

Performance of *kharif* blackgram under integrated use of fly ash, farm yard manure and soil test based fertilizer recommendations

BISWESWAR MAHATO¹, BAPPA PARAMANIK², BIMAL DAS³, PRIYANKA SAHA⁴, RANAJIT PANDA⁵,
PARIJAT DE⁶ AND ANIMESH MANDAL²

Kalyan Krishi Vigyan Kendra, Purulia, West Bengal 723 147

Received: March 2024; Revised accepted: January 2025

ABSTRACT

Soil test-based fertilizer recommendation is an imperative-approach that helps in economic benefit to the growers for crop production. A field experiment of blackgram was conducted during *kharif* 2019–20 and 2020–21 in at Farmers' Field under Jambad, Block, Purulia, West Bengal. Five different treatments viz. T₁, application of ash (3.0 t/ha); T₂, Application of ash (3.0 t/ha) with FYM (4 t/ha); T₃, application of ash (3.0 t/ha) with FYM (4 t/ha) and DAP (2% foliar application before flowering); T₄, application of ash (3.0 t/ha) with FYM (4 t/ha) and inorganic fertilizers (RDF – N:P:K 20:40:60); and T₅, application of ash (3.0 t/ha), FYM (4 t/ha) and soil test based fertilizer recommendations (N:P:K 25:50:25). The experiment was carried out in randomized block design with 4 replications. The results indicated that soil organic carbon, available N, P, K, Fe and B was significantly increased with the application of T₅. The application of T₅ improved seed yield of blackgram by 11.26% and 11.32%, respectively in 2019–20 and 2020–21, and also resulted higher B:C ratio (2.41 and 2.17). Character association analysis of yield component features revealed a positive and significant relationship between seed yield with plant height ($r = 0.90$), number of branches/plant ($r = 0.98$), number of pods/plant ($r = 0.96$) and number of seeds/pod ($r = 0.90$). Results in field that the application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test-based fertilizer recommendations (T₅), could be a viable option for enhancing the blackgram productivity under slightly acidic soil conditions.

Key words: Blackgram, Inorganic fertilizer, Ash, Soil testing

Blackgram (*Vigna mungo* L.) is an important short duration pulses crop widely grown and consumed in India which producing 29.26 lakh tonnes from 44.93 lakh hectares with productivity of 469 kg/ha (Anonymous, 2017). India is the largest producer and as consumer of blackgram. Its primary nutritional element is easily digestible protein (21–29%) of the dried grains and (Kavitha *et al.*, 2013). Additionally, blackgram contains significant amounts of other essential nutrients such as fat (4.4 to 5.6 g/100 g),

phosphorus (380 to 420 mg/100 g), calcium (107 to 134 mg/100 g), and iron (3 to 4.4 mg/100 g) (Kavitha *et al.*, 2013). Besides this it also contains 60.4% carbohydrates. Further, blackgram being a legume plant, serves as valuable sources of nitrogen, crucial for plant growth and the enhancement of soil texture. It possesses the capacity to enhance soil fertility by engaging in symbiotic nitrogen fixation, with the root nodules contributing 72 to 350 kg/ha nitrogen fixation annually (Tiwari and Shivhare, 2016). However, despite this, the yield potential of blackgram is very low because of the fact that the crop is mainly grown in rain-fed conditions with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with the crop (Saravanakumar *et al.*, 2021). The physiological and biotic factors, such as inadequate assimilate partitioning, poor setting from flower abscission, lack of nutrients during critical stages of crop growth, and to a number of diseases and pests, contributed to the low yield production in blackgram. Nutrients are one of the major determinants of crop production and productivity, however, fertilizer application without knowledge of

¹Corresponding author's Email: paramanikbappa@gmail.com

¹Subject Matter Specialist (Soil Science) Kalyan Krishi Vigyan Kendra, Purulia, West Bengal 723 147; ²Subject Matter Specialist (Soil Science), ⁷Course Facilitator, Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Majhian, Dakshin Dinajpur 733 133, West Bengal; ³Assistant Professor (Genetics and Plant Breeding), College of Agriculture, Uttar Banga Krishi Viswavidyalaya, Majhian, Dakshin Dinajpur, West Bengal 733 133; ⁴Subject Matter Specialist (Agronomy), ICAR-Indian Agricultural Research Institute, New Delhi 110 012; ⁵Assistant Professor (Soil Science), Brainware University, Barasat, Kolkata, West Bengal 700 125; ⁶Subject Matter Specialist (Soil Science) Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Kalimpong, West Bengal 734 301

