LR-5384
[1-7]

RESEARCH ARTICLE Legume Research- An International Journal

Influence of Nano Urea on Growth Yield and Nutrient Uptake of Blackgram

M.R. Nandhakumar[1], R. Muthukrishnan[1], P. Nivethadevi[1], K. Kiruthika[1], C. Tamilarasan[1]

10.18805/LR-5384

ABSTRACT

Background: There is no doubt that the enormous increase in global food production is a direct result of greater use of inorganic fertilizers. However, a number of research studies indicate that the rising use of conventional fertilizers has resulted in major environmental risks, including soil and water body contamination. Nanotechnology and nano-fertilizers have recently been used in agriculture to create healthier solutions. Therefore, there is a pressing need to improve the N availability for plants, while reducing its harmful effects to the soil and environment.

Methods: Keeping this point of view, the pot culture experiment was carried out to study the "Impact of nano-urea (Liquid) on blackgram (VBN 8) (*Vigna mungo* L.) Productivity" with an objective of study the influence of Nano-Urea on growth and yield attributes of Blackgram. The experiment was conducted at Vanavarayar Institute of Agriculture, Pollachi during the *Kharif* (June-September) season of 2022 and 2023. The treatment includes application of various level of nano urea (1.25 litres ha^{-1}) as foliar spray and soil application along with recommended dose of P and K in comparison with RDF and control (without any nutrient). The treatments were replicated three times in a completely randomized block design.

Result: Among the different treatment combination, application of nano-urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF (T_2) resulted in higher pod weight (4.1 and 6.2 g $plant^{-1}$) and seed weight (3.2 and 3.6 g $plant^{-1}$) in 2022 and 2023, respectively. Application of nano-urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) + PandK RDF responded equally with RDF + Urea 1% foliar spray on better growth and development of blackgram. At the critical juncture, adequate nitrogen from nano-urea would have ensured a steady supply of nitrogen, stimulating meristematic activity and cell elongation in plants and improving the crop performance.

Key words: Blackgram, Growth, Nano fertilizer, Nano-urea, Nutrient uptake, Yield.

INTRODUCTION

The use of modern agricultural inputs in the second half of the twentieth century has significantly increased agricultural production in the majority of countries. At the same time, agricultural output has been met with new hurdles. Nonetheless, the world has seen the emergence of innovative technology to solve production constraints and sustain agricultural production. In this context, nanotechnology has a growing role in crop production with strong promise to alter the existing state of fertilizer use with environmental safety, ecological sustainability and economic stability (Nandhakumar *et al.,* 2023). It reduces soil pollution as well as potential negative consequences when conventional mineral fertilizers are used (Velmurugan *et al.,* 2022). Nano fertilizers (NF) are more efficient and effective than conventional fertilizers because of their positive effects on the quality of food crops, reduce stresses that occur to the plant, small applied quantities and costs, fast absorption by plant cells and penetration of cells and fats of transport and representation within plant tissue (Hayyawi *et al.,* 2020).

Fertigation is one of the most effective ways to manage water and nutrients while also being more efficient for food production and soil fertility. It is an excellent approach for lowering the cost of fertilizer application. One of the most important benefits of this technology is the application of nutrients in proportion to the growth of the crop to meet nutritional needs with great accuracy and then achieve a high crop yield.

Foliar nutrition refers to the application of nutrients to the vegetative part at specific concentrations and times so that the plant can absorb them through the leaf's stomata or through the cell walls and membranes to participate in vital plant processes. This enhances the vegetative and

[1]Vanavarayar Institute of Agriculture (Affiliated to TNAU and Accredited by ICAR), Pollachi, Coimbatore-642 103, Tamil Nadu, India.

Corresponding Author: M.R. Nandhakumar, Vanavarayar Institute of Agriculture (Affiliated to TNAU and Accredited by ICAR), Pollachi, Coimbatore-642 103, Tamil Nadu, India.
Email: nandhuag20@gmail.com

How to cite this article: Nandhakumar, M.R., Muthukrishnan, R., Nivethadevi, P., Kiruthika, K. and Tamilarasan, C. (2024). Influence of Nano Urea on Growth Yield and Nutrient Uptake of Blackgram. Legume Research. 1-7. doi: 10.18805/LR-5384.

