Journal of Food Legumes
38(1): 43-48, 2025
DOI: 10.59797/jfl.v38.i1.241

Research Paper

Influence of different plant growth regulators on growth and yield of blackgram under new alluvial Gangetic zone of West Bengal

Kalyan Jana[1*], Arup Sarkar[1], Subhajit Banerjee[2], Ramyajit Mondal[2], Kanu Murmu[1] and Antara Pramanik[1]

[1]*Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia - 741252, West Bengal, India*
[2]*Department of Agronomy, School of Agriculture, Seacom Skills University, Kendradangal, Birbhum-731236, West Bengal, India*

***Corresponding author e-mail:** kjanarrs@gmail.com*

***Received:** May 16, 2024*
***Accepted:** December 23, 2024*

ABSTRACT

In the present investigation, a field experiment was conducted to observe the influence of plant growth regulators (PGRs) on blackgram variety Sulata. Results revealed that blackgram plot treated with recommended dose of fertilizer (RDF) along with the foliar application of sodium para-nitrophenolate 0.3% SL @ 5 ml/litre of water recorded the maximum value in plant height, leaf area index, dry matter accumulation and number of branches/plant, total dry matter. The maximum seed yield of blackgram was recorded as 1256 kg/ha with sodium para-nitrophenolate 0.3% SL @ 5 ml/L followed by sodium para-nitrophenolate 0.3% SL @ 6 ml/L. Among the foliar spray treatments, highest seed protein content (25.78%) was recorded with sodium para-nitrophenolate 0.3% SL @ 5 ml/L followed by sodium para-nitrophenolate 0.3% SL @ 6 ml/L. Based on the experimental results, it may be recommended that an integration of recommended dose of fertilizers (N, P_2O_5 and K_2O at 20, 40 and 40 kg/ha) along with foliar application of sodium para-nitrophenolate 0.3% SL @ 5 ml/L at 35 DAS (1st spray) and 50 DAS (2nd spray), respectively, enhanced the growth and yield of blackgram as well as improved the soil nutrient status in lower Gangetic alluvial zone of West Bengal.

Key words: Blackgram, Plant growth regulators, Yield, Nutrient uptake

INTRODUCTION

Pulses contribute significantly to Indian agriculture because they play a crucial role in the vegetarian diet by providing high protein. These pulses have enormous potential to improve human health, protect the environment, and contribute to food security throughout the globe (Phogat *et al.* 2020, Pratihar *et al*. 2023). The pulses are not only a rich source of protein but their low fat and high fibre content adds to their nutritional value and preference (Gorai and Mondal 2023). Along with serving as a key source of human and animal food, it also maintains the fertility of the soil (Das *et al*. 2023). Blackgram (*Vigna mungo* L.) belonging to the family Leguminosae is the richer source of protein (26%), 1.2% fat, and 56.6% carbohydrates on a dry weight basis (Das *et al.* 2021) along with 154 mg calcium, 9.1 mg iron, 0.37 g riboflavin and 0.42 g thiamine (Shroti *et al*. 2018). At present, India occupies more than 70% of the world's production and produces around 24.5 lakh tonnes of blackgram annually from about 4.6 m ha of area, with an average productivity of 533 kg per hectare (2020-21). This accounts for ~19 percent of India's total pulse acreage with 23 percent of total pulse production. Plant growth regulators (PGRs) also have an important role during stress conditions such as being thermo-protectants, reactive oxygen scavengers, improving photosynthesis, accumulation of stress proteins, and many other regulatory functions related to metabolisms (Sharma *et al*. 2020). The PGRs interrelate with complex signaling systems to equilibrate the responses to evolve eco-friendly strains and thereby, overcome damages caused by stressful environmental conditions (Iqbal *et al*. 2019). The use of growth regulators like Napthalene Acetic Acid (NAA) has a positive influence on physiological attributes *i.e.* promotion of photo-synthesis activities, enhancing the metabolism of nitrogen in plants, promotion of flowering, uniform pod development and improved quality of seeds, induction flowering synchronous and delayed in leave senescence (Sharma *et al*. 2013). It can promote development and growth, boost endogenous auxin levels, increase nutrient absorption by plant roots, and promote antioxidant and photosynthetic activities of plants (Ashvathama *et al.* 2020, Suseendran *et al*. 2020). The application of Triacontanol (TRIA) as an exogenous application

