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Dr. Santosh Kumar Singh
Associate Professor, Department of Agronomy, Shri Durga Ji Post Graduate College, Chandeshwar, Azamgarh, Uttar Pradesh, India

Corresponding Author:
Dr. Santosh Kumar Singh
Associate Professor, Department of Agronomy, Shri Durga Ji Post Graduate College, Chandeshwar, Azamgarh, Uttar Pradesh, India

Effect of organic and inorganic fertilizer on productivity and economics of blackgram (*Phaseolus mungo*) under Wheat-Blackgram cropping sequence

Dr. Santosh Kumar Singh

Abstract
The field experiment was conducted at agriculture research farm of S.D.J Post Graduate College Chandeshwar, Azamgarh, (U.P.) during 2005-06 and 2006-07. The experiment laid out in Randomized Block Design (RBD) with nine treatment combination *viz*., three soil treatments in main plot [Control (C_0), Gypsum @ 100 kg/ha (C_1), FYM @ 5 t/ha (C_2)] and six chemical fertilizer treatments in sub plot [Black gram; F_1-100% Recommended ($N_{20}P_{40}K_{20}$), F_2- 75% of recommended ($N_{15}P_{30}K_{15}$), F_3-50% of recommended ($N_{10}P_{20}K_{10}$) & Wheat; F_1-100% Recommended ($N_{120}P_{60}k_{40}$), F_2-75% of Recommended ($N_{90}P_{45}K_{30}$), F_3-50% of recommended ($N_{60}P_{30}K_{20}$)],total number of plots were 36 along with four replications. The result indicates that significantly higher grain yield (pooled 2005-06, 2006-07); Stover yield (2005-06, 2006-07) and biological yield (2005-06, 2006-07) and harvest index (2005-06, 2006-07) were recorded with the application of soil test based FYM @ 5t ha^{-1} [C_2]and in 100% Recommended ($N_{20}P_{40}K_{20}$)[F_1]. Growth parameters were also found higher with the application of 5 t hac^{-1} FYM and with 100% recommended dose of chemical fertilizer as compare to other treatments. With regards to economics, soil test based application of 5t FYM ha^{-1} resulted in highest gross returns (Rs. 16591 ha^{-1}), net returns (3251 ha^{-1}) and benefit: cost ratio (1.25) over other nutritional treatments. Similarly, in chemical fertilizer treatments the100% Recommended ($N_{20}P_{40}K_{20}$) obtained the highest gross return (Rs. 16510 ha^{-1}), net return (Rs.2661 ha^{-1}) and benefit cost ratio (1.27) among the other treatment respectively.

Keywords: Blackgram, organic, nutrients, economics and yield

Introduction
Blackgram (*Phaseolus mungo*) commonly called as Urad in India. India is the world's largest producer as well as consumer of blackgram. It produces about 24.5 lakh tonnes of Urad annually from about 4.6 million hectares of area, with an average productivity of 533 Kg per hectare in 2020-21. Blackgram area accounts for about 19 per cent of India's total pulse acreage which contributes 23 per cent of total pulse production (Anonymous, 2020-21) [1]. Pulses occupy a unique role in Indian agriculture since they are the primary and only source of high protein in the normal Indian diet (Phogat *et al.*, 2020) [2]. Blackgram is a high-protein snack that contains approximately 26% protein, 1.2 percent fat, and 56.6 percent carbs by dry weight, as well as being a good source of calcium and iron (Amruta *et al.*, 2015) [3]. Application of balanced fertilizer increases vegetative growth and improves yield and quality of produce (Singh *et al.*, 2015) [4]. Protein and phospholipids are significant elements of the nutrients available to plants, particularly nitrogen and phosphorus. It has the same unique properties as other pulse crops in terms of maintaining and rebuilding soil fertility through biological nitrogen fixation. Organic manure application provides a good substrate for microorganism growth while also maintaining a favorable nutrient supply environment and improving soil physical qualities (Tyagi *et al.*, 2014) [5].
Black gram is a highly priced pulse, very rich in phosphoric acid. India currently represents the largest producer of black gram accounting for more than 70% of the global production. India is followed by Myanmar and Pakistan. Agriculture in India has achieved grain self-sufficiency but the production is resource intensive, cereal centric and regionally biased. Crop responses to organic and biological nutrient carriers are not as spectacular as to fertilizers but the supplementary and complementary use of such sources is known to enhance the utilization efficiency of applied fertilizer besides improving soil physico-chemical properties and preventing emergence of micro-nutrient deficiencies (Yadav *et al.*, 1998) [7].

