Evaluation of Biofertigation for Enhancing Growth and Yield of Blackgram (*Vigna mungo* L.)

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ABSTRACT
Blackgram (*Vigna mungo* L.) is an important pulse crop whose productivity is often constrained by poor nutrient management and declining soil fertility. A field experiment was conducted during the summer, 2026 at the SRM College of Agricultural Sciences, Baburayanpettai, Chengalpattu, Tamil Nadu, India, to evaluate the influence of biofertigation on the growth and yield of blackgram. The experiment was laid out in a Randomized Block Design with nine treatments and three replications. Treatments comprised different levels of recommended fertilizers integrated with biofertigation of Rhizobium, phosphate-solubilizing bacteria (PSB), potassium-solubilizing bacteria (KSB), fish amino acid, fulvic acid, and humic acid. Growth parameters, physiological traits and yield attributes were recorded and statistically analyzed. Among the treatments, T_8 (50% RDF + biofertigation of Rhizobium, PSB, KSB, fish amino acid, fulvic acid and humic acid) recorded the highest plant height (34.22 & 45.83 cm), number of branches per plant (5.39 & 8.76), SPAD value (48.95 & 24.85) and leaf area index (5.50 & 4.75) at 45 days after sowing and at the time of harvest respectively. In addition, the same treatment produced the highest number of pods per plant (24.46), grain yield (1479 kg/ha) and haulm yield (2413 kg/ha). The results indicate that integrated biofertigation with a complete consortium of beneficial microorganisms and organic formulations, combined with 50% RDF, significantly enhanced crop growth, physiological performance and productivity of blackgram. The study demonstrates the potential of biofertigation as a sustainable nutrient management strategy for improving blackgram yield while reducing dependence on chemical fertilizers.
Keywords: Blackgram, Biofertigation, Rhizobium, LAI, SPAD, Yield.

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INTRODUCTION

Blackgram (*Vigna mungo* L.), commonly known as urdbean, is an important short-duration pulse crop cultivated widely in South and Southeast Asia. India is the center of origin and the largest producer, accounting for nearly 10% of the country's pulse production. During 2022, blackgram occupied 4.63 million hectares with a production of 2.78 million tonnes and a productivity of 987 kg/ha (Marimuthu *et al*., 2024). The crop is nutritionally rich, containing about 24% protein and 59.6% carbohydrates, and serves as a major dietary protein source for vegetarian populations (Dodewar *et al*., 2026). Apart from its nutritional value, blackgram improves soil fertility through biological nitrogen fixation by Rhizobium, lowering dependence on chemical nitrogen fertilizers. Its short duration and adaptability make it suitable for rice-fallow systems, intercropping, and sequential cropping, thereby supporting sustainable agricultural intensification.

Despite its importance, blackgram productivity remains low due to several biotic, abiotic, and management-related constraints. Yield-gap analyses have indicated differences of 5–67% between actual and potential yields, with an average gap of about 515 kg/ha (Dodewar *et al*., 2026). Major biotic stresses such as yellow mosaic virus disease, insect pests, and fungal pathogens can cause yield losses of up to 70% (Nair *et al*., 2024). Drought conditions during the reproductive stages of flowering and pod filling can significantly hinder pod set and subsequent seed development. In addition, improper agronomic practices, inadequate nutrient management, declining soil organic matter and indiscriminate use of chemical fertilizers have resulted in nutrient imbalance, reduced soil health and lower crop productivity (Adhikari *et al*., 2022; Swaminathan *et al*., 2023; Tripathy *et al*., 2024). These challenges highlight the need for sustainable approaches that improve nutrient use efficiency and crop performance while maintaining soil fertility.

Drip fertigation, which involves the delivery of nutrients through a drip irrigation system, enhances crop growth, yield and water-use efficiency in pulse crops. Biofertilizers comprise beneficial microorganisms that improve nutrient availability and uptake through various biological mechanisms. Biofertigation combines fertigation with the application of biofertilizers, thereby enhancing microbial activity and improving nutrient availability within the rhizosphere (Abdelhamid *et al*., 2011). The effectiveness of biofertigation can be further enhanced through integration with organic formulations such as fish amino acid, fulvic acid and humic acid. Fulvic acid promotes root growth, nodulation, and nutrient uptake, while humic and fulvic substances improve root development, stress tolerance, and nutrient availability (Capstaff *et al*., 2020). Synergistic effects between humic substances and amino acids have also been associated with substantial yield improvements (Han *et al*., 2025).