improves the plant biomass as a photosynthetic pigment, acquisition of mineral nutrients, leaf carbonic anhydrase (CA), nitrate reductase (NR) activity, activities of modulates antioxidant enzyme as well as yield and quality attributes (Naeem *et al.* 2019, Zaid *et al*. 2019). The strategic application of growth regulators, such as foliar sprays at optimal growth stages and concentrations, can alleviate stresses by minimizing nutrient loss through leaching. This approach reduces issues related to nutrient fixation and immobilization, ultimately enhancing efficient nutrient utilization (Sarkar *et al*. 2022). Consequently, crop production and quality are significantly improved. Considering these findings, the present study aimed to investigate the impact of growth regulators on soil nutrient status, yield, nutrient uptake, and protein content of blackgram variety Sulata in the lower Gangetic zone of West Bengal.

MATERIALS AND METHODS

Experimental site and growing conditions

The field experiment was carried out during the *Kharif* (2019 and 2020) at the Instructional Farm (22°93′ N latitude, 88°53′ E longitude and 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal in the medium land situation under the sub-humid sub-tropical climate. The average rainfall was 1445 mm, 75% of which was received during the June to September period. The topography of the land is known as medium land and the soil was sandy loam in texture having a pH of 7.1, 51.8% of sand, 28.4% of silt, 19.8% of clay, 0.45%, soil organic carbon, 282.6 kg/ha available N, 41.6 kg/ha P_2O_5 and 301.3 kg/ha K_2O. Meteorological data pertaining to the cropping seasons revealed that maximum temperature ranged between 33.30°C to 27.93°C, and minimum temperature prevailed between 12.26°C to 22.91°C. The maximum and minimum relative humidity ranged between 97.33 to 90.26% and 49 to 79.64%, respectively.

Experimental design and lay-out

The experiment was laid out in randomized complete block design (RCBD) with three replications comprising of eight treatments *viz.* untreated plot (Control), sodium para-nitrophenolate 0.3% SL @ 3 ml/L, sodium para-nitrophenolate 0.3% SL @ 4 ml/L, sodium para-nitrophenolate 0.3% SL @ 5 ml/L, sodium para-nitrophenolate 0.3% SL @ 6 ml/L, NAA @ 10 ppm (10 ml/L), Triacontanol 0.1% EW @ 250 ml/ha and sodium para-nitrophenolate 0.3% SL @ 10 ml/L. The seeds of blackgram var. 'Sulata' were sown at 30 cm (row to row) ×10 cm (plant to plant) spacing in the plots of size 5m × 5m. Seeds were sown at a depth of 3-4 cm having 30 cm (row to row distance) with continuous sowing and during thinning operation maintained plant-to-plant spacing of 10 cm. Gaps were filled up within 7 days after sowing. Nitrogen, phosphorus, and potassium at 20, 40, and 40 kg/ha in the form of urea, single super phosphate, and muriate of potash, respectively across all treatments was considered as recommended dose of fertilizer (RDF). From each plot, five healthy plants were randomly selected to observe growth parameters. The observations on yield parameters were recorded at harvest. The full dose (100%) of N, P_2O_5, and K_2O were applied as basal (during final land preparation). Organic manure (farm yard manure) was applied 1 day after the ploughing operation. Only one irrigation was applied at the pod filling stage to obtain a good-filled seed yield of blackgram. The treatments were applied at 35 DAS (1st spray) and 50 DAS (2nd spray at 15 days after 1st spray), respectively. Harvesting was done manually excluding the two border rows on each side of a plot. Then the harvested crop was left as such in the field for 4 days for sun-drying. The produce was then taken to the threshing floor and threshed separately for each plot manually. The stalk (haulm) and seeds of each or individual plot were dried separately in the sun. After proper cleaning and drying, seeds and haulm (stover) of each net plot were weighed and yields were recorded. Observations were recorded on germination (%), plant height (cm), branches per plant at harvest (no.), total dry matter accumulation (g), branches/ plant (no.) and yield attributes *viz.* pods per plant (no.), seeds per pod (no.), pods per plant (no.), pod length (cm), pod width (cm), seed per pod (no.), test weight (g), seed yield, stover yield, and qualitative traits, viz. protein content (%) and nutrient uptake by plants (N, P and K). Nutrient uptake in seeds and stover was calculated by multiplying nutrient content by seed and stover yield. The protein content of the seed samples was calculated by micro-kjeldhal procedure by multiplying the percent nitrogen by the factor 6.25.