Gypsum is cheaper and good source for improving the physicochemical properties and fertility status of soil. It is used for reclamation of saline and alkaline soils and improving normal soils. It decreases soil pH, electrical conductivity, exchangeable sodium percentage; calcium carbonate, chlorides, hydraulic conductivity and to increase humus content, organic content, water infiltration rate and redistribution of salts (Suri and Verma, 1999) [6]. Hence, there is a scope for improving the production potential of black gram by conjoint use of organic manures, inorganic manures and biofertilizers (Shrikant M. Vadgave, 2010) [9]. 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 (Gayathri *et al.* 2009) [8]. The growing demand-supply imbalance for fertilizers, as well as its negative impact on soil health, necessitates a reduction in fertiliser use. Manure-fertilizer applications to Kharif pulses, cereals, and oilseeds not only improved soil health, but also lowered fertiliser requirements for Rabi crops. As a result, the current study on the performance of blackgram-based crop rotation was done with the goal of determining the ideal crop rotation for increasing system productivity, net return, and soil fertility.

Materials and Methods

The present experiment initiated "Effect of organic and inorganic fertilizer on growth and productivity of blackgram (*Phaseolus mungo*) under Wheat- Blackgram cropping sequence" was conducted at the agriculture research form of S.D.J. post-graduate college Chandeshwar, Azamgarh, U.P. during 2005-2006 and 2006-2007. The mean annual rainfall is about 1100 mm most of which is usually received between July and September month. The weekly mean maximum and minimum temperature during the experiment were 45.7 ^{0}C and 4.5 ^{0}C, respectively. It falls under semiarid and sub-tropical climate with hot dry summer and severe cold winter. The soil was found sandy loam having neutral pH and organic carbon with a value of 0.55, EC (0.36). The soil was moderate for the cultivation of the black gram. The blackgram variety used in experiment wad Narendra-1. The experiment was planned with 9 treatment combinations in a Randomized block design, with 4 replication. Chemical fertilizer treatments were used in sub plots and soil treatments were in main plots. In both years, only one irrigation was given to maintain the essential soil moisture for blackgram development. The experiment laid out in Randomized Block Design (RBD) with nine treatment combination along with four replications. The experiment comprises three soil treatments [Control (C_0), Gypsum @ 100 kg/ha (C_1), FYM @ 5 t/ha (C_2)] and six chemical fertilizer treatments [Wheat; F1 - Recommended (N120P60k40), F2-75% of Recommended (N90P45K30), F_3-50% of recommended (N60P30K20) & Black gram; F_1- Recommended (N20P40K20), F_2- 75% of recommended (N15P30K15), F_3-50% of recommended (N10P20K10)] with three replications. 36 plots were made for the experiment each with a gross size of 5 m x 3 m= 15 m^{-2} and net plot size of 4.1 m x 2.2 m= 9.02 m^{-2} having a row to row distance of 45 cm for blackgram. The suitable sampling approaches were inferred for the proper balance in sampling at the lowest cost in order to obtain exact precision. Plants were chosen at random in each plot for biometric observation to investigate the probable association between various growth parameters and climate variability. The land was prepared according to the experiment's specifications.

Results and Discussion

Plant stand: The data on plant stand was heterogeneous at initial stage and homogeneous at final stage. The data under the effects of soil treatments and fertilizers doses are summarized in Table 1. Soil treatments and fertilizer doses did not affect the initial stand in both the years and final stand in pooled results significantly.

Table 1: Effect of soil treatments and fertilizer doses on plant stands (Number of plants m^{-2})

Treatments	Initial		Final
	2005-06	2006-07	Pooled
Soil treatments			
Control	14.93	14.97	14.68
Gypsum	15.09	15.35	14.85
FYM	16.00	14.34	14.91
SE ±	0.08	0.13	0.10
CD 5%	NS	NS	NS
Fertilizer doses			
100%	15.12	15.59	14.92
75%	15.06	15.09	14.82
50%	14.93	14.97	14.69
SE ±	0.08	0.13	0.10
CD 5%	NS	0.37	NS

Table 2: Effect of soil treatments and fertilizer doses on plant height (cm) of blackgram at flower initiation and pod setting stages

Treatments	Flower initiation		Complete pod setting	
	2005-06	2006-07	2005-06	2006-07
Soil treatments				
Control	44.81	28.66	57.97	37.16
Gypsum	48.11	29.41	62.57	39.75
FYM	46.44	30.33	59.65	40.41
SE ±	1.59	0.69	2.83	0.92
CD 5%	NS	NS	NS	2.68
Fertilizer doses				
100%	49.69	30.32	63.91	39.94