Submitted: 15-06-2024 **Accepted:** 27-11-2024 **Online**: 13-01-2025

qualitative aspects to prevent circumstances that restrict the availability of plant nutrients in the soil (Surender Kumar and Kuldeep, 2024).

Black gram (*Vigna mungo* L.) is a widely cultivated legume with significant culinary and nutritional value. In India, it is planted as a single crop, intercrop, or fallow crop in both rainfed and irrigated environments. Globally, India is the major producer and user of blackgram, accounting for 70% of total production. It accounts for roughly 19% of the total pulse acreage and 23% of overall pulse production in India (MoA, 2021). The total area under pulses in India is about 4.2 million hectares, with a yield of 2.34 million tonnes and a productivity of 557 kg ha^{-1} (DMI, 2021). In Tamil Nadu, blackgram is grown in 2.69 lakh hectares with a production of 4.07 lakh tonnes and an average productivity of 863 kg ha^{-1} (MoA, 2024).

This low yield is linked to numerous factors, including low yielding cultivars, cultivation in marginal soils, primarily as rainfed crops, poor management practices and low fertilizer usage efficiency by crops. As a result, boosting pulse output requires higher productivity and efficiency, which improves blackgram productivity and minimizes environmental problems. Nano urea (liquid) for agricultural usage delivers nutrients to plants more efficiently. At the same time, it is critical to understand its efficacy and advantages over traditional fertilizer materials. This is critical to reducing chemical fertilizer consumption and increasing nano urea without sacrificing crop production. Hence, the present study a pot culture experiments were conducted to investigate the effect of nano urea (liquid) on blackgram productivity.

MATERIALS AND METHODS

The pot culture experiment was conducted at north farm of Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi during the *Kharif* (June-September) season of 2022 and 2023. The soil of the experimental was well drained sandy clay loam in texture. The initial soil sample was analyzed for chemical properties nearly alkaline in soil reaction (pH 7.91), low in organic carbon (0.68%), available N (276 kg ha^{-1}; medium), available P (15 kg ha^{-1}; medium) and available K (290 kg ha^{-1}; high). Nutrient sources were urea, single super phosphate, muriate of potash and nano urea to fulfill the requirement of nitrogen, phosphorus and potassium. The experiment was laid out in completely randomized block design (CRBD) with eight treatments and replicated thrice. The treatment details are T_1 - Recommended Dose of Fertilizer (RDF) (25:50:25 kg ha^{-1}) (CPG, 2020), T_2 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P (Phosphorus) and K (Potassium) RDF, T_3 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Soil application (Basal Dose) + PandK RDF, T_4 - Nano-Urea (Liquid) 50% as basal + 50% as FS + P and K RDF, T_5 - RDF + Urea 1% FS, T_6 - RDF (50% N as Urea Basal Dose) + Urea 1 % (FS), T_7 - RDF (50% N as Urea Basal Dose) + Nano-Urea (Liquid) 50% (FS) and T_8 - Control (No NPK). The foliar spraying of Nano urea was applied once in 15 days.

The growth parameters were recorded at critical stages of blackgram. These parameters were statistically analyzed using analysis of variance (ANOVA) as applicable to completely randomized block design. The black gram (*Vigna mungo*) variety was VBN8. The variety VBN8 is derivative of VBN 3/VBN 04-008 with duration of 65-75 days and an average yield potential of 900 kg ha^{-1} under irrigated condition.

The pots with a size of 30 cm diameter and 30 cm height were used for the experiment. The number of pots taken up for the study was 24 numbers. The pots were filled with 1:2 ratio of vermicompost and soil at the time of sowing. In each pot, five seeds were sown. However, after the germination of seeds, two germinated seeds were maintained in each plot by thinning. Observations in each pot, were recorded from both of the germinated seeds.

