Indian Journal of Agricultural Sciences **80** (1): 76–9, January 2010

Integrated nutrient management in blackgram (*Vigna mungo*) and its residual effect on succeeding mustard (*Brassica juncea*) crop*

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Received: 11 March 2009; Accepted: 10 November 2009

Key words: Biofertilizer, Blackgram, Economics, Integrated nutrient management, Mustard, Nutrient uptake, Yield

Blackgram [*Vigna mungo* (L.) Hepper] is one of the major rainy season pulse crops of Rajasthan and India. Pulses are generally grown in soils with low fertility status or with application of low quantities of organic and inorganic sources of plant nutrients, which has resulted in deterioration of soil health and productivity. The productivity of blackgram can be increased by inoculation of biofertilizers prepared from *Rhizobium* and phosphate-solubilizing micro-organisms. These biofertilizers have shown encouraging results in sustaining the crop productivity and improving the soil fertility (Govindan and Thirumurugan 2005). 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. Use of biofertilizers with organic manures may prove a viable option for sustaining crop production. With the short supply and escalating price of inorganic fertilizers, there is an increasing awareness in favour of adopting biofertilizers. However, information on the use of organic, inorganic and biofertilizers is lacking in many crops including blackgram.

Thus, integrated approach of nutrient supply by chemical fertilizers along with organic manures and biofertilizers is gaining importance as this system not only reduces the use of inorganic fertilizers but is also an environment-friendly approach. Hence, the present investigation was conducted to find out suitable nutrient management strategies for blackgram and its residual effect on Indian mustard [*Brassica juncea* (L.) Czernj & cosson] in southern Rajasthan.

The field trial was conducted during rainy *(kharif*) and winter *(rabi*) seasons of 2006–07 and 2007–08 under blackgram-mustard cropping system approach at Dryland Farming Research Station, Arjia, Bhilwara (25° 20' N and 74° 20' E at an altitude of 432.6 m above msl). The soil was well drained clay loam in texture with *p*H 7.9, EC 1.39 dS/m, low in organic carbon (0.39%), available P (36.5 kg/ha) and available K (362 kg/ha). The experiment was laid out in randomized block design having 4 replications with 12 nutrient management treatments, viz. T_1, 100% of recommended dose of fertilizers (RDF); T_2, 75% of RDF + bacterial culture [*Rhizobium* + phosphate-solubilizing bacteria (PSB)]; T_3, 75% of RDF + FYM 1.25 tonnes/ha; T_4, 75% of RDF + vermicompost 0.63 tonnes/ha; T_5, 50% of RDF+ FYM 2.5 tonnes/ha; T_6, 50% of RDF + vermicompost 1.25 tonnes/ha; T_7, FYM 5 tonnes/ha; T_8, vermicompost 2.5 tonnes/ha; T_9, 25% of RDF + FYM 2.5 tonnes/ha + *Rhizobium* + PSB; T_{10}, 25% of RDF + vermicompost 1.25 tonnes/ha + *Rhizobium* + PSB; T_{11}, FYM 5 tonnes/ha + *Rhizobium* + PSB; and T_{12}, vermicompost 2.5 tonnes/ha + *Rhizobium* + PSB. The blackgram variety 'T9' was sown at 30 cm rows on 2 July, 2006 and 14 July, 2007. The RDF was 20 kg N and 40 kg. P_2O_5/ha, applied basal through urea and single super-phosphate as per treatment. Biofertilizers were applied as seed treatment just before sowing. The FYM and vermicompost were applied about 20 and 4 days before sowing of blackgram, respectively. All other operations were performed as per recommendations of the crop. The data on various growth and yield attributes, seed and straw yields were recorded under various treatments. The treatments were applied to blackgram in *kharif* for direct effect and their residual effect was studied on mustard during *rabi* on same lay-out. Mustard variety 'Laxmi' was sown at 30 cm on 17 October during both the years. Economic analysis (gross returns, net returns, benefit : cost ratio) was carried out using current price of 2006–07 and 2007–08 of inputs. Seed and straw yields were recorded after harvest.

The representative dry samples of seed and straw were analyzed for ascertaining the nutrient (N and P) content. The results of both the years were more or less similar and hence 2 years data were averaged and statistically analysis was carried out as per standard methods of analysis.