soil fertility and crop nutrient needs can harm crops. Soil testing is a reliable way to quickly assess soil fertility, ensuring balanced fertilization, higher yields, and increased profitability. The unique fertility gradient field experimental technique by crop responses on representative soils with varied fertility levels from previous fertilizer applications, guiding targeted fertilizer recommendations based on soil tests and desired yields (Choudhary *et al.*, 2017). The distinctive soil testing-based recommendation approach not only suggests optimal fertilizer doses but also predicts achievable yields with effective management practices. To maintain yields and minimize fertilizer costs, the soil testing based fertilizer recommendation is crucial for sustainable cultivation (Chatterjee *et al.*, 2010). Adoption of recommended doses of fertilizers on soil test basis by farmers is a belated modern concept in agricultural sector especially in the state of West Bengal. However, when it reaches, it comes vigorously causing a great concern to the environment and soil health. Organic manure is a crucial factor in crop production, influencing soil physical characteristics. It enhances the formation of soil crumbs, rendering the soil friable and promoting effective air and water movement, facilitating optimal water absorption (Kumar *et al.*, 2021; Paramanik *et al.*, 2024). The application of fly ash as soil ameliorant has been proven helpful as it improves physical properties of soil and hence fertility (Srinivasa *et al.*, 2020; Usman *et al.*, 2023) and crop yield (Varshney *et al.*, 2022). The efficiency of ash can be enhanced by the addition of organic, chemicals and/or biofertilizers. Soil amendment with low amount of fly ash enhances both growth and yield, while adverse effects at higher levels were observed in several crops such as pigeon pea, wheat, alfalfa, barley and beans (Mishra *et al.*, 2007). When more than 10% fly ash along with FYM (4–5 t/ha) is added to the soil, it can increase the yield of legumes (20–25%) and has high nutritional value (Yavarzadeh and Shamsadini, 2012). Considering the importance of soil health management, proper application of recommended doses of fertilizer through soil testing, this experiment was undertaken to evaluate the integrated effect ash, FYM and inorganic fertilizer on productivity, profitability and soil physical and chemical characteristics.

MATERIALS AND METHODS

The study was conducted on blackgram cv. 'WBU 108' at Farmers' Fields under Jambad, Block- Purulia-II, Purulia, West Bengal, in 2019–21. The soil of the experimental site was sandy loam in texture. Five distinct treatments viz. T₁, application of ash (3.0 t/ha) only; T₂, application of ash (3.0 t/ha) with FYM (4 t/ha); T₃, application of ash (3.0 t/ha) with FYM (4 t/ha) and DAP (2% foliar application before flowering); and T₄, application of ash

(3.0 t/ha) with FYM (4 t/ha) and inorganic fertilizers (RDF - N:P:K- 20:40:60 kg/ha) and T₅, application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (N:P:K- 25:50:25 kg/ha). Four replications were taken for each treatment in randomized completely block design (RCBD). For each treatment the plot size were maintained at 5m × 3m. The FYM, used in our study, contained on an average 0.51% N, 0.22% P₂O₅ and 0.50% K₂O, as well as traces of micronutrients. On the other hand, the ash sample contained Total N= 0.29%, total P₂O₅= 1.78%, total K₂O= 3.12%, as well as total micronutrients contents as follows: total Cu= 46 ppm, total Zn= 85 ppm, total Mn= 508 ppm, total Fe= 4.12%, total B= 29 ppm, total Mo= 4.90 ppm. Soil testing procedure were maintained as per the procedure of Choudhary *et al.*, 2017.

After fifteen to twenty days from sowing, one hand weeding was completed and irrigated prior to the flowering stage.

For soil analysis soils were collected from each treated plot. The soil at a depth of 0-15 cm was collected from the field directly before treatment used and after harvest time in both the growing season. The collected samples were composited and taken to soil testing laboratory, in a sealed polythene bag and air-dried properly to be sieved <2 mm. In both the year the initial (pre-sowing) and final (post-harvest) soil fertility status (pH, organic carbon, available nitrogen, phosphate and potash) was determined. The pH and electrical conductivity (EC) was measured using a pH meter and a conductivity meter, respectively, by diluting samples with double distilled water in a 1:2 ratio. Soil organic carbon (SOC) was determined using a dichromate oxidation method. Available phosphorus in samples was determined according to the procedure described. The available nitrogen was determined using KEL PLUS nitrogen estimation system. Kjeldahl method was used to determine available N. Ammonium acetate extraction method was adopted to determine available K.

For yield traits analysis ten plants were randomly selected in each plot. Data recorded for yield traits of blackgram were plant height at maturity (cm), number of branches/plant, number of pods/plant, seed weight/plant, test weight, and seed yield.