MATERIALS AND METHODS

The field experiment was conducted during the summer, 2026 at the SRM College of Agricultural Sciences farm, SRM Institute of Science and Technology, Baburayanpettai, Chengalpattu, India. The experimental site is located at an altitude of 36 meters above the Mean Sea Level, falling within the North Eastern zone of Tamil Nadu. Geographically, the location is situated at a latitude of 12.39° N and a longitude of 79.74° E. It is characterized by consistently warm temperatures and moderate to high rainfall. The region experiences distinct wet and dry seasons with relatively high humidity, creating favorable conditions for black gram cultivation under proper nutrient and moisture management. The soil of the experimental site was alluvial soil in texture owning available nutrient levels of 263 kg N/ha, 10 kg P_2O_5/ha and 110 kg K_2O/ha. With moderate fertility and slightly alkaline reaction, the soil had an organic carbon content of 0.63%, soil pH of 7.67 and electrical conductivity of 0.26 dS/m

The experimental design employed for the study was Randomized Block Design (RBD). It consisted of nine treatments that were replicated three times, giving rise to 27 experimental plots. The treatments consisted of different levels of inorganic fertilizers combined with biofertigation of biofertilizers and organic formulations. The treatments are T_1: 25% Recommended dose of Nitrogen (RDN) + biofertigation of rhizobium + fish amino acid, T_2: 50% RDN + biofertigation of rhizobium + fish amino, T_3: 25% Recommended dose of Phosphorous (RDP2O5) + biofertigation of PSB + fulvic acid, T_4: 50% RDP_2O_5 + biofertigation of PSB + fulvic acid, T_5: 25% Recommended dose of Potassium (RDK_2O) + biofertigation of KSB + humic acid, T_6: 50% RDK_2O + biofertigation of KSB + humic acid, T_7: 25% Recommended dose of fertilizers + biofertigation of Rhizobium + PSB + KSB along with fish amino acid, fulvic acid and humic acid, T_8: 50% RDF + biofertigation of Rhizobium + PSB + KSB along with fish amino acid, fulvic acid and humic acid and T_9: Farmer's practice. The first and second treatment were provided with 100 % RDP2O5 and RDK_2O. The third and fourth treatment were provided with 100% RDN and RDK_2O. Likewise the fifth and sixth treatment were offered with 100 % RDN and RDP2O5.

Vamban 11 was the variety of blackgram used for the study, which was sown at a spacing of 30 × 10 cm in each of the experimental plots measuring 32.7 m^2 (27 m × 1.2 m). Fertigation was administered using a drip line system with emitters of 4 L/h discharge rate. Two laterals ran through each of the treatment beds, which were set apart by 60 cm, and fertigated 4 rows of crops in each bed. Inorganic fertilizers, biofertilizers and organic formulations were applied in split doses at defined growth stages in accordance with treatment schedules. The inputs were delivered through the irrigation system at once in three days to ensure uniform distribution, improved nutrient availability and higher uptake efficiency with minimal nutrient loss.

Plant height and the number of branches per plant were noted as growth characteristics. Additionally, physiological markers including LAI and SPAD were examined. Yield data including number of pods per plant, grain yield, haulm yield and harvest index were recorded and evaluated. The experimental data were statistically analyzed using analysis of variance (ANOVA) as described by Gomez and Gomez (1983). Critical difference (CD) values were computed to compare the treatments, and the significance of treatment effects was examined at the 5% probability level.