RESULTS AND DISCUSSION

Plant height

There was a significant influence of the treatments on the height of black gram. Plants with maximum height (39.0 cm) were recorded statistically significant in RDF + Urea 1% FS (T_5) at 40 DAS whereas the shortest plant height (26.5 cm) was recorded in RDF - 50% N as Urea Basal Dose + Nano-Urea (Liquid) 50% (FS) + P and K RDF treatment (T_7) as compared to other treatments during 2022. The similar trend was observed during 2023 too.

However, at 60 DAS, the tallest plants were observed in RDF + Urea 1% FS (T_5) (42.1 cm) and shortest plants (31.6 cm) were observed in Control (No NPK) (T_8) (Table 1) Similar results were observed during 2023 also. The tallest plant was significantly recorded under the treatment of RDF + Urea 1% FS compared to others. Increase of growth attributes of black gram under the treatment of RDF + Urea 1% FS (T_5) could be attributed to improved nutrient availability throughout the crop growth phases, with chemical fertilizer supplying NPK at the crop's initial growth stages and later stages of nutrients. These results also corroborate the findings (Gaurav and Chaturvedi, 2023).

Number of branches $plant^{-1}$

All the treatments showed marked variation on number of branches during 2022 and 2023. At 40 and 60 DAS, maximum number of branches were recorded (26.7 and 37.7 numbers $plant^{-1}$) in treatment RDF + Urea 1% FS (T_5) that was at par with Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF (T2) and RDF - 50 % N as Urea Basal Dose + Urea 1 % (FS) + P and K RDF (T_6). The least number of branches per plant (13.7 and 21.7 numbers $plant^{-1}$) were noted in Control (No NPK) (T_8) (Fig 1). As a matter of thumb, as the number of leaves $plant^{-1}$ increases, so does the leaf area, may haves received observed increased photosynthesis from the source and sink, which results in the growth of additional branches. Application of Nitrogen as a basal dose results in more number of branches (Marimuthu *et al.,* 2024). A combina-

tion of soil application and foliar spray, matching the N requirement of crop in demand with time series and subsequent nano N spray probably sustained the N content, so helping to promote cell division, elongation and in turn the number of branches (Arun Kumar *et al.,* 2024). Alqader *et al.* (2020) also reported that the application of nano nutrients, particularly nitrogen, has a good influence on the branching development of pea and other pulse crops.

Number of pods plant^{-1}

Significant variation was noticed among the treatments during both the years of experimentation. Recommended Dose of Fertilizer + Urea 1% foliar spray (T_5) registered more number pods per plant (19.0) over others which was at par with T_2 (Nano-Urea (Liquid) 1.25 litres ha^{-1} as foliar spray (FS) (IFFCO) + PandK RDF). Persistently, lesser number of pods per plant (9.1) in 2022 was produced by

Table 1: Influence of various treatment on plant height (cm) of blackgram.

Treatments	*Kharif* 2022			*Kharif* 2023		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1	21.5	31.5	38.1	27.1	32.1	41.1
T_2	21.7	31.9	42.1	28.3	33.2	42.8
T_3	20.7	26.7	37.6	25.1	28.9	40.1
T_4	22.0	27.4	39.1	28.0	31.9	41.1
T_5	24.3	39.0	35.5	31.2	40.1	46.7
T_6	21.8	29.3	41.0	27.8	32.0	40.4
T_7	20.2	26.5	37.0	26.2	31.1	37.8
T_8	21.3	28.7	31.6	26.6	29.8	36.8
Mean	21.7	30.1	37.8	27.5	32.4	40.9
SEd	1.7	1.3	1.8	2.7	1.2	1.9
CD (P=0.05)	NS	2.9	3.1	NS	2.6	4.1

T_1 - Recommended dose of fertilizer (RDF) (25:50:25 kg/ha) (CPG).
T_2 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF.
T_3 - Nano-Urea (Liquid) litres ha^{-1} as Soil application (Basal Dose) + P and K RDF.
T_4 - Nano-Urea (Liquid) 50% as basal + 50 % as FS + P and K RDF.
T_5 - RDF + Urea 1% FS.
T_6 - RDF (50 % N as Urea Basal Dose) + Urea 1 % (FS).
T_7 - RDF (50 % N as Urea Basal Dose) + Nano-Urea (Liquid) 50 % (FS).
T_8 - Control (No NPK).

