



Productivity Enhancement in Blackgram (*Vigna mungo* L.) through Foliar Application of Potassium Salt of Active Phosphorus (PSAP)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani during December 2023 to March 2024, to assess the performance of blackgram in terms of yield. The field experiment was laid out in Factorial Randomized Complete Block Design (FRCBD) with 12 different treatment combinations and one control treatment, which were replicated thrice. The treatments comprised of two fertilizer sources (s_1 - nano-DAP, s_2 - PSAP), three concentrations (c_1 - 0.1%, c_2 - 0.2 % and c_3 - 0.4 %) and two nutrient levels (l_1 - 100% RDN and l_2 - 75% RDN) which were compared against a control (KAU POP). The treatment s_2 (PSAP) showed earliness in reaching days to 50 % flowering and highest in number of pods per plant, pod length, pod weight, number of seeds per pod, pod yield and seed yield compared to s_1 . Among concentrations 0.4 % (c_3) took lesser days to reach 50 % flowering and highest in number of pods per plant, pod length, pod weight, number of seeds per pod, pod yield and seed yield compared to c_1 . Whereas in nutrient levels 100 % RDN (l_1) recorded highest in seed yield compared to 75 % RDN (l_2) in blackgram.

Keywords: Blackgram; potassium salt of active phosphorus; nano-DAP; pod; seed yield.

1. INTRODUCTION

Pulses are regarded as a remarkable gift of nature due to their unique capacity for biological nitrogen fixation. They are known as enhancers of soil fertility because they help to mobilize insoluble soil nutrients and bring about qualitative improvements in soil properties. However, over the past four decades, the continuous increase in Indian population combined with stagnant pulse production compared to cereals, has led to a decreased availability of pulses. As a result, significant efforts have been made to increase pulse production in India (Shashikumar et al., 2013). Black gram (*Vigna mungo* L.) commonly known as 'Urad dal', is a highly prized leguminous pulse crop belongs to family Fabaceae. It is a preferred short-duration pulse crop due to its ability to thrive in all seasons. It can be cultivated as a sole crop (a farming system where a single crop is planted in a field at a time), intercrop (growing two or more crops in close proximity on the same land at the same time) or catch crop system (a fast-growing plant grown between cash crops to improve soil health, reduce nutrient loss, and compete with weeds), representing 13 per cent of the total pulse cultivation area and 10 per cent of the country's total pulse production (MoA and FW, 2021). Beyond its genetic makeup, major physiological challenges include inefficient assimilate partitioning, poor pod setting due to flower drop, and nutrient deficiencies during critical growth stages, along with various pests and diseases (Kumar et al., 2019). Furthermore, black gram is typically grown under rainfed conditions with sub-optimal management practices. Therefore, implementing proper agronomic practices is crucial to improve black

gram productivity. The major crop nutrients which are traditionally supplied through chemical fertilizers in soil are only partially absorbed by crop plants since they are subjected to many losses. Whereas, foliar application of nutrients using water soluble fertilizers has the advantages of quick and efficient utilization of nutrients, elimination of nutrient losses through leaching and fixation in soil. Hence, foliar feeding is more appropriate, efficient and economical compared to soil application (Balusamy and Meyyazhagan, 2000). Applying nutrients through foliar sprays facilitates the movement of nutrients from the leaves to all parts of the plant, aiding in the synchronization of flowering and pod setting. This method can also delay leaf senescence due to its higher absorption efficiency, thereby enhancing photosynthetic efficiency. Applying water-soluble fertilizers through foliar sprays positively impacts the growth, yield, and quality of crops (Babu et al., 2024; Dolgopolova and Eremenko, 2024). Potassium Salt of Active Phosphorus (PSAP) is a highly 180 % water-soluble fertilizer containing 40 per cent each of phosphorus and potassium that can be easily 100 % absorbed by plant roots and leaves, and increases plant productivity from 30 to 50 per cent (Bhatt et al., 2022). The outcome of this study would go as a recommendation to small and marginal farmers for enhancement of blackgram production.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The field experiment was conducted on a sandy clay loam soil at the Instructional Farm, College of Agriculture, Vellayani during December 2023