Statistical analysis

Collected data from field and laboratory were statistically analysed through analysis of variance (ANOVA) and comparison among the treatment means was done using the significance level of $p \leq 0.05$ (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Crop growth attributes

The present study observed no significant difference in plant height of blackgram crop at 35 DAS between the treated and control. At 45 DAS and harvest, plant height was 29.3 cm and 55.7 cm, respectively, in the treatment with sodium para-nitrophenolate 0.3% SL @ 5 ml/L followed by sodium para-nitrophenolate 0.3% SL @ 6 ml/L. The shortest plant height of 23.7 cm and 49.3 cm was obtained in control (no foliar application) at 45 DAS and harvest respectively (Table 1). The leaf area index (LAI) of blackgram variety progressed with the increase in crop age up to 45 DAS. At 30 and 45 DAS, the maximum value of leaf area index 0.89 and 3.10 was recorded in sodium para-nitrophenolate 0.3% SL @ 5 ml/L, whereas the minimum value was obtained from control. The highest leaf area index increased the source-sink relationship with increased photosynthates, it reflected in grains hence more grain yield was recorded due to an increase in content and activities of natural auxin (AbdAlla *et al*. 2015). The Maximum number of branches per plant (6.7) was obtained from spraying the sodium para-nitrophenolate 0.3% SL @ 5 ml/L followed by sodium para-nitrophenolate 0.3% SL @ 6 ml/L (6.6) at 35 DAS (1st spray) and 50 DAS (2nd spray). At harvest, the highest total dry accumulation was 20.63 g/m^2 with the treatment having an application of sodium para-nitrophenolate with 0.3% SL @ 5 ml/L followed by 0.3% SL @ 6 ml/L (20.21g/m^2). The lowest value of total dry matter accumulation (17.70 g/m^2) was observed in the untreated plot (control) at 60 DAS.

Table 1. Effect of plant growth regulators on growth attributes of blackgram during K*harif* season (Pooled value two years)

Treatments	Plant height (cm)			Leaf area index		Number of branches per plant at harvest	Total dry matter (g/ plant) at harvest
	30DAS	45 DAS	At harvest	30 DAS	45 DAS		
T_1	10.3	23.7	49.3	0.78	2.83	5.8	17.70
T_2	10.2	26.5	51.1	0.83	3.00	6.1	19.10
T_3	11.6	27.5	53.9	0.81	3.05	6.2	19.89
T_4	11.8	29.3	55.7	0.89	3.10	6.7	20.63
T_5	11.5	28.2	54.3	0.85	3.07	6.6	20.20
T_6	10.9	25.8	50.6	0.80	2.93	5.9	18.92
T_7	11.4	19.3	45.4	0.78	2.65	5.1	15.46
T_8	11.3	22.7	47.2	0.82	2.83	5.3	15.76
SEm±	**0.52**	**0.38**	**0.37**	**0.008**	**0.012**	**0.07**	**0.12**
CD (p=0.05)	**NS**	**1.14**	**1.11**	**0.024**	**0.038**	**0.21**	**0.38**