75%	45.14	28.46	58.49	39.08
50%	44.53	27.98	57.79	38.30
SE ±	159	0.69	2.83	0.92
CD 5%	NS	NS	NS	NS

Table 3: Effect of soil treatments and fertilizer doses on number of branches per plant of blackgram

Treatments	Total branches		Pod bearing branches	
	2005-06	2006-07	2005-06	2006-07
Soil treatments				
Control	16.18	11.96	9.38	8.41
Gypsum	17.05	12.19	10.07	8.76
FYM	17.55	13.43	10.38	9.45
SE ±	0.90	0.22	0.48	0.14
CD 5%	NS	0.64	NS	0.43
Fertilizer doses				
100%	18.20	13.27	10.61	9.36
75%	17.38	12.59	10.11	8.98
50%	15.21	11.72	9.11	8.29
SE ±	0.90	0.22	0.48	0.14
CD 5%	NS	0.64	NS	0.43

Number of branches per plant

The data on number of branches per plant as well as on number of pod bearing branches per plant were found heterogeneous. Such data under main effects of soil treatments and fertilizer doses are reported in Table 3. In both the cases, FYM was superior to Gypsum but Gypsum was at par with Control. In second year both number of branches per plant and number of pod bearing branches per plant were influenced significantly with decreasing fertilizer doses. The maximum percentage of reduction in both number of branches per plant and number of pod bearing branches was recorded from 75 to 50% reduction of fertilizers than 100 to 75% which was 6.91 and 7.68%, respectively.

Table 4: Effect of soil treatments and fertilizer doses on Pods per plant, pod weight per plant and number of grains per pod, grain weight per plant and 1000-grain weight of blackgram

Treatments	Pods/plant		Pod wt./ plant (g)	Grains/ Pod	Grain wt./ plant (g)	1000-grain wt. (g)	
	2005-06	2006-07	Pooled	Pooled	Pooled	2005-06	2006-07
Soil treatments							
Control	15.33	26.34	6.53	5.35	6.58	33.36	31.31
Gypsum	18.38	27.67	7.25	5.78	6.61	33.59	31.78
FYM	17.61	29.81	7.90	5.98	7.63	34.06	33.09
SE+_	0.49	1.14	0.19	0.09	0.15	0.76	0.23
CD 5%	1.45	NS	0.51	0.28	0.44	NS	0.69
Fertilizer doses							
100%	19.96	28.84	7.66	5.87	7.05	33.89	32.70
75%	16.11	27.94	7.16	5.70	6.97	33.58	31.89
50%	15.25	27.03	6.86	5.54	6.80	33.54	31.59
SE+_	0.49	1.14	0.19	0.09	0.15	0.76	0.23
CD 5%	1.45	NS	0.51	0.28	NS	NS	0.69

Yield attributing characters of blackgram

The important yield attributing characters *viz*., number of branches per plant, number of pod bearing branches per plant, number of pods per plant, pod weight per plant, number of grains per pod, grain weight per plant and 1000-grain weight were recorded on blackgram.

The data with respect to number of pods per plant was found subjected to homogeneity test. The data under effects of soil treatments and fertilizer doses were summarized in Table 4. Soil treatments affected the number of pods per plant significantly in first year and non-significantly in second year. In first year, Gypsum followed by FYM was superior to Control. Reduction in fertilizer doses significantly affected number of pods per plant in first year (Table 4). Recommended dose was statistically superior to 75% of recommended dose but 75% of recommended dose was only numerically superior to 50% of recommended dose. The maximum per cent reduction (19.29 per cent) was recorded with recommended to 75% fertilizer reduction followed by 75 to 50% of fertilizer (5.34 per cent). It is revealed from significant data on number of pods per plant reported in Table 4. that 75% fertilizers followed by 100% maintained the significant superiority over 50% fertilizers with the application of FYM. The trend was slightly different in case of Gypsum application where 50% followed by 75% fertilizer was significantly inferior to 100% fertilizers. The same trend of fertilizers was noticed in case of Control. The data with respect to pod weight per plant were observed homogeneous. The ear-wise and pooled data under main effects of soil treatments and fertilizer doses are accordingly summarized in Table 4. The effect of different soil treatments on pod weight per plant was significant in pooled data (Table 4.). FYM was statistically superior to Gypsum and Gypsum was statistically superior to Control in pooled data. The pod weight per plant was influenced significantly due to reduction in fertilizer doses (Table 4.). Recommended dose (100%) was statistically