RESULTS AND DISCUSSION

The growth, physiological and yield parameters of blackgram were significantly influenced by biofertigation treatments integrating reduced levels of inorganic fertilizers with beneficial microorganisms and organic formulations under drip irrigation. Distinct differences among treatments were observed for plant height, number of branches, SPAD value, leaf area index (LAI), number of pods per plant, grain yield and haulm yield. In general, treatments receiving 50% of the recommended fertilizer dose combined with integrated biofertigation performed better than treatments with lower fertilizer levels or individual nutrient-specific biofertigation. Among all treatments, T_8 (50% RDF + biofertigation of Rhizobium, PSB, KSB, fish amino acid, fulvic acid, and humic acid) consistently recorded the highest values for most parameters, whereas T_5 (25% RDK_2O + biofertigation of KSB + humic acid) recorded the lowest performance. Overall, integrated biofertigation with 50% RDF enhanced nutrient availability, improved physiological efficiency and increased the productivity of blackgram while reducing dependence on inorganic fertilizers.

Growth parameters

Plant height (cm)

Plant height of blackgram was significantly influenced by biofertigation treatments at both 45 DAS and harvest. Among the treatments, T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest plant height of 34.22 cm at 45 DAS and 45.83 cm at harvest. The superior performance of T_8 may be attributed to the synergistic effect of Rhizobium, PSB and KSB along with organic formulations, which enhanced nutrient availability, root growth and photosynthetic activity, resulting in improved vegetative growth. The present results are consistent with the findings of previous studies (Maurya *et al*., 2026; Mosaad *et al*., 2025). The lowest plant height was observed in T_5 (22.93 cm at 45 DAS and 35.83 cm at harvest). This could be attributed to the relatively limited influence of potassium on shoot elongation, as its primary functions are associated with metabolic regulation and stress tolerance rather than direct promotion of vegetative growth.

Number of Branches

The number of branches per plant was significantly affected by biofertigation treatments at both observation stages. Treatment T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest number of branches, 5.39 at 45 DAS and 8.76 at harvest, respectively. The increased branching under T_8 could be attributed to enhanced nutrient uptake and improved physiological activity resulting from the combined action of beneficial microorganisms and organic formulations. Adequate nitrogen fixation by Rhizobium, phosphorus solubilization by PSB and potassium mobilization by KSB likely promoted axillary bud development and lateral branching. Results support the findings of an earlier work (Gautam *et al*., 2022). Fish amino acid and humic substances may have further stimulated branching by improving nutrient assimilation and growth-promoting hormone activity (Faezah *et al*., 2021). In contrast, T_5 recorded the lowest values, 3.61 and 5.87, respectively, at 45 DAS and at harvest. The lower number of branches in T5 may be attributed to restricted potassium availability at 25% RDK_2O, which limited photosynthate translocation and cytokinin-mediated axillary bud development. The absence of fish amino acid and fulvic acid further reduced microbial activity and nutrient availability in the rhizosphere (Alsudays *et al*., 2024).

Physiological Parameters

SPAD value

Biofertigation treatments significantly influenced SPAD values of blackgram at both 45 DAS and harvest. Among the treatments, T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest SPAD values of 48.95 and 24.85 at 45 DAS and harvest, respectively. The superior SPAD values in T_8 reflect the combined role of Rhizobium-fixed nitrogen, PSB-mobilized phosphorus and fish amino acids in maximizing chlorophyll biosynthesis, as nitrogen is the core constituent of the chlorophyll molecule and phosphorus is essential for thylakoid membrane integrity. Similar increases in chlorophyll content following biofertilizer application were reported in a previous study (Selvakumar *et al*., 2012). The lowest SPAD values were observed in T_5(25% RDK + KSB + humic acid) with 43.10 and 19.40, respectively at 45 DAS and at harvest. The decline in SPAD values from 45 DAS to harvest across all treatments could be due to chlorophyll degradation and remobilization of nutrients from leaves to developing seeds during crop maturity. The lower values at both 45 DAS and at harvest might be due to the complete absence of Rhizobium, PSB, fish amino acid, and fulvic acid from its biofertigation package, which resulted in the lack of nitrogen supplementation beyond the chemical dose, leading to a restricted chlorophyll synthetic capacity. Similar findings were reported by (Veer *et al*., 2022).