Table 1. Chemical properties of soil of the experimental site

| Sl. No | Parameter | Content | Rating | Method adopted |
|--------|---|---------|-------------------|---|
| 1 | Soil reaction (pH) | 5.72 | Moderately acidic | 1:2.5 soil solution ratio using pH meter (Jackson, 1973) |
| 2 | Electrical conductivity (dS m ⁻¹) | 0.21 | Normal | 1:2.5 soil solution ratio using conductivity bridge (Jackson, 1973) |
| 3 | Organic carbon (%) | 1.14 | Medium | Walkley and Black rapid titration method (Jackson, 1973) |
| 4 | Available N (kg ha ⁻¹) | 215.57 | Low | Alkaline permanganate method (Subbiah and Asija, 1956) |
| 5 | Available P (kg ha ⁻¹) | 29.14 | High | Bray colorimetric method (Jackson, 1973) |
| 6 | Available K (kg ha ⁻¹) | 223.18 | Medium | Ammonium acetate method (Jackson, 1973) |

to April 2024, the blackgram variety sumanjana was procured from Regional Agricultural Research Station, Pattambi, Palakkad, Kerala, India. The soil of the research plot was moderately acidic in reaction (5.72), medium in organic carbon (1.14%), low in available nitrogen (215.57 kg ha⁻¹), high in available phosphorus (29.14 kg ha⁻¹) and medium in available potassium status (223.18 kg ha⁻¹) (Table 1). The mean maximum temperature ranged between 32.16°C to 33.99°C and the mean minimum temperature ranged between 20.01°C to 25.53°C. A total rainfall of 136.3 mm was received during the experimental period.

2.2 Treatments, Design and Experimental Procedures

The experiment was laid out in factorial randomized block design with 13 different treatments [(2 x 3 x 2) + 1] and replicated thrice. The treatments comprised combinations of two fertilizer sources (s₁- nano-DAP, s₂- PSAP), three concentrations (c₁- 0.1 %, c₂- 0.2 % and c₃- 0.4 %) and two nutrient levels (l₁- 100 % RDN and l₂- 75 % RDN) which were compared against a control (KAU POP). The nutrient source used for foliar application were Nano Di Ammonium Phosphate (nano-DAP) with 8 per cent N and 16 per cent P₂O₅ and Potassium Salt of Active Phosphorus (PSAP) with 40 percent each of P and K. Nano-DAP is a nanotechnology-based product developed by the Indian Farmers Fertilizer Co-operative Ltd (IFFCO). Potassium Salt of Active Phosphorus was developed by Isha Agro Sciences Pvt. Ltd. Foliar application of nano-DAP and PSAP of different concentrations has done at 30, 45 and 60 day after sowing. The spacing followed for blackgram was 25 cm x 15 cm and nutrient recommended followed was 20:30:30 kg NPK ha⁻¹ as per Kerala Agricultural

University Package of Practices (KAU POP) recommendations. All others cultural practices were carried out as per KAU POP. The yield attributes and yield of blackgram were recorded by following standard procedures. The field experiment data were analyzed statistically using the analysis of variance (ANOVA) technique, suitable for a factorial randomized block design (Panse & Sukhatme, 1985). Statistical analyses were conducted using the General R-based Analysis Platform Empowered by Statistics (GRAPES 1.0.0) software, developed by Gopinath et al. (2021).

2.3 Chemical Properties of Soil of the Experimental Site

The experimental site soil was black soil with clay loam in texture and soil fertility status details has given in below Table 1.

3. RESULTS AND DISCUSSION

3.1 Days to 50 % Flowering

Application of PSAP (s₂) and 0.4 % concentrations (c₃) showed earliness in flowering to reach days to 50 % flowering (36.80 and 35.00 days) of blackgram are presented in Table 2. Overall, the treatments took less time than the control (KAU POP) to reach 50 % flowering stage. This due to combined application of phosphorus and potassium fertilizers results in a synergistic effect, promoting early flowering in blackgram by supporting both rapid growth and sustained plant vigor. Similarly the same results were found with Kumar et al. (2021). Whereas, phosphorus is essential for triggering flower initiation and plays a significant role in grain filling and seed development (Ndakidemi and Dakora, 2007). Furthermore, Potassium is vital for the

processes of flowering, pod formation and seed setting in legume crops (Zahran et al., 1998).

3.2 Number of Pods Per Plant

Fertilizer source (s_2) PSAP and 0.4 % concentrations (c_3) resulted in highest number of pods per plant of blackgram (45.65 and 48.14, respectively). However, these treatments were significantly increased by 61.15 per cent compared to the control (KAU POP) with respect to number of pods per plant are presented in Table 2. Application of PSAP through foliar method provides both phosphorus and potassium nutrients, which were rapidly absorbed by the leaves and quickly translocated in plant and enables stomatal opening, boosts metabolism and in turn enhances yield traits in soybean given by Kumari et al. (2023).