superior to 75% dose but 75% dose was at par with 50% dose. The per cent reduction was 6.52 and 4.19 with 100 to 75 to 50% fertilizer reduction, respectively. The data pertaining to number of grains per pod was homogeneous. The data under main effects of soil treatments and fertilizer doses are accordingly given in Table 4. Number of grains per pod was influenced significantly with reduction in fertilizer doses. FYM followed by Gypsum was superior to Control. Number of grains per pod was influenced significantly with reduction in fertilizer doses (Table 4.). The data under main effects of soil treatments and fertilizer doses are accordingly reported in Table 4. In the data pooled over 2005-06 and 2006-07, FYM was significantly superior to Control but Control was at par with Gypsum. Fertilizer doses failed to influence the grain weight per plant significantly in the pooled data (Table 4.), though 100% dose was numerically superior to 75% and 75% dose. Thousand-grain weight was non-significant in first year while it was significant in second year (Table 4.). In second year FYM was superior to Gypsum while Gypsum was at par with Control. Reduction in fertilizer doses did not affect 1000-grain weight significantly in first year of study while in second year it was influenced significantly. In second year 100% dose was statistically superior to 75% dose but 75% dose was not statistically superior to 50% dose. The maximum reduction in 1000-grain weight was recorded from 100 to 75% and lesser from 75 to 50% fertilizers being 2.48 and 0.94%, respectively.

Table 5: Effect of soil treatments and fertilizer doses on Yields of blackgram

Treatments	Biological yield (q ha^{-1})		Grain yield (q ha^{-1})	Stover yield (q ha^{-1})		Harvest Index	
	2005-06	2006-07	Pooled	2005-06	2006-07	2005-06	2006-07
Soil treatments							
Control	28.10	30.54	9.81	18.52	20.50	33.99	32.86
Gypsum	27.86	32.79	10.27	17.91	22.20	35.85	32.32
FYM	28.59	33.28	10.79	17.98	22.30	36.73	32.78
SE+_	0.77	0.42	0.09	0.80	0.36	1.23	0.39
CD 5%	NS	1.25	0.26	NS	1.05	NS	NS
Fertilizer doses							
100%	29.17	33.37	10.72	18.69	22.40	36.13	32.65
75%	28.17	32.20	10.32	18.14	21.57	35.98	33.04
50%	27.21	31.04	9.83	17.57	21.03	34.46	32.28
SE+_	0.77	0.42	0.09	0.80	0.36	1.23	0.39
CD 5%	NS	1.25	0.26	NS	1.05	NS	NS

All the soil treatment showed non-significantly response in first year in term of biological yield. The data indicated that the biological yield was significantly higher in FYM and gypsum was at par with control treatment. This might be due to the cumulative effect of insufficient amount of nutrients required for proper growth and development. While in second year it was significant in which both FYM and Gypsum were at par and both were significantly superior to Control. Non-significant effect of fertilizers was also observed in first year while it was significant in second year in which 100% fertilizer dose was significantly higher than rest of the treatments. 75% fertilizer dose was at par with 50% fertilizer dose. The reduction was 3.60% with 75 to 50% and 3.51% with 100 to 75%. The data pertaining grain yield were found undergone to variance ratio study. The data under treatments and fertilizer doses are accordingly summarized in Table 5. The reduction in grain yield in control and gypsum treatments is might be due to lesser amount of nutrients which directed to insufficient vegetation growth and yield attributing characters number of branches per plant, number of pod bearing branches per plant, number of pods per plant, pod weight per plant, number of grains per pod, grain weight per plant and 1000-grain weight. The highest gain yield was obtained in the crop sown with FYM (10.79 q ha^{-1}) was at par with gypsum (10.27 q ha^{-1}). The lowest yield obtained in control (9.81q ha^{-1}) respectively. Reduction in 100% to 75% and 75 to 50% fertilizer doses affected grain yield significantly in pooled data (Table 5.). The maximum per cent reduction (4.75 per cent) was recorded with 75 to 50% fertilizer followed by 100 to 75% of fertilizers (3.73 per cent). Stover yield was not influenced significantly (Table 5.) due to different soil treatments in first year of experimentation while the effect of soil treatments on stover yield was significant in second year. In second year, FYM and Gypsum each produced more or less equal stover yield but both were statistically superior to Control. Reduction of fertilizer doses did not influence stover yield significantly in first year but it was significant in second year (Table 5.) in which 100% followed by 75% produced higher stover yield over 50% fertilizers. The maximum reduction (3.71 per cent) in stover yield was observed with 100 to 75% reductions than 2.50 per cent with 75 to 50% reductions. Harvest index was not affected significantly in both the years of experimentation (Table 5.) though FYM was significantly superior to Gypsum and Gypsum was at par to Control in first year, same trend was follow in second year. Harvest index due to fertilizer doses was not influenced significantly, during both the years of experimentation. 100% fertilizer dose (32.65) was significantly superior to 75% dose and 75% dose to 50% dose in first year but in second year 100% dose was not superior to 75% dose but 75% dose was superior to 50% dose.