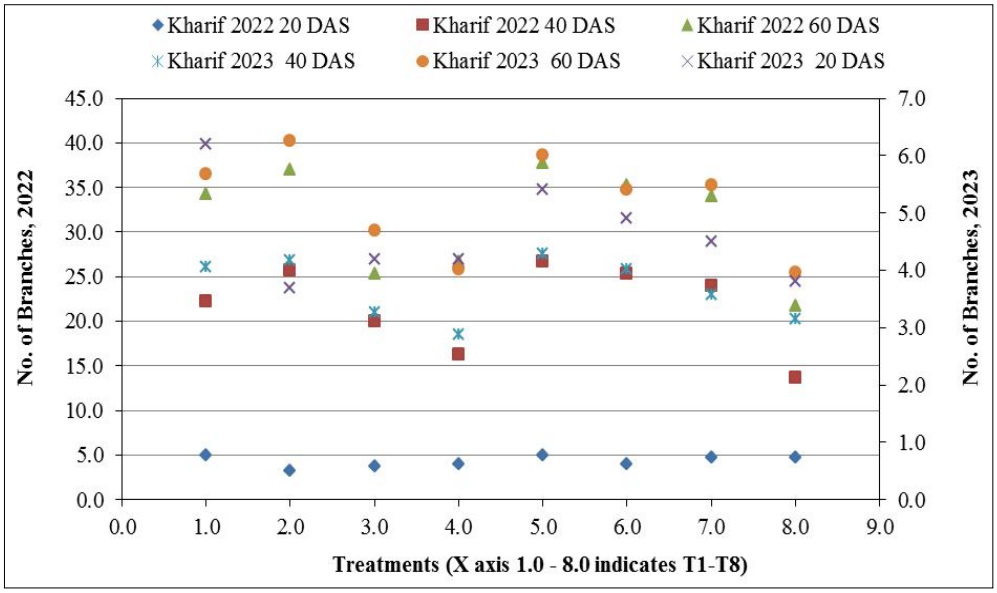

Fig 1: Impact of various treatment on number of branches of blackgram during *kharif* 2022 and 2023.

Control (No NPK) (T_8) (Table 2). Similar findings were recorded during 2023. The improved yield characteristics and overall productivity observed with this treatment can be attributed to increased growth parameters caused by a greater availability of vital plant nutrients (Marimuthu *et al.,* 2024). Nitrogen promotes vegetative growth, phosphorus stimulates root development and flowering, while potassium aids in a variety of physiological functions. When these vital nutrients are delivered in appropriate quantities, they promote development and increase production characteristics. Adequate availability of these nutrients is believed to contribute to enhanced carbohydrate buildup and efficient translocation from source to sink, particularly in reproductive organs. This method results in a significant rise in many yield-attributing characters. These results pertain in close agreement with numerous researchers like Sahu *et al.* (2021); Pareek *et al.* (2022) and Aniket *et al.* (2024). It is possible that sufficient nitrogen through nano urea at the crucial period, which would have maintained a constant supply of nitrogen, led to meristematic activity and promotion of cell elongation in plants, resulting in a greater number of pods per plant. These result findings were in close agreement with the findings of Rajesh *et al.* (2023).

Number of grains per pod

Statistically maximum number of grains per pod (6.2 and 6.8) were recorded in Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF (T_2) during 2022 and 2023 (Table 2). The least number of grains per pod (3.4 and 3.5) was observed with Control (No NPK) during 2022 and 2023, respectively. The same outcomes were observed in 2023 as well. The total number of grains per pod may be due to the foliar spray of nano urea, which leads to increased photosynthate assimilation and translocation of photosynthates from the source to the sink Algym *et al.* (2020); Hafize and Bati (2023) and Aniket *et al.* (2024). Islam *et al.* (2023) reported that, timely supply of nitrogen stimulates the initiation of grain formation, which contributes to the increase in grain count per pod.