Economic analysis of the experiment in terms of Cost A (it includes wages of hired labour, ploughing cost, chemical input cost, interest on working capital, depreciation on farm machinery), Cost B (it includes Cost A + rent paid for leased land + imputed rental value of owned land + interest on owned fixed capital) and Cost C (it includes Cost B + imputed value of family labour) was evaluated by following the farm management concepts.

Analysis of variance was carried out on the effect of

treatments on soil chemical properties and yield traits of blackgram using SPSS Statistics Software version 16. Duncan's multiple range test was employed to test the significance difference between means of treatments. Linear regression and correlation as well as graphical presentation were performed using Microsoft Excel Program.

RESULTS AND DISCUSSION

Soil chemical properties

To determine chemical properties of soil in the treated field, soil samples were collected before the implementation of the experiment and at the time of harvesting. Initial soil test values for biochemical and physical parameters before application of treatments in blackgram field are presented in Table 1. The application of different nutrients significantly altered the soil fertility status of blackgram field in both the growing season (Table 2). There were significant differences and higher pH accumulation occurred from T_5 , treatment i.e. application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations. The changes of EC were maximum noticed from the treatment of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (T_5). This might be due to the alkaline nature of ash which serves to elevate the pH levels of acidic soils. The presence of hydroxide and carbonate salts in ash constitutes a key advantageous chemical attribute, facilitating its role in neutralizing soil acidity (Cernec *et al.*, 2005). The organic carbon, available nitrogen, available phosphorus and available potassium status of soil after harvest of the crop increased by application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test-based fertilizer recommendations (T_5) as compare to other treatments in both the year (Table 2). The highest soil organic carbon was found in treatment T_5 which was receiving nutrient in integration of ash, soil test-based fertilizer and manure (FYM). The improved soil physical con-

dition due to application of FYM and fly ash along which the required amount of inorganic fertilizer through soil testing may improve microbial activity leading to a congenial environment for nutrient cycling (Das *et al.*, 2013, Kaur and Sukul, 2019). Minimum value of organic carbon (%) was noted under application of ash (3.0 t/ha) (T_1), application of ash (3.0 t/ha) with FYM (4 t/ha) (T_2), and application of ash (3.0 t/ha) with FYM (4 t/ha) and DAP (2% foliar application before flowering) (T_3), respectively. The SOC increased with continuous application of FYM and inorganic fertilizers (Brar *et al.*, 2015). The soil testing based fertilizer application following the application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (T_5) significantly ($P < 0.05$) increased SOC by 29.41% and 28.30%, N by 9.14% and 11.82%, P by 10.58% and 3.72%, K by 3.49% and 4.21%, respectively as compared with the ash (3.0 t/ha) application (T_1) in both the year 2019 and 2020. Similar results were also repeated by Nallagatla *et al.*, (2024). The soil available micronutrient Zn and B, was highest with the T_5 treatment and significantly ($P < 0.05$) increased by 12.96% and 18.18%; 14.06% and 15.15%, respectively as compared with the ash (3.0 t/ha) application (T_1).

Effect of integrated nutrient management on growth and yield of blackgram

Wide range of variation was observed for yield traits among the treatments. Different treatments indicate significant effect on yield traits of blackgram in both the season (Table 3). The application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (N:P:K- 25:50:25) in blackgram fields exhibited maximum in plant height (45.87 and 46.98 cm), branches/plant (7.39), pods/plant (23.57 and 29.00), test weight (21.46 and 22.45 g) and seed yield (8.14 and 8.21 kg/ha) as compared to the T_4 with recommended dose of fertilizer (N:P:K- 20:40:60). Among the treatments application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (T_5) exhibited maximum response and significantly enhancement occurred for yield traits with an increment of 23.93% and 22.20% for plant height; 28.68% and 22.46% for branches/plant; 42.93% and 58.96% for pods/plant; 19.25% and 25.85% for seeds/pod; 1.25% and 6.94% for test weight; 30.35% and 44.09% for seed yield, respectively in comparison to ash application (T_1) during 2019 and 2020. The application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test based fertilizer recommendations (T_5) also increased 1.35% and 6.61% plant height; 8.25% and 5.81% branches/plant; 3.30% and 19.55% pods/plant; 7.66% and 14.56% seeds/pod; 0.18% and 2.27% test weight; 11.26% and 11.32% seed yield, respectively in comparison to recommended

Table 1. Initial Soil biochemical properties in blackgram field (before incubation of treatments)

Soil Properties	Values
pH	5.67
EC	0.19
OC (%)	0.34
N (kg/ha)	136.24
P (kg/ha)	8.65
K (kg/ha)	133.24
Sand (%)	58.1
Silt (%)	20.00
Clay (%)	21.90
Texture	Sandy clay loam
Bulk Density (gm/cm ³)	1.31
Particle Density (gm/cm ³)	2.61

Table 2. Effect of integrated use of nutrients on soil properties in blackgram field.