3.3 Pod Length

In fertilizer sources and concentrations, the pod length of black gram was found to be significantly greater (4.94 cm) and (5.13 cm) with application of PSAP (s_2) and 0.4 concentrations (c_3), respectively are presented in Table 2. The treatments were significantly increased on an average by 28.40 per cent compared to control (KAU POP) with respect to pod length of black gram. This might be due to phosphorus provides the energy needed for pod elongation, while potassium improves nutrient transport and cell expansion. The combined application of these nutrients often results in greater pod length. Similar results were found with Yadav et al. (2017) yield traits viz., number of pods per plant, pod length, pod weight and number of seeds per pod were significantly increased with the combined application of phosphorus and potassium fertilizers.

3.4 Pod Weight

Pod weight was significantly affected with different fertilizer sources and concentrations with the highest pod weight of 20.19 and 21.45 g was recorded with the application of PSAP (s_2) and 0.4 % concentrations (c_3), respectively. Compared to control (KAU POP), treatments were observed to be increased on an average by 57.88 per cent in enhancing number of seeds per pod of black gram are presented in Table 2. This might be due to phosphorus is essential for energy transfer (ATP) and efficient nutrient uptake, supporting pod formation and filling stages, it also stimulates root growth, which aids

in the effective absorption of other nutrients and potassium encourages cell division and expansion, directly contributing to pod length and weight through the application of phosphorus and potassium in the form of PSAP. Similarly, Kumari et al. (2023) noted an increase in the number of pods per plant, pod length and pod weight with the application of PSAP combined with RDF in soyabean.

3.5 Number of Seeds Per Pod

Application of fertilizer sources and concentrations had significant impact on increasing the number of seeds per pod. The highest number of seeds per pod (8.01) and (8.19) was recorded in the treatment which received by the application of PSAP (s_2) and 0.4 % (c_3), respectively. The treatments were significantly increased on an average by 21.16 per cent compared to control (KAU POP) with respect to number of seeds per pod of black gram are presented in Table 3. This could be attributed due to enhancing vegetative growth and reproductive characteristics when phosphorus was adequately available to plants. Additionally, potassium contributes to the formation of robust cell walls, which collectively improves the number of pods and seeds per pod so that combined application of phosphorus and potassium in the form of PSAP increased in the number of seeds per pod. Similar findings were also noted by Singh et al. (2018) and Sahithi et al. (2023).

3.6 Pod Yield

Pod yield was found to be significantly influenced by fertilizer sources and concentrations. Application of PSAP (s_2) and 0.4 % (c_3) recorded significantly higher pod yield (1856 and 1996 kg ha⁻¹, respectively) than s_1 and c_1 . The comparison made between treatments and control proved to be significant and the treatments increased on an average by 44.07 per cent over the control (KAU POP) with respect to the pod yield of black gram are presented in Table 3. This might be due to synergistic effects of potassium and phosphorus on nutrient availability, enhances physiological processes and stress tolerance. Both potassium and phosphorus are crucial in pulse growth particularly during flowering, pod formation and seed filling stages, which are essential for maximizing pod yield. Yadav et al. (2017) reported a significant increase in pod yield and seed yield of black gram with the combined application of phosphorus and potassium.

Table 2. Effect of sources, concentrations and nutrient levels on days to 50 % flowering, number of pods per plant, pod length and pod weight of blackgram

