Original Research Article

Influence of soil and foliar application of nutrients on growth and yield of black gram (*Vigna mungo* L.)

ABSTRACT

The present investigation, conducted during the *Rabi* season of 2022-2023 in Coimbatore, scrutinizes the intricacies of nutrient management for optimizing the cultivation of ~~Black~~ black gram (*Vigna mungo* L.). Employing a meticulous Randomized Block Design (RBD) with three replications, diverse treatments were explored, encompassing recommended dose of inorganic fertilizer (RDF), rhizobium and phosphobacterium microbial inoculants as soil applicants and TNAU pulse wonder, nano urea, and DAP as foliar sprays. The outcome of the study delineates a substantial efficacy of treatment T_7 (75% RDF, rhizobial culture, phosphobacteria, and 1% TNAU Pulse Wonder) is significantly augmenting the plant growth metrics, including an appreciable increase in plant height (39.89 cm at 60 DAS) and leaf count (15.33 at 60 DAS). Moreover, the mentioned treatment (T_7) exerted a positive impact on crucial yield attributes, manifesting in elevated pod count (24.33), seeds per pod (9.33), and test weight (4.98 g). Economic scrutiny identified that the treatment T_7 as the epitome of economic viability, featuring a cost of cultivation at 30,240 INR, gross return of 1~~,~~25,587.80 INR, net income of 95,347.80 INR, and a commendable B: C ratio of 4.15. These findings underscore the profound significance of strategic nutrient management paradigms for fostering sustainable and economically robust ~~Black~~ black gram cultivation.

Keywords: Black gram, Nutrient management, Plant growth, Yield attributes, Economic viability, Rabi season, TNAU Pulse wonder, T_7 treatment, B:C ratio.

1. INTRODUCTION

Black gram (*Vigna mungo* L.) cultivation, renowned for its nutritional value and adaptability, faces challenges demanding comprehensive research for sustainable and efficient production. Nutrient management emerges as a critical issue [1,2]. Studies have explored the positive impacts of inorganic fertilizers and microbial inoculation on net profit [1] and addressed concerns related to heavy metal release [2]. Investigations into a nutrient combination of RDF, and rhizobium by various authors [3–5] unveiled synergies influencing growth parameters, seed yield, and economic returns. The positive impact of potassium and ~~Sulphur~~ sulphur on pulse yield was specifically highlighted [5], echoing sentiments from related studies [6]. Broader issues affecting black gram physiology were explored, including the influence of nutrient combinations on soil health and microbial dynamics [4,7]. Concerns about climate change impact were emphasized, stressing the role of proper nutrient management in enhancing resilience ~~,~~ [8,9]. Thimmisetty *et al.* [10] reported the economic and environmental benefits of reduced fertilizer application, proposing as a potential solution. The physiological influences of rhizobium, phosphobacteria, and vermicompost on plant growth, nodulation, and nutrient uptake were investigated [11–13]. Beniwal and Tomer [14] highlighted the influence of recommended dose fertilizer (RDF) on plant height, while Tyagi and Singh [15] showcased the positive effects of RDF,

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Comment [A1]: Please adhere to the journal's template for the appropriate formatting of this article.

Comment [A2]: Adding inorganic/mineral fertilizer (both the type and application dose).... helps to compare the conventional practice with the different nutrient management options.

Comment [A3]: The introduction seems to be lacking the harmony of coherent sentences.

Comment [A4]: Note that clear and concise language is key in scientific writing.

This sentence is unclear. Is it the co-application of inorganic and bio-fertilizer, or are they applied separately? Also, how is the net profit related to the release of heavy metals in a single sentence?

Comment [A5]: What do you want to mentioned, in relation to your study?

Comment [A6]: Resilience to what? Be sepecific

vermicompost, and rhizobium on plant growth and biomass accumulation. Insights from such studies are crucial for developing strategies that enhance both yield and physiological health. In this exploration of nutrient management's intricate realm, we unravel diverse interactions of soil and foliar applications on nutrients in shaping black gram crops' physiological responses. The research aims to unveil a specific ~~a~~ success in providing a holistic perspective of applying soil and foliar nutrients towards a sustainable and optimized cultivation practices for black gram.

Comment [A7]: Use more simple and clear words in scientific writing instead of their synonyms.