Pod weight and seed weight

Discernible variations have been observed due to various treatment combinations during two years of field experiments. Among the different treatment combination, application of nano-urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF (T_2) resulted in higher pod weight and seed weight (4.5 and 3.2 g per plant) during 2022, respectively (Table 3). It was closely on par with RDF + Urea 1% FS (T_5) as compared to others. Lowest pod and seed weight (2.6 and 1.4 g per plant) were recorded in control pot (T_8) during the year of 2022, respectively.

During 2023, marked difference of pod weight and seed weight was manifested due to various treatments. Higher pod and seed weight (6.2 and 3.6 g per plant) was noted under nano-urea (Liquid) 1.25 litre ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF (T_2) than other treatments. It was on par with T_5 (RDF + Urea 1% FS). The lowest values for pod and grain weight (4.5 and 1.6 g per plant) was registered under T_8 [Control (No NPK] during 2023, respectively.

It was found to be enhanced by foliar applying fertilizer containing nano-urea. greater starch translocation from

Table 2: Influence of various treatments on yield attributes of blackgram.

Treatments	2022			2023		
	No. of Pods per plant	No. of grains per pod	100 seed wt. (g)	No. of Pods per plant	No. of grains per pod	100 seed wt. (g)
T_1	14.2	4.3	5.8	17.1	5.5	5.4
T_2	17.6	6.2	5.3	19.5	6.8	5.5
T_3	15.8	4.0	5.0	15.2	3.5	5.0
T_4	15.4	4.7	5.7	11.2	4.3	4.9
T_5	19.0	5.2	5.4	18.2	6.3	5.3
T_6	15.3	3.8	5.3	16.9	4.8	5.0
T_7	9.7	4.2	5.6	15.0	5.1	5.1
T_8	9.1	3.4	4.9	10.1	3.5	4.2
Mean	14.5	4.5	5.4	15.4	5.0	5.1
SEd	1.2	0.7	0.5	1.5	0.9	0.8
CD (P=0.05)	3.1	1.3	NS	2.9	1.7	NS

T_1 - Recommended dose of fertilizer (RDF) (25:50:25 kg/ha) (CPG).

T_2 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF.

T_3 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Soil application (Basal Dose) + P and K RDF.

T_4 - Nano-Urea (Liquid) 50% as basal + 50 % as FS + P and K RDF.

T_5 - RDF + Urea 1% FS.

T_6 - RDF (50 % N as Urea Basal Dose) + Urea 1 % (FS).

T_7 - RDF (50 % N as Urea Basal Dose) + Nano-Urea (Liquid) 50 % (FS).

T_8 - Control (No NPK).

the active site of leaves and straw to grain (sink), as well as increased nitrogen provided by nano-urea and a basal dose of potassium throughout the growth phases, could be the cause of this. Consequently, more photosynthetically active radiations are intercepted, increasing photosynthesis. The results were in conformity with the findings Islam *et al.* (2023).

The pod and seed weight per plant considerably increased under Recommended Dose of Fertilizer + Urea 1% FS, showing the function of balanced fertilization in increasing agricultural output. It could be attributed to phosphorus enhanced nodulation and efficient working of nodule bacteria for fixation of nitrogen to be used by plants during grain development stage in protein synthesis as

Table 3: Influence of various treatments on yield attributes of blackgram.