The integrated use of organic, inorganic and biofertilizers

* Short note

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Table 1 Effect of integrated nutrient management on yield attributes and yield of blackgram (mean data of two years)

Treatment	Plant height (cm)	Pods/ plant	1000–seed weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	N uptake (kg/ha)			P uptake (kg/ha)		
						Seed	Straw	Total	Seed	Straw	Total
T_1 100% RDF	55.0	51.0	43.6	1 135	3 139	37.7	27.1	64.8	4.7	6.7	11.4
T_2 75% RDF + *Rhizobium* + PSB	54.8	49.8	42.9	1 227	3 048	40.8	27.1	67.9	5.2	6.9	12.1
T_3 75% RDF + FYM 1.25 tonnes/ha	60.8	52.7	45.8	1 290	3 246	43.3	30.3	73.6	5.7	7.6	13.3
T_4 75% RDF + vermicompost 0.63 tonnes/ha	59.2	53.0	44.6	1 292	3 377	43.5	32.7	76.2	5.8	8.2	14.0
T_5 50% RDF + FYM 2.5 tonnes/ha	55.5	50.4	42.7	1 1.87	3 2.12	39.4	29.9	69.3	5.1	7.4	12.5
T_6 50% RDF + vermicompost 1.25 tonnes/ha	57.8	51.3	44.2	1 185	3 264	39.4	31.1	70.5	5.0	8.0	13.0
T_7 FYM 5 tonnes/ha	54.1	55.4	43.3	1 106	3 044	36.7	28.1	64.8	4.7	7.2	11.9
T_8 Vermicompost 2.5 tonnes/ha	55.1	55.9	44.5	1 137	3 135	37.8	28.8	66.6	4.8	7.4	12.2
T_9 25% RDF + FYM 2.5 tonnes/ha+ *Rhizobium*+PSB	58.1	57.5	45.3	1 342	3 056	45.1	27.6	72.7	6.0	6.8	12.8
T_{10} 25% RDF + FYM 1.25 tonnes/ha+ *Rhizobium* + PSB	58.7	55.9	44.1	1 319	2 998	44.4	27.2	71.6	5.9	6.8	12.7
T_{11} FYM 5 tonnes/ha + *Rhizobium* + PSB	57.8	55.8	42.9	1 250	3 369	41.8	31.8	73.6	5.4	8.1	13.5
T_{12} Vermicompost 2.5 tonnes/ha + *Rhizobium* + PSB	58.3	54.3	43.2	1 287	3 310	43.1	31.5	74.6	5.7	8.0	13.7
S Em±	0.7	0.6	0.4	19	90	0.6	1.1		0.1	0.4	
CD ($P = 0.05$)	1.9	1.8	1.2	54	259	1.8	3.3		0.4	1.0	

as a source of nutrients increased the plant height, pods/plant, 1 000-seed weight, seed and straw yield of blackgram (Table 1). Maximum plant height was registered with application of 75% RDF along with FYM 1.25 tonnes/ha (T_3), which was significantly superior to all other treatments except treatments consisting of 75% RDF with vermicompost 0.63 tonnes/ha (T_4) and 25% RDF + vermicompost 1.25 tonnes/ha along with *Rhizobium* + PSB (T_{10}). The trend was almost similar in case of 1 000-seed weight also.

Application of 25% RDF + FYM 2.5 tonnes/ha along with *Rhizobium* and PSB (T_9), 25% RDF + vermicompost 1.25 tonnes/ha along with *Rhizobium* and PSB (T_{10}), vermicompost 2.5 tonnes/ha (T_8) and FYM 5 tonnes/ha with *Rhizobium* and PSB (T_{11}) treatments were at par with regards to pods/plant but significantly superior to rest treatments. Combined use of organic, inorganic and biofertilizers resulted in better growth associated with increased availability of nutrients might have resulted in better development of yield attributes under these treatments.

Integrated nutrient management had significant impact on the seed and straw yield of blackgram (Table 1). Application of 25% RDF + FYM 2.5 tonnes/ha with *Rhizobium* + PSB (T_9) gave maximum seed yield (1 342 kg/ha), followed by treatment T_{10} consisting of 25% RDF + vermicompost 1.25 tonnes/ha with *Rhizobium*+PSB (1 319 kg/ha) which was 18.2 and 16.2% higher than 100% RDF (T_1), respectively. Further, all other treatments except 50% RDF + vermicompost 1.25 tonnes/ha (T_6), FYM 5 tonnes/ha (T_7) and vermicompost 2.5 tonnes/ha (T_8) also gave significantly higher seed yield as compared to 100% RDF. The increased growth along with better expression of yield attributes might have led to increase in the seed yield under these treatments. The higher straw yield was realized with 75% RDF with vermicompost 0.63 tonnes/ha (T_4), which was remained at par with treatments consisting of FYM 5 tonnes/ha and vermicompost 2.5 tonnes/ha along with *Rhizobium* + PSB inoculation (T_{11} and T_{12}). The favourable effect of integration of chemical fertilizers, *Rhizobium* and PSB on growth and yield were also reported by Afzal and Bano (2008).