Comment [A8]: You attempted to address previous studies related to this topic. However, you did not indicate the research gap or the unknown elements that should be filled by the current study.

2. MATERIALS AND METHODS

2.1 Study area location

The study was conducted in the instructional farm of the School of Agricultural Sciences, Karunya Institute of Technology and Science, Coimbatore, during the *Rabi* season of 2022-2023. The geographical coordinates of the experimental site are approximately 10°56'N latitude and 76°44'E longitude, situated at an altitude of 474 meters above mean sea level. The choice of this location was made to represent the Northwestern Agroclimatic Zone of Tamil Nadu, providing a suitable environment for the cultivation of the selected crop. The monsoon season typically commences in late June and extends through September. Over the specified period, a total precipitation of 326.6 millimetres was recorded. The average high temperature stood at 31.12 degrees Celsius, with an average low of 23.56 degrees Celsius. The mean maximum relative humidity was 76.35%, while the minimum relative humidity averaged at 53.49%.

2.2 Experimental details

The research was conducted using a Randomized Block Design (RBD) to ensure the robustness of the experimental setup, and each treatment was replicated three times to enhance the reliability of the results. The chosen crop was ~~Black~~ black gram (Vamban 8). The experimental plots were designated with a gross size of 4m x 3m and a net size of 3.5m x 2.1m, adhering to a seed rate of 20 kg ha^{-1} and a spacing of 30cm x 10cm. The study focused on investigating the influence of various soil and foliar nutrient management approaches on black gram cultivation. The treatments employed in the field experiments were T_1 - Recommended Dose Fertilizer (RDF) @ 25:50:25 kg of N, P_2O_5, and K_2O ha^{-1} as a basal dose, T_2 - RDF + Foliar spray of 1% (5 kg ha^{-1} in 500 litres of water) TNAU Pulse wonder , T_3 - RDF + Foliar spray of 1% urea at 30 and 45 days after sowing (DAS), T_4 - RDF + Foliar spray of Nano urea@ 2 ml $litre^{-1}$ at 30 and 45 DAS, T_5 - RDF + Foliar spray of 2% DAP at 30 and 45 DAS with, T_6 - 75% RDF + Soil application of Rhizobium and Phosphobacteria @ 2 kg ha^{-1}, T_7 - 75% RDF + Soil application of Rhizobium and Phosphobacteria @ 2 kg ha^{-1} + Foliar spray of 1% TNAU Pulse wonder at 30 and 45 DAS, T_8 - 75 % RDF + Soil application of Rhizobium and Phosphobacteria @ 2 kg ha^{-1} + Foliar spray of 1% urea at 30 and 45 DAS, T_9 - 75 % RDF + Soil application of Rhizobium and Phosphobacteria @ 2 kg ha^{-1} + Foliar spray of Nano urea @ 2ml $litre^{-1}$ of water at 30 and 45 DAS T_{10} - 75 % RDF + Soil application of 2 kg each of Rhizobium culture and Phosphobacteria @ 2

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kg ha^{-1} + Foliar spray of 2% DAP @ 30 and 45 DAS. All the treatments received a uniform and meticulous management practices such as field preparation, weed management and irrigation. The selection of treatments aimed to explore the synergies of different nutrient combinations and their impact on black gram physiology and yield.

Comment [A10]: Please include the description of the different fertilizers used in this study. What is TNAU and its nutrient content, DAP, nano-Urea..... at least a short description of each inputs.

2.3 Statistical Analysis

Fisher's method of analysis of variance (ANOVA) was used to statistically analyse the experimental data acquired, according to Gomez & Gomez [16]. Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level.