[T_1- Untreated plot (Control); T_2-Sodium para-Nitrophenolate 0.3%SL@3 ml/L; T_3- Sodium para-Nitrophenolate 0.3%SL@4ml/L; T_4-Sodium para-Nitrophenolate 0.3%SL@5ml/L; T_5-Sodium para-Nitrophenolate 0.3%SL@6ml/L; T_6- NAA@10 ppm (10 ml/L); T_7-Triacontanol 0.1% EW@250 ml/ha; T_8-Sodium para-Nitrophenolate 0.3%SL@10ml/L]

Table 2. Effect of plant growth regulators on yield attributes and seed yield of blackgram during *kharif* season (Pooled value two years)

Treatments	Number of pods per plant	Pod length (cm)	Pod width (cm)	No. of seed per pod	100 seed weight (g)	Protein (%)	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1	61.7	4.42	0.56	6.92	4.2	22.07	825.6	1024.7
T_2	68.2	5.12	0.72	9.20	4.3	25.03	985.3	1168.2
T_3	68.5	5.17	0.78	9.65	4.4	24.89	1035.4	1226.3
T_4	80.5	5.44	0.87	10.72	4.4	25.78	1256.3	1515.1
T_5	85.4	5.25	0.83	10.39	4.5	24.96	1078.2	1347.6
T_6	63.7	5.06	0.61	8.63	4.3	24.39	956.8	1142.1
T_7	54.7	4.68	0.50	7.83	3.9	23.75	917.1	1064.6
T_8	58.2	4.83	0.52	7.93	4.0	23.22	875.4	1085.3
SEm±	**1.82**	**0.37**	**0.13**	**0.21**	**0.24**	**0.05**	**35.3**	**45.4**
CD (p=0.05)	**4.46**	**NS**	**NS**	**0.63**	**NS**	**0.017**	**105.9**	**136.2**

[T_1- Untreated plot (Control); T_2-Sodium para-Nitrophenolate 0.3%SL@3 ml/L; T_3- Sodium para-Nitrophenolate0.3%SL@4ml/L; T_4-Sodium para-Nitrophenolate 0.3%SL@5ml/L; T_5-Sodium para-Nitrophenolate 0.3%SL@6ml/L; T_6- NAA@10 ppm (10 ml/L); T_7-Triacontanol 0.1% EW@250 ml/ha; T_8-Sodium para-Nitrophenolate0.3%SL@10ml/L]

Table 3. Effect of plant growth regulators on nutrient up take of blackgram during *kharif* season (Pooled value of two years)

Treatments	Nitrogen uptake (kg/ha)			Phosphorous uptake (kg/ha)			Potassium uptake (kg/ha)		
	Seed	Stover	Total uptake	Seed	Stover	Total uptake	Seed	Stover	Total uptake
T_1	22.60	23.50	46.10	2.20	2.40	4.60	5.96	6.02	11.98
T_2	24.20	23.60	47.8	3.06	3.12	6.18	7.42	7.94	15.36
T_3	24.50	24.06	48.56	3.11	3.00	6.11	7.68	8.03	15.71
T_4	25.06	24.33	49.39	3.40	3.46	6.86	8.23	8.45	16.68
T_5	25.23	25.00	50.23	3.93	4.20	8.13	8.70	8.53	17.23
T_6	24.40	22.23	46.63	2.56	2.56	5.12	6.64	7.05	13.69
T_7	22.93	22.40	45.33	2.70	2.68	5.38	6.32	6.35	12.67
T_8	23.80	21.80	45.60	2.32	2.66	4.98	7.19	7.40	14.59
SEm±	**0.09**	**0.11**	**0.2**	**0.11**	**0.15**	**0.26**	**0.11**	**0.08**	**0.19**
CD (p=0.05)	**0.29**	**0.36**	**0.65**	**0.36**	**0.45**	**0.81**	**3.75**	**2.21**	**5.96**