Significant variation in N and P uptake by seed and straw of blackgram was noticed under different nutrient management treatments (Table 1). Integrated use of organic, inorganic and biofertilizers significantly improved the N and P uptake by seed and straw over 100% RDF (T_1). Difference between the treatments received 75% RDF along with FYM 1.25 tonnes/ha, vermicompost 0.63 tonnes/ha (T_3, T_4) and 25% RDF + *Rhizobium* + PSB with FYM 2.5 tonnes/ha, vermicompost 0.25 tonnes/ha (T_9, T_{10}) remained non-significant in case of N uptake by seed. The highest N uptake by seed (45.1 kg/ha) and straw (32.7 kg/ha) was recorded from the treatments consisting of 25% RDF + FYM 2.5 tonnes/ha + *Rhizobium* + PSB (T_9) and 75% RDF along with vermicompost 0.63 tonnes/ha (T_4), respectively. Maximum total N uptake was noticed from treatment consisting of 75% RDF with vermicompost 0.63 tonnes/ha (T_4) which was 17.6% higher over 100% RDF (T_1).

The highest P uptake from seed and straw was recorded from treatments consisting of 25% RDF + FYM 2.5 tonnes/ha + *Rhizobium* + PSB (T_9) and 0.75% RDF + vermicompost 0.63 tonnes/ha (T_4), respectively. Treatments receiving 25% RDF + vermicompost 1.25 tonnes/ha along with *Rhizobium* + PSB (T_{10}), 75% RDF with FYM 1.25 tonnes/ha and vermicompost 0.63 tonnes/ha (T_3 and T_4) and vermicompost

Table 2 Effect of integrated nutrient management on yield of succeeding mustard, nutrient uptake, economics and soil nutrients status (mean data of 2 years)

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	N uptake (kg/ha)			P uptake (kg/ha)			Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit: cost ratio
			Seed	Straw	Total	Seed	Straw	Total			
T_1 100% RDF	1 429	3 608	47.7	41.1	88.8	7.9	5.4	13.3	64 736	44 036	3.1
T_2 75% RDF + *Rhizobium* + PSB	1 490	3 864	50.0	44.7	94.7	8.1	6.5	14.6	68 258	47 608	3.3
T_3 75% RDF + FYM 1.25 tonnes/ha	1 523	3 837	51.3	44.9	96.2	8.5	6.3	14.8	70 660	48 365	3.2
T_4 75% RDF + vermicompost 0.63 tonnes/ha	1 469	3 650	49.2	41.9	91.1	8.0	5.5	13.5	69 439	46 904	3.1
T_5 50% RDF + FYM 2.5 tonnes/ha	1 487	3 631	49.6	41.6	91.2	8.3	5.3	13.6	67 409	44 309	2.9
T_6 50% RDF + vermicompost 1.25 tonnes/ha	1 479	3 662	49.7	42.1	91.8	8.4	5.5	13.9	67 225	42 975	2.8
T_7 FYM 5 tonnes/ha	1 483	3 712	49.8	43.0	92.8	8.3	6.0	14.3	65 379	39 829	2.6
T_8 Vermicompost 2.5 tonnes/ha	1 483	3 677	49.7	42.3	92.0	8.3	5.9	14.2	66 143	38 593	2.4
T_9 25% RDF + FYM 2.5 tonnes/ha+ *Rhizobium* + PSB	1 594	3 746	53.6	43.5	97.1	9.1	5.9	15.0	73 367	50 342	3.2
T_{10} 25% RDF + FYM 1.25 tonnes/ha+ *Rhizobium* + PSB	1 600	3 785	53.8	44.0	97.8	9.0	6.2	15.2	72 962	48 787	3.0
T_{11} FYM 5 tonnes/ha + *Rhizobium* + PSB	1 642	3 862	55.4	44.8	100.2	9.1	5.9	15.0	72 885	47 235	2.8
T_{12} Vermicompost 2.5 tonnes/ha + *Rhizobium* + PSB	1 510	3 685	50.6	42.3	92.9	8.5	5.9	14.4	70 295	42 145	2.5
S Em±	28	76	0.96	1.17		0.20	0.3				
CD (P = 0.05)	80	NS	2.75	NS		0.6	NS				