3. RESULTS AND DISCUSSION

3.1 Optimizing the crop growth attributes of black gram through soil and foliar nutrient management practices

The data on plant growth parameters of black gram recorded at 20 DAS, 40 DAS, and 60 DAS are presented in Table 1. On 20 DAS among the various nutrient management practices studied, there was no significant difference in any of the growth parameters recorded, but there was a significant difference among the treatments were observed at 40 DAS and 60 DAS. The treatment, T_7 registered a superior growth parameter among all the treatments, with an increased plant height of 29.80 cm at 40 DAS, and 39.89 cm at 60 DAS, a higher mean leaf count of 8.67 at 40 DAS and 15.33 at 60 DAS and a greater dry matter production of 1210.46 kg ha^{-1} at 40 DAS and 2685.43 kg ha^{-1} at 60 DAS. This significant increase in plant height, number of leaves per plant and dry matter production under the treatment T_7, with 75% RDF, soil-applied rhizobium and Phosphobacteria, and foliar spray of TNAU pulse wonder, might be attributed to the enhanced synergistic effects influenced by the substantial contribution of micronutrient-rich TNAU pulse wonder in combination with the applied soil applied 75% RDF and the microbial culture in the form of biofertilizers. This combined effects of soil and foliar applied nutrients might have triggered the plant growth vigour through enhanced physiological processes and improved photosynthetic efficiencies of the crop. This conforms with the findings of Sachin *et al.* [17] and Balaji *et al.* [18].

3.2 Enhancing the yield attributes and yield of black gram through soil and foliar nutrient management practices

The data on yield attributes and yield of black gram are presented in Table 2. Among all the treatments, the treatment T_7, (75% RDF, soil applied Rhizobium and Phosphobacteria, and a foliar spray of TNAU pulse wonder at 30 and 45 DAS), registered a significantly higher pod count per plant (24.33), seeds per pod (9.33), test weight (4.98 g) and eventually the higher grain yield (1073.4 kg ha^{-1}) and stover yield (1612.03 kg ha^{-1}). The significant increase in the grain yield under the

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treatment T_7 could be attributed to the better nutrient availability for the crop during its growth stages and could have had an enhanced source-sink relationship leading to better grain filling and development. This would have eventually resulted in better yield attributes and finally impacted a higher grain and stover yield. This is in line with the findings of Kumaran *et al.* [4].

3.3 Evaluating the economic viability of soil and foliar nutrient management practices in black gram cultivation

The data on the economic viability of soil and foliar application of nutrients in black gram is presented below in Table 3. Among all the treatments, the treatment T7 (75% RDF, soil applied Rhizobium and Phosphobacteria, and a foliar spray of TNAU pulse wonder at 30 and 45 DAS), emerged as the most economically efficient practice, boasting a cost of cultivation at 30,240 INR, a gross return of 1,25,587.80 INR, net income of 95,347.80 INR, and a commendable B: C ratio of 4.15. The superior economic performance of this treatment can be attributed to their higher grain yield, coupled with a 25% reduction in inorganic fertilizer application, resulting in lower production costs. These outcomes substantiate the studies by Anil *et al.* [19] and Gayethri *et al.* [20], underscoring the pivotal role of strategic nutrient management in enhancing the economic sustainability of black gram cultivation.

4. Conclusion

Based on the results of the experiment it can be concluded that the soil and foliar application of nutrients in the form of 75% of recommended dose of fertilizer along with soil-applied Rhizobium and Phosphobacteria, and a foliar spray of TNAU pulse wonder at 30 and 45 DAS proves to be beneficial and advantageous in terms of, grain yield and returns per rupee invested, rather than going for the blanket application of recommended dose of fertilizer. On the other hand, reducing the application of recommended inorganic fertilizers by 25% serves as an environmentally sustainable nutrient management measure while also improving the yield of black gram. ~~On the other hand, reduced the application inorganic recommended dose of inorganic fertilizers by 25% do serves as an environmentally sustainable nutrient management measure in improving the yield of black gram.~~

Comment [A11]: It is a bite longer sentence; consider to split into two.

Comment [A12]: Possible suggestion for rewrite:

On the other hand, reducing the application of recommended inorganic fertilizers by 25% serves as an environmentally sustainable nutrient management measure while also improving the yield of black gram.

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Comment [A13]: Follow the journal guideline for the reference style and format.

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UNDER PEER REVIEW

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Table 1. Effect of nutrient management on growth parameter in black gram