[T_1- untreated plot (Control); T_2-Sodium para-Nitrophenolate 0.3%SL@3 ml/L; T_3- Sodium para-Nitrophenolate 0.3%SL@4ml/L; T_4-Sodium para-Nitrophenolate 0.3%SL@5ml/L; T_5-Sodium para-Nitrophenolate 0.3%SL@6ml/L; T_6- NAA@10 ppm (10 ml/L); T_7-Triacontanol 0.1% EW@250 ml/ha; T_8-Sodium para-Nitrophenolate 0.3%SL@10ml/L]

Yield attributes and yield

The application of plant growth regulators (PGRs) as a foliar spray enhanced the yield attributes and seed yield of blackgram compared to the control (Table 2). Under different treatments applied in the experiment plot, the best result was obtained with the application of sodium para-nitrophenolate 0.3% SL @ 6 ml/L which showed the maximum number of pods per plant (85.4), but in terms of pod length and pod width, the best value (5.44 cm length and 0.87cm width) was obtained from the application of sodium para-nitrophenolate 0.3% SL @ 5 ml/L. The maximum number of seeds per pod (10.72) was also recorded with the application of sodium para-nitrophenolate 0.3% SL @ 5 ml/L followed by the application of sodium para-nitrophenolate 0.3% SL @ 6 ml/L (10.39). The highest 100-seed weight (4.5 g) was also recorded from treatment sodium para-nitrophenolate 0.3% SL @ 5 ml/L. The highest value of seed protein (25.78%) was obtained with the same treatment. The highest seed yield (1256 kg/ha) and stover yield (1515 kg/ha) was recorded from the application of sodium para-nitrophenolate 0.3% SL @ 5 ml/L. The plant growth regulators sodium para-nitrophenolate 0.3% SL @ 5 ml/L increased the yield and yield attributes by improving various physiological and biochemical processes (Przybysz *et al.* 2014). The weight of grain is associated with the mobilization and translocation of assimilates from plant parts to developing grains (Adam and

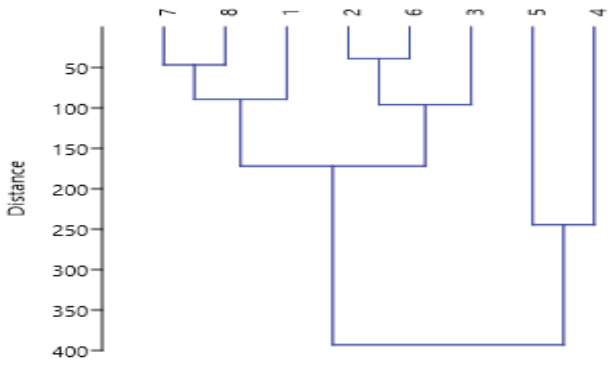

Fig. 1. Cluster dendro grams representing the yield and yield attributes of blackgram