2.5 tonnes/ha with *Rhizobium* + PSB (T_{12}) were at par in case of P uptake by seed, while treatments receiving 50% RDF + vermicompost 1.25 tonnes/ha (T_6), FYM 5 tonnes/ha and vermicompost 2.5 tonnes/ha along with *Rhizobium* + PSB (T_{11} and T_{12}) were at par with regards to P uptake by straw. Treatment receiving 75% RDF with vermicompost 0.63 tonnes/ha (T_4) recorded maximum total P uptake (14.0 kg/ha) which was 22.8% higher over 100% RDF (T_1).

The residual effect of integrated nutrient management significantly increased the seed yield of mustard (Table 2). Application of FYM 5 tonnes/ha along with *Rhizobium* + PSB (T_{11}) registered highest seed yield (1 642 kg/ha) of mustard which was significantly higher than the treatment 100% RDF (T_1). However, treatments receiving 25% RDF + FYM 2.5 tonnes/ha with *Rhizobium* + PSB (T_9) and 25% RDF+ vermicompost 1.25 tonnes/ha along with *Rhizobium* + PSB (T_{10}) were at par. The results indicating a profound influence of residual effect of organic manures along with biofertilizers on mustard productivity. These results are in close conformity with the findings of Singh and Rai (2004).

The uptake of N and P by mustard seed was also significantly improved by the residual effect of FYM and vermicompost along with *Rhizobium* + PSB inoculation applied to preceding blackgram crop. This might be due to the fact that it modified the soil environment, besides improving the physical properties of soil and also the slow microbial decomposition of humus gradually increased the availability of nutrients during the succeeding crop, which was manifested in higher nutrient uptake by the mustard. Similarly, beneficial effect of integrated nutrient management on residual wheat crop in a sunnhemp-wheat cropping sequence was also reported by Maitra *et al.* (2008).

The maximum net returns was realized with integrated use of 25% RDF + FYM 2.5 tonnes/ha with inoculation of *Rhizobium* + PSB (T_9) (Table 2). Integration of organic, inorganic and biofertilizers was more remunerative with higher benefit: cost (B: C) ratio (3.0 to 3.3) than application of only FYM and vermicompost (2.4 to 2.6) which was also lower than 100% RDF (3.1).

Thus, it is concluded that integrated nutrient management consisting of chemical fertilizer @25% RDF with FYM 2.5 tonnes/ha with *Rhizobium* + PSB in blackgram-mustard cropping system can be used to achieve high yield and resource utilization with maximum returns.

SUMMARY

The experiment was conducted during rainy *(kharif)* and winter *(rabi)* season of 2006–07 and 2007–08 at Arjia, Bhilwara to evaluate the direct and residual effect of integrated nutrient management practices on blackgram and succeeding Indian mustard under sub-humid southern plain and Aravalli hills region of Rajasthan. Integrated nutrient management showed significant influence on productivity and nutrient uptake of blackgram. Application of 25% RDF + FYM 2.5 tonnes/ha along with *Rhizobium* + PSB registered maximum improvement in seed yield (1 342 kg/ha) which was 18.2% higher than 100% RDF. Treatment receiving 75% RDF with vermicompost 0.63 tonnes/ha gave maximum N

and P uptake. Residual effect of integrated nutrient management practices was also equally effective in improving the yield and nutrient uptake of mustard. Application of FYM 5 tonnes/ha along with *Rhizobium* + PSB recorded the highest seed yield of mustard (1 642 kg/ha), followed by treatments receiving 25% RDP + vermicompost 1.25 tonnes/ha with *Rhizobium* + PSB (1 600 kg/ha) and 25% RDF + FYM 2.5 tonnes/ha with *Rhizobium* + PSB (1 594 kg/ha). Similar trend was also observed for N and P uptake. Maximum net returns (Rs 50 342/ha) with B: C ratio (3.2) was obtained from treatment receiving 25% RDF + FYM 2.5 tonnes/ha with *Rhizobium* + PSB.

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