Treatments	2022			2023		
	Pod length (cm)	Pod weight (g/plant)	Seed weight (g/plant)	Pod length (cm)	Pod weight (g/plant)	Seed weight (g/plant)
T_1	4.0	3.6	2.3	3.5	4.8	2.6
T_2	4.2	4.1	3.2	5.0	6.2	3.6
T_3	3.8	3.0	2.1	4.1	4.6	2.0
T_4	3.7	3.3	1.9	3.8	4.0	2.3
T_5	4.1	4.5	3.4	4.6	5.8	3.5
T_6	4.0	3.6	2.4	3.8	5.5	2.5
T_7	3.7	3.5	2.1	4.0	4.6	2.2
T_8	3.7	2.6	1.4	3.1	3.9	1.6
Mean	3.9	3.5	2.4	4.0	4.9	2.5
SEd	1.1	0.25	0.3	1.0	0.6	0.3
CD (P=0.05)	NS	0.60	0.9	NS	1.5	0.9

T_1 - Recommended dose of fertilizer (RDF) (25:50:25 kg/ha) (CPG).

T_2 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + P and K RDF.

T_3 - Nano-Urea (Liquid) 1.25 litres ha^{-1} as Soil application (Basal Dose) + P and K RDF.

T_4 - Nano-Urea (Liquid) 50% as basal + 50% as FS + P and K RDF.

T_5 - RDF + Urea 1% FS.

T_6 - RDF (50 % N as Urea Basal Dose) + Urea 1 % (FS).

T_7 - RDF (50 % N as Urea Basal Dose) + Nano-Urea (Liquid) 50 % (FS).

T_8 - Control (No NPK).

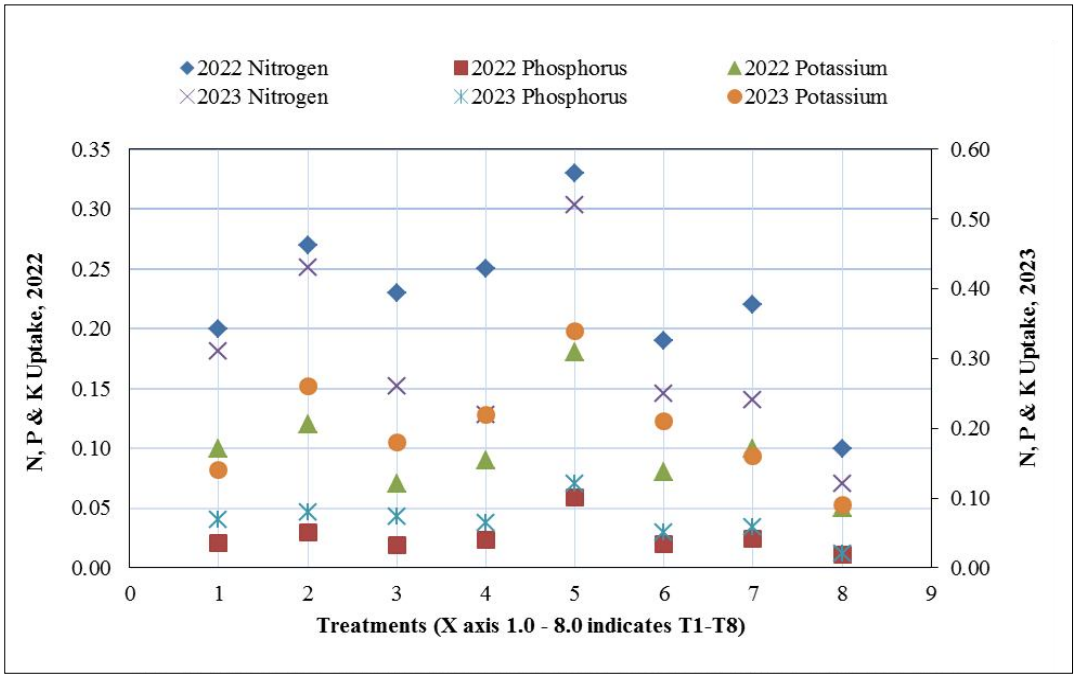

Fig 2: Influence of various treatment on nutrient uptake of blackgram (*kharif* 2022 and 2023).

shown in N uptake, which led to a rise in pod and seed weight (Satyanandam *et al.,* 2022). Furthermore, potassium may increase the feeding environment of the rhizosphere and the plant system, resulting in increased nutrient transfer in multiple plant sections, which may directly contribute to pod and seed weight. These findings agree with Kunwar and Victor, 2023.