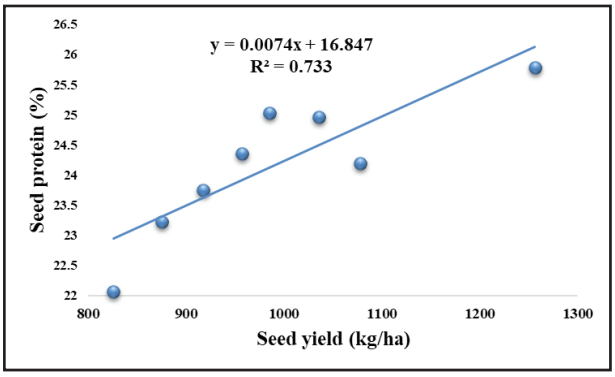

Fig. 2. Correlation between seed yield (kg/ha) and seed protein (%) of blackgram

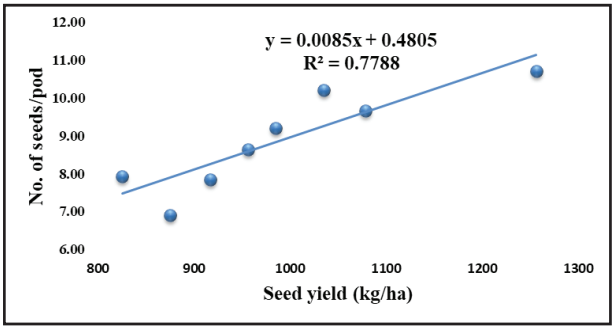

Fig. 3. Correlation between seed yield (kg/ha) and no. of seeds/pod of blackgram

Jahan 2011). A similar result was also reported by Djanaguiraman *et al.* (2009) who observed that nitrophenolate spray enhanced the photo assimilates to partitioning between plant sinks by delaying leaf senescence. The seed yield and protein content in the seed show a positive correlation between them (R^2= 0.733). In case of the seed yield and number of seeds/pod in plants also show a positive correlation between them (R^2= 0.778). Cluster dendrogram were made to illustrate the yield and yield attribute patterns of blackgram. At the similarity where two clusters were merged to originate the final cluster, the final cluster splits into the two parent clusters, and so on. Fig. 1 represents the dendrogram patterns of blackgram. In this cluster dendrograms seed and haulm yield was correlated with all the yield attributes of blackgram. From the figure it can be concluded that correlations between the yield and yield-related traits demonstrated their usefulness for the prediction of the yield of blackgram.

Nutrient uptake

The maximum nutrient content in seed and stover may be due to the greater availability of nutrients through the application of plant growth regulators (PGRs) and their efficient absorption by the roots of blackgram. The maximum N uptake (50.23 kg/ha), P uptake (8.13 kg/ha) and K uptake (17.23 kg/ha) were recorded with sodium para-nitrophenolate 0.3% SL @ 6 ml/L treated plot. Basuchaudhuri (2016) reported that NAA-influenced root activities effectively created a potential gradient for further nutrient uptake and the stimulatory effect of NAA (synthetic auxin) in absorbing nutrients increased the uptake of NPK (Islam and Jahan 2016).

CONCLUSION

In conclusion, foliar application of sodium para-nitrophenolate 0.3% SL @ 5 ml/L at 35 DAS (1^{st} spray) and 50 DAS (2^{nd} spray), in conjunction with recommended dose of fertilizer (RDF) (N, P_2O_5 and K_2O at 20, 40 and 40 kg/ha) were found to be more beneficial in terms of enhancing growth, yield attributes and yield as well as nutrient uptake of blackgram under new alluvial Gangetic zone of West Bengal.

REFERENCES

AbdAlla MA, El-Greadly, NHM and Emam YT. 2015. Effect of foliar spray with bio stimulants on growth, head yield, phytohormones and nutrients of cabbage (*Brassica oleracea* var. *Capitata*). Egyptian Journal of Horticulture **42**(2): 707-719.

Adam AMMG, and Jahan N. 2011. Effects of naphthalene acetic acid on yield attributes and yield of two varieties of rice (*Oryza sativa* L.) Bangladesh Journal of Botany **40**(1): 97-100.

Ashvathama VH, Gollagi SG, Soregaon CD and Mangi VL. 2020. Effect of sodium para nitrophenolate on flowering and yield of cucumber (*Cucumiss ativus* L.). International Journal of Chemical Studies **8**(4): 2557-2559.

Basu chaudhuri P. 2016. 1-Naphthalene acetic acid in rice cultivation. Current Science **110**(1): 52-56.

Das D, Baruah IK, Panda D, Paswan RR, Acharjee S and Sarmah BK. 2021. Bruchid Beetle Ovi positioning Mediated Defense Responses in Black Gram Pods. BMC Plant Biology **21**: 1–22.

Das S, Jana K, Mondal R and Sarkar A. 2023. Effect of foliar application of micro nutrients on summer mungbean varieties on alluvial soil of West Bengal. Journal of Food Legumes **36**(2 & 3): 157-163.

Djanaguiraman M, Annie Sheeba J, Durga Devi D and Bangarasamy U. 2009. Cotton leaf senescence can be delayed by nitrophenolate spray through enhanced antioxidant defence system. Journal of Agronomy and Crop Science **195**: 213-224.

Gomez KA and Gomez AA. 1984. Statistical procedures for agricultural research. Second edition. An International Rice Research Institute Book. A Wiley-Inter-Science Publication, John Wiley & Sons, New York.