Leaf Area Index (LAI)

Leaf area index was significantly affected by biofertigation treatments at both observation stages. The highest LAI was recorded in 50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid (T_8) with 5.50 at 45 DAS and 4.75 at harvest. The increased LAI under T8 could be attributed to the synergistic effect of Rhizobium, PSB, KSB, and organic formulations, which improved nutrient availability, photosynthetic efficiency and canopy development. Rhizobium-mediated nitrogen fixation supplies amino acids and proteins for leaf expansion, while PSB-solubilized phosphorus supports energy metabolism and cell division. Fish amino acid enhances microbial activity and nutrient cycling, promoting leaf area development. Fulvic acid improves root growth and nutrient uptake, ensuring a continuous nutrient supply that supports canopy expansion during vegetative growth. These findings were in agreement with (Choudhary *et al*., 2025). The lowest LAI was recorded in T_5 (25% RDK + KSB + humic acid), recording values of 3.69 at 45 DAS and 3.18 at harvest. The gradual decline in LAI at harvest was mainly due to leaf senescence and shedding during the reproductive stage. In T_5, restricted leaf area development stems from the limited organic nitrogen and phosphorus supply available for leaf cell division and expansion, as KSB addresses only potassium mobilization. Without the synergistic combination of all three microbial groups and their organic adjuvants, the crop's capacity to build an expansive photosynthetic canopy was substantially suppressed. Similar findings were presented in existing studies (Thakur *et al*., 2017).

Yield parameters

Number of Pods per Plant

T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest number of pods per plant (24.46). The higher pod number in T_8 may be attributed to its superior vegetative growth, characterized by greater plant height, branching, LAI and chlorophyll content, which enhanced assimilate production and supply to developing floral buds. Fish amino acid supplementation improved nitrogen availability during flowering, reducing flower drop and promoting better pod set and retention. The combined action of Rhizobium, PSB and KSB at the root zone improved nutrient availability, resulting in better nodulation and plant growth. These observations substantiate the findings of previous studies (Sasidhar *et al*., 2022). T_5 (25% RDK + KSB + humic acid) recorded the lowest value for the number of pods per plant (15.48). The lower pod number in T_5 may be attributed to the absence of Rhizobium, PSB, fish amino acid and fulvic acid, which reduced nutrient availability and reproductive growth. Although KSB and humic acid improved potassium availability, they were insufficient to support maximum flower retention and pod development, resulting in fewer pods per plant. Related markings were described in past research (Kant *et al*., 2016).

Harvest Index

The effect of various biofertigation treatments on the harvest index (HI) of blackgram is presented in Table 2. The analysis revealed non-significant differences among treatments (CD: NS), indicating that the treatments did not markedly influence the efficiency of assimilate partitioning between grain yield and haulm yield. Nevertheless, T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest numerical harvest index value (0.380), whereas the lowest value (0.350) was observed in T_5 (25% RDK + biofertigation of KSB + humic acid).

Grain yield (kg/ha)

The highest grain yield recorded in T_8 (1479 kg/ha) may be attributed to the synergistic effect of 50% RDF integrated with Rhizobium, PSB, KSB, fish amino acid, fulvic acid and humic acid, which ensured a balanced and continuous supply of essential nutrients throughout the crop growth period. Enhanced nitrogen fixation, phosphorus solubilization, potassium mobilization and improved nutrient uptake promoted higher SPAD values, LAI and photosynthetic efficiency, resulting in greater assimilate production and ultimately increased grain yield. Similar observations were documented in an earlier study (Charles Wesley & Dawson, 2023). The treatment T_5 (25% RDK + KSB + humic acid) exhibited the lowest grain yield with 954 kg/ ha. This may be attributed to the absence of Rhizobium, PSB, fish amino acid and fulvic acid, which limited nitrogen fixation, phosphorus availability and overall nutrient uptake. Consequently, pod formation, seed development and grain filling were adversely affected. The lack of these biofertilizers and organic formulations also reduced rhizospheric activity and nutrient cycling, resulting in poorer reproductive performance and lower grain yield compared to the integrated biofertigation treatments. Comparable findings were described in previous research (Hussain *et al*., 2015).