Treatment	Plant Height (cm)			No of Leaves			Dry Matter Production		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1	16.5	20.1	26.5	3	5.33	7.03	269.74	607.4	1705.74
T_2	17.63	23.6	31.58	3	6.33	10	290.45	811.42	2045.86
T_3	16.82	23.1	31.02	3	6	9.33	280.44	792.44	2006.63
T_4	17.27	23.4	31.03	2.67	6	9.67	280.64	798.5	2019.67
T_5	17.49	23.5	31.3	2.67	6.33	9.67	285.46	815.74	2030.52
T_6	16.8	20.3	27.36	3	5	7.15	279.33	623.16	1712.66
T_7	18.48	29.8	39.89	3	8.67	15.33	299.33	1210.46	2685.43
T_8	17.59	26.5	35.25	2.67	7.3	12.33	295.26	987.1	2336.94
T_9	18.46	27	36.21	3	7.67	12.67	295.46	1040.5	2396.32
T_{10}	17.35	26.6	35.45	2.67	7.67	12.67	295.41	1025.28	2364.41
Mean	17.44	24.39	32.56	2.87	6.63	10.59	287.15	871.2	2130.42
SE(d)	0.62	1.29	1.73	0.86	0.43	1.03	25.82	80.24	137.71
CD (5%)	NS	2.71	3.63	NS	0.9	2.17	NS	168.58	289.31

**** T_1- RDF (25:50:25 kg of N, P_2O_5 & K_2O ha^{-1} applied as basal), T_2 - RDF + Foliar spray of 1% (5 kg ha^{-1} in 500 litres of water) TNAU Pulse wonder @ 5 kg ha^{-1} at 30 and 45 DAS, T_3 - RDF + Foliar spray of 1% urea at 30 and 45 DAS, T_4 - RDF + Foliar spray of Nano urea @ 2ml $litre^{-1}$ of water at 30and 45 DAS, T_5 - RDF + Foliar spray of 2% DAP @ 30 and 45 DAS, T_6 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria, T_7- 75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 1% TNAU Pulse wonder at 30and 45 DAS, T_8 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 1% urea at 30 and 45 DAS, T_9 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of Nano urea @ 2ml $litre^{-1}$ of water at 30 and 45 DAS, T_{10} -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 2% DAP @ 30 and 45 DAS.***

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Table 2. Effect of nutrient management on yield and yield attributes in black gram

Treatment	Pods per Plant	Seeds per Pod	100 Grain Weight (g)	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Harvest Index
T_1	11.33	6	3.31	524.56	1011.18	0.34
T_2	16	7.67	4.03	771.3	1242.96	0.38
T_3	15.33	7.33	3.84	658.96	1216.67	0.35
T_4	15.33	7.33	3.98	661.66	1228.01	0.35
T_5	15.67	7.67	4	677.56	1238.06	0.35
T_6	11.67	6.33	3.45	531.53	1041.13	0.34
T_7	24.33	9.33	4.98	1073.4	1612.03	0.4
T_8	19.67	8.33	4.44	897.9	1416.99	0.39
T_9	20.67	8.67	4.6	946.71	1456.61	0.39
T_{10}	20.33	8.33	4.52	927.42	1429.04	0.39
Mean	17.03	7.7	4.12	767.1	1289.27	-
SE(d)	1.72	0.22	0.17	60.25	73.16	-
CD (5%)	3.62	0.45	0.36	126.57	153.7	-

**** T_1- RDF (25:50:25 kg of N, P_2O_5 & K_2O ha^{-1} applied as basal), T_2 - RDF + Foliar spray of 1% (5 kg ha^{-1} in 500 litres of water) TNAU Pulse wonder @ 5 kg ha^{-1} at 30 and 45 DAS, T_3 - RDF + Foliar spray of 1% urea at 30 and 45 DAS, T_4 - RDF + Foliar spray of Nano urea @ 2ml litre^{-1} of water at 30and 45 DAS, T_5 - RDF + Foliar spray of 2% DAP @ 30 and 45 DAS, T_6 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria, T_7- 75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 1% TNAU Pulse wonder at 30and 45 DAS, T_8 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 1% urea at 30 and 45 DAS, T_9 -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of Nano urea @ 2ml litre^{-1} of water at 30 and 45 DAS, T_{10} -75 % RDF + Soil application of 2 kg each of Rhizobial culture and Phosphobacteria + Foliar spray of 2% DAP @ 30 and 45 DAS.***

Comment [A14]: Why don't you use LSD instead of CD? How can a reader know whether there is a significant difference between T1 and any other treatment without comparing their difference with CD?

The table should be standalone and must be clear to the reader. For instance, if you put a letter after each treatment for each parameter, the reader can easily identify the variation among treatments.