Gorai MS and Mondal R. 2023. Effect of date of sowing and level of phosphorus on growth and yield of summer mungbean (*Vigna radiata* L.) in Red and Lateritic soils of West Bengal. Journal of Food Legumes **36**(2&3): 164-168.

Iqbal M A, Abdul H, Siddiqui MH, Imtiaz H, Tanveer A and Saia I. 2019. A meta-analysis of the impact of foliar feeding of micro nutrients on productivity and revenue generation of forage crops. Planta Daninha **37.**

Islam S and Jahan N. 2016. Effects of NAA and different nitrogen levels on nutrient uptake by bari gom-26 (*Triticuma aestivum* L.). The Journal of the Asiatic Society of Bangladesh **42**(1): 69-76.

Karam EA and Keramat B. 2017. Foliar spray of triacontanol improves growth by alleviating oxidative damage in coriander under salinity. Indian Journal of Plant Physiology **22**: 120-124.

Naeem M, Ansari AA, Aftab T, Shabbir A, Alam MM, Khan MMA and Uddin M. 2019. Application of triacontanol modulates plant growth and physiological activities of *Catharanthus roseus* L.. International Journal of Botany **4**: 131-135.

Phogat M, Rai AP and Kumar S. 2020. Interaction effect of phosphorus and sulphur application on nutrient uptake, yield and yield attributing parameters of black

gram. Legume Research-An International Journal **43**(2): 212-220.

Pratihar D, Mondal R and Banerjee S. 2023. Effect of foliar nutrition on growth and yield of Green gram (*Vigna radiata* L.) in Red and Lateritic soils of West Bengal. Journal of Food Legumes **36**(1): 93-97.

Przybysz A, Gawronska H and Gajc-Wolska J. 2014. Biological mode of action of a nitrophenolates - based biostimulant: case study. Frontiers in Plant Science **5**(713): 1-14.

Sarkar A, Jana K and Mondal R. 2021. Growth and yield of hybrid mustard (*Brassica juncea* L.) as influenced by foliar nutrition in Gangetic plains of West Bengal. Journal of Crop and Weed **17**(3): 35-40.

Sarkar A, Jana K, Mondal R, Mondal K, Banerjee S and Murmu K. 2022. Effect of foliar nutrition on growth, oil yield, production economics of hybrid mustard (*Brassica juncea* L.) and soil microbial properties. The Pharma Innovation Journal **11**(6): 1456-1460.

Sharma L, Priya M, Kaushal N, Bhandhari K, Chaudhary S and Dhankher OP. 2020. Plant growth-regulating molecules as thermo protectants: functional relevance and prospects for improving heat tolerance in food crops. Journal of Experimental Botany **71**: 569–594.

Sharma P, Sardana V and Sukhvinder Singh K. 2013. Dry matter partitioning and source-sink relationship as influenced by foliar sprays in groundnut. The Bioscan **8**: 1171–1176.

Shroti SK, Pathak A, Tiwari A, Gupta A and Chauhan SK. 2018. Morphological, physiological and yield analysis of black gram under different levels of FYM, PSB and Phosphorus. International Journal of Chemical Studies **6**(3): 03-411.

Singh L, Kumar A, Kaur S and Gill RK. 2020. Multivariate Analysis of Yield Contributory Traits for Selection Criteria in Urdbean. Electronic Journal of Plant Breeding **11**: 1134-1142.

Suseendran K, Kalaiyarasan C, Jawahar S, Stalin P, Murugan G, Vinodkumar SR and Arivukkarasu K. 2020. Response of rice to foliar application of plant growth regulator on growth and yield of rice. Plant Archives **20**(1): 1510.

Zaid A, Mohammad F and Fariduddin Q. 2019. Plant growth regulators improve growth, photosynthesis, mineral nutrient and antioxidant system under cadmium stress in menthol mint (*Menthaar vensis* L.). Physiology and Molecular Biology of Plants **26**(1): 25-39.