Haulm Yield (kg/ha)

T_8 (50% RDF + biofertigation of Rhizobium + fish amino acid + PSB + fulvic acid + KSB + humic acid) recorded the highest haulm yield of 2413 kg/ha. The higher haulm yield in T_8 may be attributed to greater plant height, branching, LAI and dry matter production resulting from the integrated biofertigation package. Enhanced nutrient availability through Rhizobium, PSB and KSB, along with the growth-promoting effects of fish amino acid and humic acid, improved vegetative growth and biomass accumulation, leading to higher haulm yield (Sabra *et al*., 2026). Treatment T_5(25% RDK + KSB + humic acid) measured the lowest haulm yield (1772 kg/ha). The lower haulm yield in T_5 may be attributed to its poor vegetative growth, characterized by reduced plant height, branching, LAI and dry matter production. Although KSB and humic acid improved potassium availability, they were insufficient to promote maximum vegetative growth, resulting in the lowest haulm yield among all treatments. Similar findings were found in earlier studies (Gummadala *et al*., 2022).

CONCLUSION

The present study demonstrated that biofertigation significantly improved the growth, physiological performance and yield of blackgram compared to individual nutrient management approaches and farmers' practices. Among the treatments, 50% RDF combined with biofertigation of Rhizobium, PSB, KSB, fish amino acid, fulvic acid and humic acid (T_8) consistently recorded superior performance in growth, physiological and yield parameters. The enhanced performance is attributed to the synergistic effect of beneficial microorganisms and organic formulations, which improved nutrient availability, nutrient uptake efficiency, photosynthetic activity and biomass accumulation throughout the crop growth period. Therefore, the integration of 50% RDF with biofertigation of Rhizobium, PSB, KSB, fish amino acid, fulvic acid, and humic acid is recommended for achieving higher productivity and improved nutrient use efficiency in blackgram under similar agro-climatic conditions.

REFERENCES

Abdelhamid, M. T., Selim, E. M., & El-Ghamry, A. M. (2011). Integrated effects of bio and mineral fertilizers and humic substances on growth, yield and nutrient contents of fertigated cowpea (Vigna unguiculata L.) grown on sandy soils.

Adhikari, R. S., Chowdhury, M. R., Sar, K., Dash, S., Patra, C., Mishra, G., ... & Acharya, S. (2022). Growth and yield of blackgram (Vigna mungo L.) under different sowing date and nutrient management practices. Growth, 53(12).

Alsudays, I. M., Alshammary, F. H., Alabdallah, N. M., Alatawi, A., Alotaibi, M. M., Alwutayd, K. M., ... & Awad-Allah, M. M. (2024). Applications of humic and fulvic acid under saline soil conditions to improve growth and yield in barley. BMC Plant Biology, 24(1), 191.

Capstaff, N. M., Morrison, F., Cheema, J., Brett, P., Hill, L., Muñoz-García, J. C., ... & Miller, A. J. (2020). Fulvic acid increases forage legume growth inducing preferential up-regulation of nodulation and signalling-related genes. Journal of experimental botany, 71(18), 5689-5704.

Charles Wesley, J., & Dawson, J. (2023). Influence of Biofertilizers and Gibberellic Acid on Growth and Yield of Blackgram (Vigna mungo L.). Int. J. Environ. Clim. Change, 13(9), 329-335.

Choudhary, C. S., Nongmaithem, D., Singh, A. P., Choudhary, S., Solo, V., & Karak, T. (2025). Effect of phosphorus levels and biofertilizers on the growth and yield of summer Black Gram (Phaseolus mungo L.). Legume Research-An International Journal, 48(1), 167-171.

Dodewar, P. G., Brahmanand, P. S., Pillai, S. N., Srivastava, S. K., Bana, R. S., Prajapati, V. K., ... & Jena, T. (2026). Crop simulation-based assessment of yield gaps and water productivity for improving blackgram (Vigna mungo L.) production across diverse ecologies of India. Frontiers in Agronomy, 8, 1775298.

Faezah, O. N., Najihah, S. N., Nakasha, J. J., & Suhaili, M. Y. (2021). Fish amino acid application to improve growth performance and yield of Chinese Kale (Brassica oleracea). Journal of Applied Horticulture, 23(2), 162-166.

Gautam, R., Khanna, R., Pal, K., Singh, V., Saini, A., & Gautam, M. (2022). Effect of biofertilizers and phosphorus levels on growth, yield and nodulation of black gram (Vigna mungo). Crop Res, 57, 245-48.