| Treatment | Days to 50 % flowering | Number of pods per plant (nos) | Pod length (cm) | Pod weight (g) |
|---|------------------------|--------------------------------|-----------------|----------------|
| Sources (S) | | | | |
| s ₁ : Nano-DAP | 39.28 | 40.98 | 4.64 | 18.14 |
| s ₂ : PSAP | 36.80 | 45.65 | 4.94 | 20.19 |
| SEm (±) | 0.58 | 0.66 | 0.07 | 0.29 |
| CD (0.05) | 1.714 | 1.944 | 0.214 | 0.874 |
| Concentrations (C) | | | | |
| c ₁ : 0.1 % | 40.35 | 39.67 | 4.55 | 17.36 |
| c ₂ : 0.2 % | 38.78 | 42.14 | 4.68 | 18.69 |
| c ₃ : 0.4 % | 35.00 | 48.14 | 5.13 | 21.45 |
| SEm (±) | 0.71 | 0.81 | 0.09 | 0.36 |
| CD (0.05) | 2.099 | 2.381 | 0.263 | 1.071 |
| Nutrient Levels (L) | | | | |
| l ₁ : 100 % | 38.35 | 44.06 | 4.87 | 4.93 |
| l ₂ : 75 % | 37.35 | 42.57 | 4.71 | 4.83 |
| SEm (±) | 0.58 | 0.66 | 0.07 | 0.04 |
| CD (0.05) | NS | NS | NS | NS |
| S x C x L | | | | |
| s ₁ c ₁ l ₁ - nano-DAP @ 0.1 % + 100 % RDN | 42.90 | 36.84 | 4.43 | 16.54 |
| s ₁ c ₁ l ₂ - nano-DAP @ 0.1 % + 75 % RDN | 40.40 | 39.40 | 4.52 | 17.02 |
| s ₁ c ₂ l ₁ - nano-DAP @ 0.2 % + 100 % RDN | 38.90 | 39.98 | 4.63 | 17.72 |
| s ₁ c ₂ l ₂ - nano-DAP @ 0.2 % + 75 % RDN | 41.60 | 38.67 | 4.49 | 16.98 |
| s ₁ c ₃ l ₁ - nano-DAP @ 0.4 % + 100 % RDN | 35.70 | 46.78 | 5.03 | 20.65 |
| s ₁ c ₃ l ₂ - nano-DAP @ 0.4 % + 100 % RDN | 36.20 | 44.19 | 4.75 | 19.94 |
| s ₂ c ₁ l ₁ - PSAP @ 0.1 % + 100 % RDN | 38.50 | 42.56 | 4.68 | 18.43 |
| s ₂ c ₁ l ₂ - PSAP @ 0.1 % + 75 % RDN | 39.60 | 39.87 | 4.57 | 17.43 |
| s ₂ c ₂ l ₁ - PSAP @ 0.2 % + 100 % RDN | 36.90 | 46.12 | 4.89 | 20.43 |
| s ₂ c ₂ l ₂ - PSAP @ 0.2 % + 75 % RDN | 37.70 | 43.78 | 4.72 | 19.63 |
| s ₂ c ₃ l ₁ - PSAP @ 0.4 % + 100 % RDN | 33.50 | 52.10 | 5.56 | 22.83 |
| s ₂ c ₃ l ₂ - PSAP @ 0.4 % + 100 % RDN | 34.60 | 49.48 | 5.19 | 22.36 |
| SEm (±) | 1.43 | 1.62 | 0.17 | 0.73 |
| CD (0.05) | NS | NS | NS | NS |
| Control (KAU POP) | 45.2 | 32.33 | 4.33 | 14.46 |
| Treatment vs Control | S | S | S | S |

NS - Non significant; S - Significant

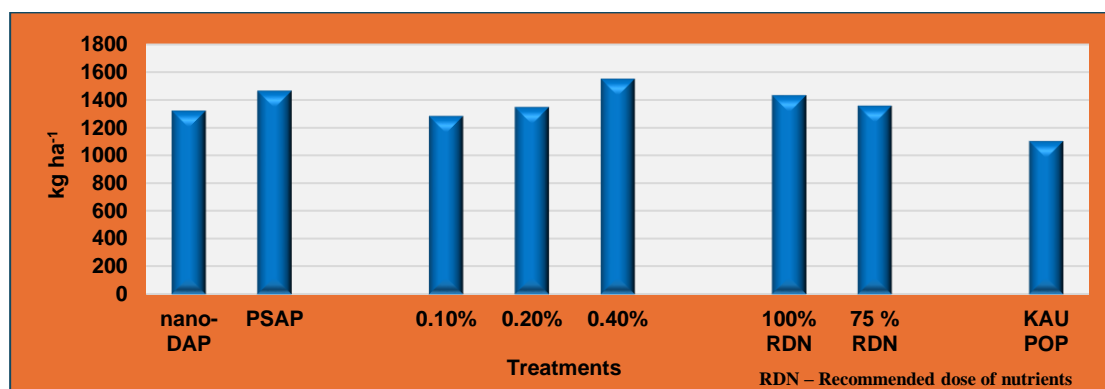


Fig. 1. Effect of sources, concentrations and nutrient levels on seed yield (kg ha⁻¹) of blackgram