Nutrient (NPK)

Recommended dose of fertilizer + Urea 1% foliar spray (T_5) recorded significantly more nitrogen, phosphorus and potassium uptake (0.33, 0.059 and 0.18 g per plant) at harvesting of crop, respectively followed by nano-urea (Liquid) 1.25 litres ha^{-1} as Foliar Spray (FS) (IFFCO) + PandK RDF (T_2) (25 × 20 cm) (Fig 2). Control (T_8) resulted in the least nitrogen, phosphorus and potassium uptake (0.10, 0.011 and 0.05 g per plant) at harvesting of the crop, respectively. Similar analyzed results were obtained during 2023 too. This may have attributed to the fact that a balanced utilization of multiple plant nutrient sources results in proper absorption, transport and digestion of those nutrients, ultimately enhancing plant drymatter accumulation and nutrient contents and therefore exhibiting greater uptake of elemental nutrients. Similar findings were reported by Shekhawat *et al.,* 2021.

CONCLUSION

The study confirmed that the foliar application of nano urea had significant effect on growth and yield parameters of blackgram. Accordingly, it can be concluded that, application of nano-urea (Liquid) 1.25 lit/ha as Foliar Spray (FS) (IFFCO) + PandK RDF responded equally, with the Recommended Dose of Fertilizer + Urea 1% foliar spray on growth and yield attributes of blackgram.

ACKNOWLEDGEMENT

The authors extend their appreciation to the Vanavarayar Institute of Agriculture, Pollachi for funding of this work.

Author contributions

The process of conceptualization collection of data K.K., C.T. and P.N. and methodology confirmation, M.R.N. and R.M.K., K.K., C.T. and P.N. formal analysis, M.R.N.; investigation, M.R.N. and R.M.K; resources, M.R.N; preparing an original draft, R.M.K and P.N.; Visualization and oversight., C.T and K.K; editing and corrections. All authors read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Algym. H., Salman M.A and Asady A.L. (2020). Effect of the method and level of adding npk nanoparticles and mineral fertilizers on the growth and yield of yellow corn and the content of mineral nutrient of some plant parts. Plant Archives. 20(1): 38-43.

Alqader, O.A., Jobouri., S.M and Eshoaa L.M. (2020). Effect of nitrogenous and urea nano -hydroxyapatite fertilizer on growth and yield of two cultivars of broad bean (*Vicia Faba* L.). Euphrates Journal of Agriculture Science. 12(2): 202-227.

Aniket, K., Swati, M., Arun, K., Dinesh, S, Narendra, S., Kumar, S.M. and Panwar, G.S. (2024). Response of Blackgram Varieties to Various NPK Doses in the Bundelkhand Region, India. International Journal of Plant and Soil Science. 36(3): 207-212.

Arun Kumar., M.R., Fathima, P.S., Yogananda, S.B. and Shekara, B.G. (2024). Influence of foliar application of nano urea and urea on productivity and nutrient status of fodder maize during *Kharif* season. Journal of Experimental Agriculture International. 46(5): 428-434.

CPG. Crop Production Guide. (2020). Published by Department of Agriculture, Govt. of Tamil Nadu, Chennai and Tamil Nadu Agric. Univ., Coimbatore. pp. 137.

Directorate of Marketing and Inspection, Ministry of Agriculture and Farmers Welfare. (2021). Government of India. Post-Harvest Profile of Blackgram. Retrieved from https://agmarknet.gov.in/Others/Blackgram.pdf.

Gaurav, M. and Chaturvedi, D.P. (2023). Performance of different graded dose of fertilizer on growth, yield and quality of black gram varieties (*Vigna mungo* L.). Journal of Experimental Agriculture International. 45(12): 76-82.

Hafize, Yıldırım, G. and Bati Ay, E. (2023). Effects of nanofertilizer applications at different growth stages of sweet corn (*Zea mays* var. saccharata) on biochemical stress factors. Legume Research- An International Journal. 46(10): 1332-1338. doi: 10.18805/LRF-766.