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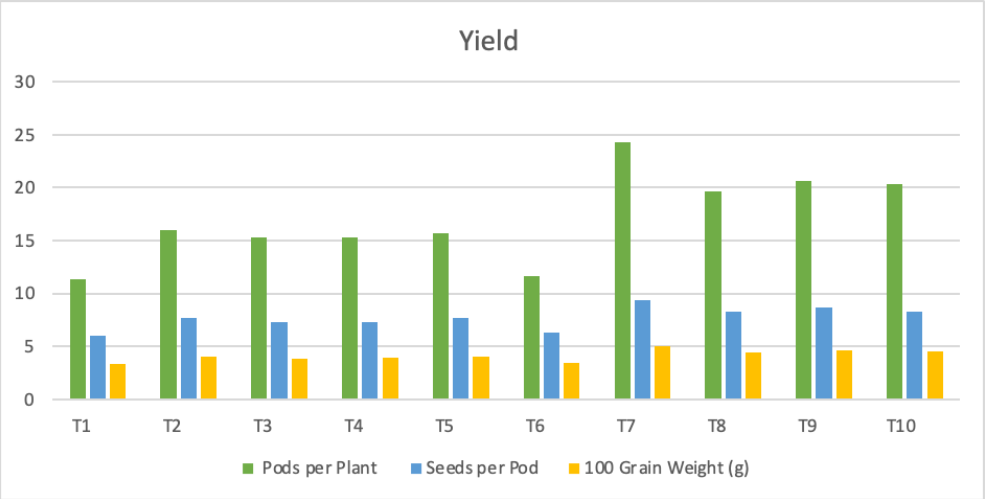

Fig 1. Effect of nutrient management on yield and yield attributes in black gram

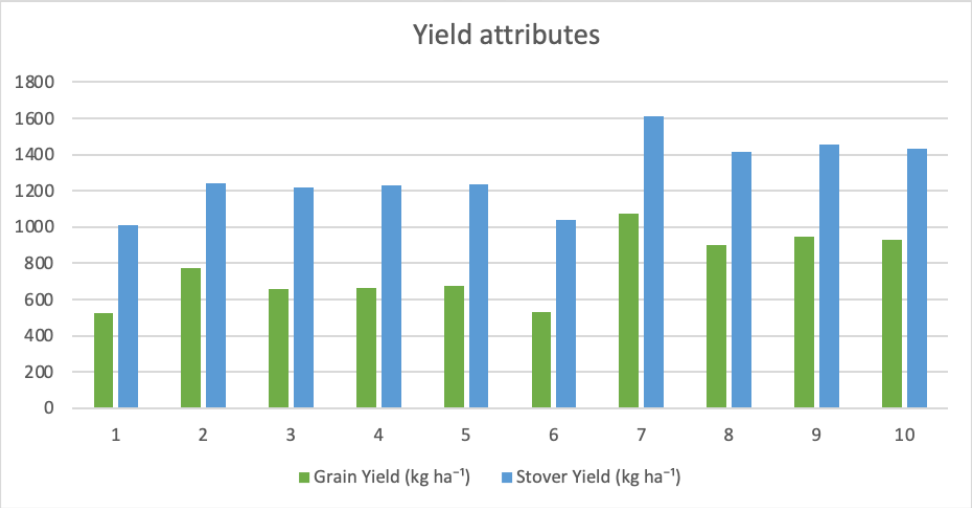

Fig 2. Effect of nutrient management on yield and yield attributes in black gram

Comment [A15]: You should put error bars on the graph so that readers can easily compare whether there is a statistical difference between treatments or not.

Instead of 1, 2 ,3... use T1, T2, T3.... On the X – axis.

Table 3. Effect of nutrient management on economic production of blackgram

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net income (₹ ha^{-1})	B:C ratio (₹ ha^{-1})
T_1	31767.00	61373.52	29606.52	1.93
T_2	31341.00	90242.10	58901.10	2.88
T_3	28170.00	77098.32	48928.32	2.74
T_4	28290.00	77414.22	49124.22	2.74
T_5	28200.00	79274.52	51074.52	2.81
T_6	31341.00	62189.01	30848.01	1.98
T_7	30240.00	125587.80	95347.80	4.15
T_8	29220.00	105054.30	75834.30	3.60
T_9	29430.00	110765.07	81335.07	3.76
T_{10}	29340.00	108508.14	79168.14	3.70

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