Treatments	pH		EC		OC		N		P		K		Zn		B	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T ₁	5.61c	5.65c	0.20c	0.19c	0.36c	0.38d	129.53c	128.95c	7.52b	8.29	144.24c	146.41c	0.47d	0.45d	0.55c	0.56c
T ₂	5.69b	5.67b	0.21b	0.22c	0.44b	0.46b	138.22b	141.23b	8.02ab	8.35	146.55b	149.24b	0.52c	0.53c	0.61b	0.63b
T ₃	5.68b	5.67b	0.23a	0.24b	0.43b	0.43c	139.05b	142.50b	8.11a	8.64a	145.29b	148.22b	0.53c	0.55c	0.59b	0.61b
T ₄	5.7b	5.68a	0.22b	0.24b	0.48a	0.51a	139.85b	143.89b	8.36a	8.68a	150.78a	152.68a	0.51b	0.54b	0.61a	0.65a
T ₅	5.91a	5.99c	0.26a	0.28a	0.51a	0.53a	142.57a	146.24a	8.41a	8.61a	149.47a	152.86a	0.54a	0.55a	0.64a	0.66a

EC, Electrical conductivity (dS/m), OC, Organic carbon (%), N, Available nitrogen (kg/ha), P, available phosphate (kg/ha), K, available potash (kg/ha), Zn, available zinc (mg/kg), B, available boron (mg/kg); Each value represents the mean value of four replications; values having the same letters do not differ significantly at Pd^{0.05}; values with different letters in a column show significant difference at Pd^{0.05} as determined by Duncan's multiple range test

dose of fertilizer for blackgram (T₄). The lowest seed yield was noticed in the T₁ i.e application of ash (3.0 t/ha), whereas application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test-based fertilizer recommendations (T₅) (Table 3). The enhanced supply of nutrients, improved physical conditions promoting superior aeration, improved capacity to retain soil moisture, increased root activity, and enhanced nutrient absorption collectively contribute to the synergistic impact observed in plots treated with both fly ash FYM and soil test based fertilizer, leading to elevated grain yield. Optimum supply of plant nutrients is always imperative for better growth and development of a crop. However, yield and quality parameters are greatly affected by inadequate availability of plant nutrients. Recently, Sharma *et al.* (2023) described that by application of Pressmud @ 2.5 t/ha + ¼th RDF had significantly increase the number of fruit bearing branches, seeds/pod, pods/plant and improvement of 12.6% in grain yield over control in blackgram. These findings are in conformity with the findings of Banerjee *et al.* (2023). Fertilizer recommendations as per the need of nutrients for the targeted yield are based on the initial soil test values. Our findings are consistent with those of Desmuka *et al.* (2012), who used nutrients based on soil testing to propose fertilizer and achieve the desired rice yield of 4.0 t/ha.

Character association study of yield component traits

The character association study of the yield component traits showed that the seed yield of blackgram was positive and significant association with plant height, seeds/pod, pods/plant and branches/plant (Fig. 1). Test weight was found significant association with branches/plant only. Positive and significant associations between various characteristics, including plant height, seeds/pod, pods/plant, and branches/plant, were documented. Notably, the seed yield of blackgram was detected to have a strong linear correlation with the plant height, branches/plant, pods/plant, seeds pod⁻¹ and test weight (Table 5) in both the year. Bharti *et al.* (2024) also revealed that seed yield per plant exhibited significant and positive association with days to 50% flowering, plant height, number of primary branches/plant, number of clusters/plant, number of pods/plant, seed index and biological yield. Yield component traits viz., number of pods/plant, test weight and single plant yield were highly correlated among themselves (Gnanasekaran *et al.*, 2023).

Profitability

The economic analysis results showed that the maximum net benefit of Rs. 31,215 and Rs. 28,645/ha from 2019 and 2020 with acceptable marginal rate of return was obtained by the application of ash (3.0 t/ha) and FYM (4 t/ha) along with soil test-based fertilizer recommendations (T₅) (Table 4). It was followed by the application of ash (3.0 t/ha) with FYM (4 t/ha) and inorganic fertilizers (RDF - N:P:K- 20:40:60) (T₄), and application of ash (3.0 t/ha) with FYM (4 t/ha) and DAP (2% foliar application before flowering) (T₃) treatments which also gave substantial net benefit. The return of most treatments increased as crop yield raised due to minimum increment in cost of production. The maximum B:C ratio obtained from T₅ treatment followed by T₃ and T₄. Therefore, by adopting improved production practices with these treatments in blackgram, yield potential and economic returns can be significantly increased in the farming community. These results were also in agreements the earlier findings by Kumar *et al.* (2022), Vinutha *et al.* (2023) and Kousalya *et al.* (2024).