Hayyawi, W.A., Juthery, K.H., Habeeb, A.K., Fadil Jawad, K.A., Duraid, K.A. Taey, A.L., Abdel, Rahman, M. and Tawaha, A.L. (2020). Effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat. Bioscience Research. 15(4): 3988-3997.

Islam, M.Z.A., Alim, S.M.A., Hoque, M.M., Islam, M.M. and Adhikary, S. (2023). Effect of nano urea foliar spray on yield and yield attributes of black gram (*Vigna mungo* L.). Journal of Agroforestry and Environment. 16(1): 64-66.

Kunwar, K.S. and Victor, D. (2023). Effect of phosphorus and potassium on growth and yield of black gram (*Phaseolus mungo* L.). International Journal Environment and Climate Change. 13(10): 2756-2763.

Marimuthu, S., Navamaniraj, N.K., Kathiravan, K., Balasubramanian, P., Surendran, U., Hendawy, S. and Mattar, M.A. (2024). Response of blackgram (*Vigna mungo* L.) cultivars for nipping and graded levels of nitrogen for higher productivity under irrigated conditions. Agronomy. 14(7): 1474. https://doi.org/10.3390/agronomy14071474.

Ministry of Agriculture and Farmers Welfare, Government of India. (2021). First Advance Estimates of Production of Food grains for 2021-22. Retrieved from https://agricoop.nic.in

Ministry of Agriculture and Farmers Welfare, Government of Tamil Nadu. (2024). Department of Economics and Statistics, Government of Tamil Nadu, Final Estimate - 2021-2022. Retrieved from https://agritech.tnau.ac.in/pdf/agriepn 202324230406092519.pdf.

Nandhakumar. M.R., Muthukrishnan, R., Sureshkumar, P. and Nandini, S. (2023). Nano Fertilizer in Crop Production; The Changing Scenario. International Journal of Environment and climate change. 13(6): 158-170.

Pareek, A., Satyajeet, S., Bhardwaj, S. and Nagora, M. (2022). Effect of varieties and fertility levels on fodder productivity, NPK content, uptake and protein content of summer green gram (*Vigna radiata* L.). Forage Research. 47(4): 507- 512.

Rajesh, M.C., Rakesh, K., Rajesh, K., Meena, M., Hardev, R., Manoj, K., Vijendra, K., Govind, M., Dinesh, K. and Umer, B. (2023). Assessment of growth parameters in oats (*Avena sativa* L.) with application of nano urea fertilizer: A field-based study. International Journal of Environment and Climate Change. 13(3): 65-72.

Sahu, S., Shankar, T., Maitra, S., Adhikary, R., Mondal, T. and Duwada, S.K. (2021). Impact of phosphorus and sulphur on the growth and productivity of green gram (*Vigna radiata*). Research son Crops. 22(4): 785- 791.

Satyanandam, T., Babu, K., Yellamanda, B., Vijaya Kumar, K., Rosaiah, G. and Vijayalakshmi, M. (2022). Diversity of indigenous symbiotic nitrogen fixing bacteria from blackgram [*Vigna mungo* (L.) Hepper] cultivated in rice fallows. Legume Research-An International Journal. 45(8): 994-999. doi: 10.18805/LR-4334.

Shekhawat, A.S., Purohit, H.S., Dilip, S., Jitendra Kumar, S., Jitendra Bamboriya, S., Kiran, D. and Ramdas, M. (2021). The Pharma Innovation Journal. 10(9): 382-386.

Surender Kumar, S. and Kuldeep, S. (2024). Impact of foliar application of nutrients on yield and economics of cluster bean (*Cyamopsis tetragonoloba* L.) under dryland condition. Environment and Ecology. 42(2): 492-497.

Velmurugan, A., Subramani, T., Bommayasamy, N. and Manoj Kumar, C. (2022). The effect of foliar application of nano urea (Liquid) on rice (*Oryza sativa* L). Journal of Andaman Science Association. 26(2): 76-81.