Table 6: Effect of soil treatments and fertilizer doses on Cost of cultivation, gross income, net profit and benefit: cost ratio of blackgram

Treatments	Cost of cultivation	Gross income (Rs ha^{-1})	Net profit (Rs ha^{-1})	B:C ratio
	Pooled	Pooled		
Soil treatments				
Control	12,405	15,209	2,804	1.23
Gypsum	12,650	15,831	3,191	1.25

FYM	13,340	16,591	3,251	1.25
SE+_	-	137	138	0.01
CD 5%	-	392	NS	NS
Fertilizer doses				
100%	13,043	16,510	3,467	1.27
75%	12,798	15,906	3,118	1.25
50%	12,553	15,214	2,661	1.21
SE+_	-	137	138	0.01
CD 5%	-	392	392	0.03

Economic aspects

These were studied in terms of cost of cultivation, gross income, net profit and benefit: cost ratio.

Cost of blackgram cultivation: The data for cost of cultivation under main effects of soil treatments and fertilizer doses are given in Table 6. The cost of cultivation was estimated common for both the years hence, was not subjected to statistical analysis. The above study indicated that the FYM involved maximum cost of cultivation (Rs.13340 ha^{-1}) while minimum (Rs.12405 ha^{-1}) was in Control. Gypsum required Rs. 12650 ha^{-1} as cost of cultivation. Among fertilizer doses recommended dose involved Rs. 13043 ha^{-1} in cultivation which was Rs.245 and Rs.490 ha^{-1} higher over 75 and 50% fertilizers, respectively.

Gross income: The year-wise and pooled data under main effects of soil treatments and fertilizer doses are reported accordingly in Table 6. On the basis of gross income, both FYM and Gypsum were superior over Control. FYM also established its superiority over Gypsum. Gross income per hectare decreased significantly with every reduction in fertilizer doses in the pooled data. A dose of 100% fertilizers earned maximum of Rs. 16510 ha^{-1} as gross income which was higher by Rs.604 ha^{-1} (3.66%) and Rs.1296 ha^{-1} (7.85%) over 75 and 50% doses of fertilizers, respectively.

Net profit: Values of net profit when put on homogeneity test were found homogeneous. The values of net profit obtained under main effects of soil treatments and fertilizer doses are reported in Table 6. Soil treatments did not influence significantly the net profit of blackgram in pooled data, though maximum net profit of Rs.3251 ha^{-1} was recorded with FYM and minimum (Rs.2804 ha^{-1}) in Control. Net profit decreased with reduction in fertilizer dose but significant decrease was noticed when fertilizers were reduced from 75 to 50% in pooled data. The maximum net profit was recorded with recommended dose (Rs.3467 ha^{-1}) and minimum of Rs.2661 ha^{-1} with 50% dose. The profit with 100% fertilizers was higher by Rs.349 ha^{-1} (10.06%) and Rs.806 ha^{-1} (23.25%) to 75 and 50% doses of fertilizers, respectively.

Benefit cost ration (B:C): The data for B:C ratio was found homogeneous. Although the effect of soil treatments on benefit: cost ratio was not significant (Table 6) however, maximum and equal B:C ratio of 1.25 was obtained with FYM as well as with Gypsum which was slightly higher than Control. B:C ratio decreased with every reduction in fertilizer doses but significant decrease was observed from 75 to 50% in the pooled results.

Conclusion

The study conducted that, on the basis of numerical differences, application of FYM was superior to Gypsum and Control. Reduction in fertilizer doses did not affect the initial plant stand in year and in pooled data significantly while initial stand showed decreasing trend with every reduction in fertilizers in second year. Percentage of reduction was 3.21 and 0.79 per cent with 100 to 75 to 50% reduction in the fertilizer doses, respectively. Number of branches per plant and number of pod bearing branches per plant both were significantly influenced owing to different soil treatments in second year only. The maximum number of gains per pod was recorded with 100% fertilizer dose followed by 75 and 50% fertilizer doses. The dose of 75% fertilizer was at par with 100% dose and 50% dose was at par with 75%. The reduction in number of grains per pod was 2.90 and 2.81% between 100 to 75 and 75 to 50% of fertilizers, respectively. Thus, it is concluded that application of 5 t FYM and fertilizer dose of F_1-100% Recommended ($N_{20}P_{40}K_{20}$) may be recommended for attaining higher productivity and profitability of blackgram in Uttar Pradesh.

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