Gummadala, K. R., Tomar, S. S., Perli, V. H., & Kaushik, M. (2022). Agronomical performance of black gram (Vigna mungo L.) in the presence of organic manures and biofertilizers in typic haplustalf. Pharma Innovation, 11(6), 1927-1931.

Han, H., Zhang, J., Meng, Q., Xu, Q., Li, Y., Li, L., ... & Gong, P. (2025). Fulvic acid-amino acid organic fertilizer: Optimal co-application, sustainable remediation, and yield improvement strategies for aline-alkaline cotton fields in Xinjiang. Industrial Crops and Products, 237, 121984.

Hussain, N., Mehdi, M., Dar, S. N. R., Hussain, M., & Fatima, N. (2015). Effect of rhizobium and PSB on growth and yield attributes of blackgram (Vigna mungo

L.). Ecology, Environment and Conservation, 21(3), 1231-1233.

Kant, S., Kumar, A., Kumar, S., Kumar, V., Pal, Y., & Shukla, A. K. (2016). Effect of rhizobium, PSB and p-levels on growth, yield attributes and yield of Urdbean (Vigna Mungo L.). J Pure Appl Microbiol, 10(4), 3093-3098.

Marimuthu, S., Vanitha, C., Surendran, U., El-Hendawy, S., & Mattar, M. A. (2024). Conception of improved blackgram (Vigna mungo L.) production technology and its propagation among farmers for the development of a sustainable seeds production strategy. Sustainability, 16(11), 4750.

Maurya, A., Singh, S., Pandey, D., Chanda, S. S., Singh, P. K., & Singh, G. (2026). Role of Bio-fertilizers in Availability of Phosphorus Fertilizer and Yield of Blackgram (Vigna mungo L.). Asian Journal of Research in Crop Science, 11(2), 55-62.

Mosaad, I. S., Selim, E. M. M., Gaafar, D. E., & Al-Anoos, M. A. (2025). Effects of humic and fulvic acids on forage production and grain quality of triticale under various soil salinity levels. Cereal Research Communications, 53(3), 1811-1829.

Nair, R. M., Chaudhari, S., Devi, N., Shivanna, A., Gowda, A., Boddepalli, V. N., ... & Somta, P. (2024). Genetics, genomics, and breeding of black gram [Vigna mungo (L.) Hepper]. Frontiers in plant science, 14, 1273363.

Sabra, D. M., Badr, E. A., Mohamed, M. H., & Amin, G. A. (2026). Foliar application of humic acid improves growth, yield, and nutritional quality of mungbean (Vigna radiata L.) genotypes under newly reclaimed soil conditions. Scientific Reports, 16(1), 12726.

Sasidhar, P., Singh, S., & Sanodiya, L. K. (2022). Effect of spacing and biofertilizer on growth and yield of black gram (Vigna mungo L.). The Pharma Innovation Journal, 11(2), 2866-2869.

Selvakumar, G., Reetha, S., & Thamizhiniyan, P. (2012). Response of biofertilizers on growth, yield attributes and associated protein profiling changes of blackgram (Vigna mungo L. Hepper). World Appl Sci J. 2012;16(10):1368–74

Swaminathan, C., Surya, R., Subramanian, E., & Arunachalam, P. (2023). Challenges in Pulses Productivity and Agronomic Opportunities for Enhancing Growth and Yield in Blackgram [Vigna mungo (L.) Hepper]: A Review. Legume Research: An International Journal, 46(1).

Thakur, V., Patil, R. P., Patil, J. R., Suma, T. C., & Umesh, M. R. (2017). Physiological approaches for yield improvement of blackgram under rainfed condition. Int. J. Curr. Microbiol. App. Sci, 6(11), 4114-4122.

Tripathy, S., Mohapatra, A. K., Mohapatra, S., & Tripathy, S. K. (2024). Productivity and Profitability of Summer Blackgram in Response to Integrated Nutrient Management. Legume Research: An International Journal, 47(9).

Veer, D., Habib, K., & Kumar, K. (2022). Response of Black Gram (Vigna mungo L. Hepper) to Rhizobium, Phosphorus and Nitrogen for Sustainable Agriculture: A Mini Review. International Journal of Plant and Environment, 8(01), 81-86.

