS on productivity of blackgram: The data revealed that grain yield, stover yield, biological yield and harvest index of blackgram were significantly influenced by the integration of inorganic fertilizers, FYM and *Rhizobium* during both years of study. In general all the integrated nutrient supply (INS) treatments produced higher grain and stover yield over the control. Further, data revealed that application of soil test based NPK+10t FYM ha^{-1} +*Rhizobium*+30kg S ha^{-1}+ 1kg Mo ha^{-1} recorded maximum grain yield (948 kg ha^{-1} and 971 kg ha^{-1}) and stover yield (2433.3 and 2525 kg ha^{-1}) over rest of the treatments (Table 1). The INM treatments have asserted significant variation on biological yield and harvest index of blackgram. The application of soil test based NPK+10t FYM ha^{-1} +*Rhizobium*+30 kg S ha^{-1}+ 1kg Mo ha^{-1} was gave higher biological yield (3381.3 and 3496 kg ha^{-1}) and harvest index (28.08 and 27.80 %) of blackgramthan control (2219.7, 2286 kg ha^{-1} and 21.10, 20.44%), respectively (Table 1). In general soil test based NPK application in conjunction with 10t FYM ha^{-1}+ *Rhizobium*+30 kg S ha^{-1}+ 1kg Mo ha^{-1} recorded 50.7, 52, 29 and 27% higher grain and stover yield over control during both 2010 and 2011, respectively. Application of soil test based NPK, S, Mo and FYM along with *Rhizobium* significantly enhanced biological yield and harvest index. Combined use of inorganic, organic and biofertilizers resulted in better growth associated with increased availability of nutrients might have resulted in better development of growth and yield attributing parameters, which ultimately resulted in higher yields. These results are corroborated by the findings of Khosro and Yousef (2012,) Amruta *et al.* (2015) and Zahida *et al.* (2016).

Effect of INS on economics of blackgram: Data on gross returns, net returns and benefit: cost ratio indicated that there

Table 3: Effect of integrated nutrient supply (INS) on available nutrients after two year of experimentation.

Treatment	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Available S (kg ha^{-1})		Available Mo (mg kg^{-1})	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
Control	188.83	186.50	14.61	13.74	205.05	202.12	9.71	9.38	0.12	0.13
100% RDF	199.00	201.00	18.10	18.60	216.33	220.27	10.83	10.33	0.11	0.12
100%RDF+5t FYM ha^{-1}	205.17	211.33	18.75	19.62	227.95	233.60	13.60	13.90	0.17	0.19
50%RDF +10t FYM ha^{-1}	216.25	219.58	18.76	19.09	238.91	240.92	14.67	14.83	0.20	0.21
50%RDF+10t FYM ha^{-1}+Rh	218.20	221.20	18.56	19.21	238.63	241.33	14.55	15.03	0.22	0.24
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}	218.67	222.67	18.33	19.37	235.58	243.60	18.83	18.96	0.23	0.24
50%RDF+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+1kg Mo ha^{-1}	219.50	224.67	18.73	19.67	233.48	246.27	18.89	19.06	0.29	0.31
STB+5t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	214.00	220.67	18.67	19.33	224.81	240.93	17.84	18.17	0.28	0.30
STB+10t FYM ha^{-1}+Rh+30kg S ha^{-1}+ 1kg Mo ha^{-1}	223.33	228.33	21.17	22.00	244.27	247.60	19.29	19.78	0.30	0.33
SEm ±	3.27	2.30	0.81	0.40	4.81	4.00	0.76	0.57	0.015	0.009
CD (P = 0.05)	9.80	6.89	2.43	1.19	14.42	12.00	2.29	1.70	0.044	0.027

RDF = Recommended dose of fertilizers, STB = Soil test based NPK fertilizers, Rh = Rhizobium, FYM = Farmyard manure.

was significant variation due to various INM treatments during the studies years. All the INS treatments recorded significantly higher gross returns, net returns and benefit: cost ratio over control. Among the INM treatments, soil test based application of NPK +10t FYM ha^{-1} + Rh + 30 kg S ha^{-1} + 1kg Mo ha^{-1} produced maximum gross returns (Rs.38584 and 50576 ha^{-1}), net returns (Rs.20624.52 and 32415.09 ha^{-1}) and benefit: cost ratio (2.15 and 2.78) over control (Table 2). This resulted in 62% and 59% higher net returns over the control during 2010 and 2011, respectively. This could be attributed to higher seed and straw yield coupled with lower cost of production resulted in higher net return and BCR value.These observations were supported by the findings of Quddus *et al*. (2012) and Chaudhary *et al.* (2016)

Effect of INS on soil fertility: The data indicated that N, P, K, S and Mo availability in soil after crop harvest differed significantly due to combination of INS treatments during both the years of investigation (Table 3). Among INM treatments, highest soil available N (223 and 228 kg ha^{-1}), P (21.17 and 22 kg ha^{-1}), K (244 and 247.60 kg ha^{-1}), S (19 and 19.78 kg ha^{-1}) and Mo (0.30 and 0.33 mg kg^{-1}), respectively was noted with the application of soil test based NPK + 10 t FYM ha^{1} + *Rhizobium* + 30 kg S ha^{-1} + 1 kg Mo ha^{-1}over control during both the years (Table 3). This result may be attributed due to the application of FYM; in addition to being a store house of almost all the nutrients, required for plant growth, improved the soil environment by way of improving the physico-chemical properties of soil. The availability of most of the plant nutrients increased owing to reduction in pH, and improvement in the cation exchange capacity of the soil. Application of FYM and inorganic fertilizers in conjunction with *Rhizobium* had favourable impact on available N, P, K, S and Mo content in soil after crop harvest. The another reason is increase of soil nutrients status with the addition of FYM might be due to the chelating action of organic compounds released during decomposition of manures and prevention of these cations from fixation, precipitation, oxidation and leaching. These findings are in agreements with those of Quddus *et al*. (2012), Kumawat *et al*. (2015), Nagar *et al*. (2016) and Bade *et al.* (2016).

Thus, it is concluded that application of 10 t FYM and soil test based N P K, 30 kg S ha^{-1} and 1 kg Mo ha^{-1} along with *Rhizobium* may be recommended for efficient nutrient management in achieving higher crop productivity and maintaining soil health of blackgram in Eastern part of Uttar Pradesh.

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