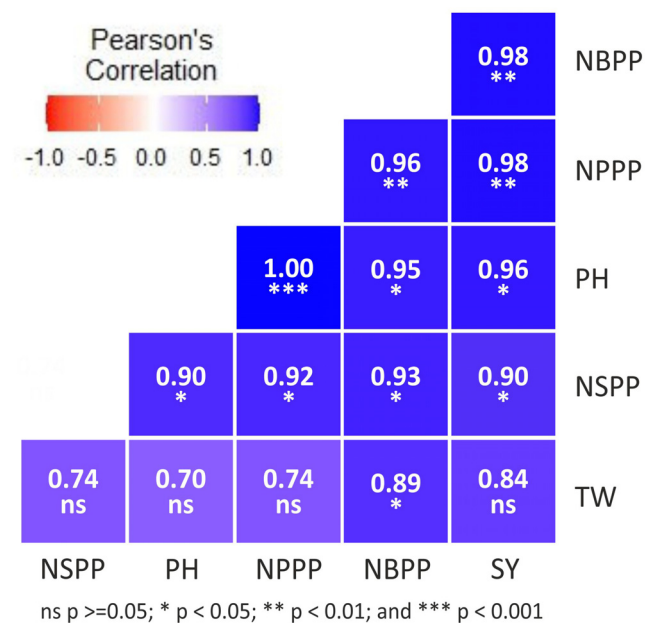
Table 3. Effect of different treatments on yield component traits in blackgram

Treatments	PH		NBPP		NPPP		NSPP		TW		SY	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T ₁	34.89c	36.55c	5.27c	5.73c	13.45c	11.90c	4.73c	4.58b	21.19	20.89	5.69c	4.59c
T ₂	43.87b	45.91b	6.48b	6.81b	22.67b	23.82b	5.34b	6.07a	21.28	21.17	6.87bc	6.95bc
T ₃	43.45b	44.63b	6.51b	6.47b	22.75b	22.86b	5.29b	5.19ab	21.30	21.23	7.12b	7.23b
T ₄	45.25a	45.87b	6.78b	6.96b	22.79b	23.33b	5.42b	5.28ab	21.42	21.94	7.25b	7.28b
T ₅	45.87a	47.98a	7.39a	7.42a	23.57a	29.00a	5.87a	6.18a	21.46	22.11	8.17a	8.21a

PH, Plant height at 65 DAS (cm); NBPP, Number of branches/plant; NPPP= Number of pods/plant; NSPP= Number of seeds/pod; TW=Test weight (g); SY= Seed yield (t/ha); Each value represents the mean value of four replications; values having the same letters do not differ significantly at P≤0.05 give in kg/ha; values with different letters in a column show significant difference at P≤0.05 as determined by Duncan's multiple range test.

Table 4. Blackgram cultivation's economic impact with different treatments

Treatments	Gross cost (₹/ha)		Gross return (₹/ha)		Net return (₹/ha)		Benefit: cost ratio	
	2019	2020	2019	2020	2019	2020	2019	2020
T ₁	16,420	20,110	29,835	36,985	13,415	16,875	1.82	1.84
T ₂	19,420	22,570	45,175	44,655	25,755	22,085	2.33	1.98
T ₃	19,870	23,020	46,995	46,280	27,125	23,260	2.37	2.01
T ₄	20,780	23,740	47,320	47,125	26,540	23,385	2.28	1.99
T ₅	22,150	24,460	53,365	53,105	31,215	28,645	2.41	2.17

**Fig. 1.** Correlation of yield components traits

Thus, study indicates that the integrated use of ash, FYM along with soil test based fertilizer recommendation have significant impact on soil fertility status and yield improvement and economic benefits of blackgram in acidic soil.

Table 5. Multiple linear regression in predicting seed yield of blackgram

Year	Multiple equation	R square (R ²)
2019	$\hat{y} = 115.12 - 0.03 PH + 5.01 NBPP - 0.18 NPPP - 3.90 NSPP - 5.36 TW$	0.98
2020	$\hat{y} = 54.39 - 0.20 PH + 5.72 NBPP + 0.30 NPPP - 2.86 NSPP - 2.69 TW$	0.98

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