Table 1. Performance of biofertigation on growth and yield attributes of blackgram (Vigna mungo L.)

Treatments	Plant height (cm)		Number of branches		SPAD Value		Leaf Area Index	
	45 DAS	At Harvest	45 DAS	At Harvest	45 DAS	At Harvest	45 DAS	At Harvest
T_1	23.95	36.98	3.77	6.13	43.92	21.15	3.85	3.33
T_2	32.51	43.96	5.12	8.32	47.20	24.10	5.23	4.51
T_3	23.61	36.61	3.72	6.04	43.48	20.82	3.80	3.28
T_4	30.11	41.82	4.74	7.71	45.90	23.05	4.84	4.18
T_5	22.93	35.83	3.61	5.87	43.10	19.40	3.69	3.18
T_6	29.09	40.36	4.58	7.45	45.20	22.65	4.68	4.04
T_7	24.98	37.94	3.93	6.39	44.26	21.65	4.02	3.47
T_8	34.22	45.83	5.39	8.76	48.95	24.85	5.50	4.75

T_9	25.67	39.05	4.04	6.57	44.78	22.05	4.13	3.56
S. Ed±	1.53	1.46	1.82	0.32	1.24	0.99	0.20	0.19
CD (P=0.05)	3.25	3.26	4.24	0.73	2.76	2.21	0.45	0.41

T_1: 25% RDN Biofertigation of Rhizobium + Fish Amnio Acid
T_2: 50% RDN + Biofertigation of Rhizobium + Fish Amnio Acid
T_3:25% RDP2O5 +Biofertigation of PSB + Fulvic acid
T_4: 50% RDP2O5 + Biofertigation of PSB + Fulvic acid
T_5: 25% RDK2O +Biofertigation of KSB + Humic acid
T_6:50% RDK2O + Biofertigation of KSB + Humic acid
T_7: 25% RDF + Biofertigation of Rhizobium + Fish Amnio Acid + PSB + Fulvic acid + KSB + Humic acid
T_8: 50% RDF + Biofertigation of Rhizobium + Fish Amnio Acid + PSB + Fulvic acid + KSB + Humic acid
T_9: Farmers practice

Note: RDN- Recommended Dose of Nitrogen, RDP2O5- Recommended Dose of Phosphorus, RDK2O - Recommended Dose of Potassium, RDF- Recommended Dose of Fertilizers

Table 2. Performance of biofertigation on growth and yield attributes of blackgram (Vigna mungo L.)

Treatments	**Number of pods per plant**	**Grain yield (Kg/ha)**	**Haulm yield (Kg/ha)**	**Harvest Index**
T_1	16.61	1071	1904	0.360
T_2	23.03	1368	2270	0.376
T_3	16.07	1020	1845	0.356
T_4	20.55	1309	2201	0.373
T_5	15.48	954	1772	0.350
T_6	19.51	1260	2145	0.370
T_7	17.33	1128	1971	0.364
T_8	24.46	1479	2413	0.380
T_9	17.98	1208	2084	0.367
S. Ed±	1.10	55	127	0.009
CD (P=0.05)	2.46	122	282	NS

T_1: 25% RDN Biofertigation of Rhizobium + Fish Amnio Acid

T_2: 50% RDN + Biofertigation of Rhizobium + Fish Amnio Acid

T_3: 25% RDP2O5 +Biofertigation of PSB + Fulvic acid

T_4: 50% RDP2O5 + Biofertigation of PSB + Fulvic acid

T_5:R25% RDK2O +Biofertigation of KSB + Humic acid

T_6: 50% RDK2O + Biofertigation of KSB + Humic acid

T_7: 25% RDF + Biofertigation of Rhizobium + Fish Amnio Acid + PSB + Fulvic acid + KSB + Humic acid

T_8: 50% RDF + Biofertigation of Rhizobium + Fish Amnio Acid + PSB + Fulvic acid + KSB + Humic acid

T_9: Farmers practice

Note: RDN- Recommended Dose of Nitrogen, RDP2O5- Recommended Dose of Phosphorus, RDK2O - Recommended Dose of Potassium, RDF- Recommended Dose of Fertilizer