Table 3. Effect of sources, concentrations and nutrient levels on number of seeds per pod, pod yield and seed yield of blackgram

| Treatment | Number of seeds per pod | Pod yield (kg ha ⁻¹) | Seed yield (kg ha ⁻¹) |
|---|-------------------------|----------------------------------|-----------------------------------|
| Sources (S) | | | |
| s ₁ : Nano-DAP | 7.55 | 1678 | 1322 |
| s ₂ : PSAP | 8.01 | 1856 | 1464 |
| SEm (±) | 0.07 | 27.17 | 21.30 |
| CD (0.05) | 0.211 | 79.697 | 62.494 |
| Concentrations (C) | | | |
| c ₁ : 0.1 % | 7.49 | 1608 | 1282 |
| c ₂ : 0.2 % | 7.65 | 1697 | 1346 |
| c ₃ : 0.4 % | 8.19 | 1996 | 1550 |
| SEm (±) | 0.08 | 33.28 | 26.09 |
| CD (0.05) | 0.258 | 97.608 | 76.540 |
| Nutrient Levels (L) | | | |
| l ₁ : 100 % | 7.80 | 1805 | 1431 |
| l ₂ : 75 % | 7.76 | 1729 | 1355 |
| SEm (±) | 0.07 | 27.17 | 21.30 |
| CD (0.05) | NS | NS | 62.494 |
| S x C x L | | | |
| s ₁ c ₁ l ₁ - nano-DAP @ 0.1 % + 100 % RDN | 7.16 | 1518 | 1207 |
| s ₁ c ₁ l ₂ - nano-DAP @ 0.1 % + 75 % RDN | 7.48 | 1589 | 1256 |
| s ₁ c ₂ l ₁ - nano-DAP @ 0.2 % + 100 % RDN | 7.51 | 1675 | 1334 |
| s ₁ c ₂ l ₂ - nano-DAP @ 0.2 % + 75 % RDN | 7.37 | 1530 | 1195 |
| s ₁ c ₃ l ₁ - nano-DAP @ 0.4 % + 100 % RDN | 7.94 | 1970 | 1550 |
| s ₁ c ₃ l ₂ - nano-DAP @ 0.4 % + 100 % RDN | 7.84 | 1786 | 1390 |
| s ₂ c ₁ l ₁ - PSAP @ 0.1 % + 100 % RDN | 7.70 | 1690 | 1367 |
| s ₂ c ₁ l ₂ - PSAP @ 0.1 % + 75 % RDN | 7.62 | 1635 | 1299 |
| s ₂ c ₂ l ₁ - PSAP @ 0.2 % + 100 % RDN | 7.91 | 1840 | 1480 |
| s ₂ c ₂ l ₂ - PSAP @ 0.2 % + 75 % RDN | 7.80 | 1743 | 1376 |
| s ₂ c ₃ l ₁ - PSAP @ 0.4 % + 100 % RDN | 8.53 | 2138 | 1648 |
| s ₂ c ₃ l ₂ - PSAP @ 0.4 % + 100 % RDN | 8.46 | 2091 | 1611 |
| SEm (±) | 0.17 | 66.56 | 52.19 |
| CD (0.05) | NS | NS | NS |
| Control (KAU POP) | 7.04 | 1484 | 1102 |
| Treatment vs Control | S | S | S |

NS - Non significant; S - Significant

3.7 Seed Yield

Fertilizer sources and concentrations had significant effect on the seed yield of black gram. Application of PSAP (s₂) and 0.4 % (c₃) was observed to significantly increment in seed yield (1464 and 1550 kg ha⁻¹, respectively). Compared to control (KAU POP), treatments were increased by on an average 49.54 per cent in enhancing seed yield of blackgram are presented in Table 3 and Fig. 1. The increased yield could be attributed to improved yield attributes such as the number of pods per plant, pod weight and the number of seeds per pod which resulted from enhanced source to reproductive area efficiency in the crop. The early initiation of flowering, fruit

and seed setting could be attributed to sufficient phosphorus. The increased pod and seed yield may result from enhanced plant metabolic activities due to potassium application (Gadi et al., 2018). Dixit et al. (2019) reported a significantly higher soybean seed yield with the foliar application of PSAP. Kumari et al. (2023) reported that the highest soybean yield was achieved when RDF was supplemented with a foliar application of PSAP (0.4%) combined with plant protection measures.

4. CONCLUSION

The present study concluded that application of 100 per cent RDN (20:30: 30 kg NPK ha⁻¹) with

additional supplemented of PSAP through foliar application at the rate of 0.4 % at vegetative, flowering and pod filling stages in blackgram enhances the pod and seed yield by 40.90 and 46.18 per cent, respectively.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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