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

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 and 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, intercrop or catch crop, 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 suboptimal 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 (Patel and Patel, 1994). 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. MATERIAL 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 to April 2024, the blackgram variety sumanjana. 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 ^{o}C to 33.99 ^{o}C and the mean minimum temperature ranged between 20.01 ^{o}C to 25.53 ^{o}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 (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 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.

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)

3. RESULTS AND DISCUSSION

3.1 Days to 50 % flowering

Application of PSAP (s_2) and 0.4 % concentrations (c_3) 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. 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). 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. These observations are conformity by (Kumar *et al*., 2021).

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, treatments were significantly increased by 61.15 % compared to the control (KAU POP) with respect to number of pods per plant are presented in Table 2. The foliar application of PSAP provides both phosphorus and potassium nutrients, which are rapidly absorbed by the leaves and quickly translocated. This process regulates stomatal opening, boosts metabolism and enhances yield traits in soybean (Kumari *et al*., 2023).

3.3 Pod length

Among the 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 by 28.40 % compared to control (KAU POP) with respect to pod length of black gram. Yield traits, including the 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 (Yadav *et al*., 2017). 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.

3.4 Pod weight

Pod weight was significantly affected with different fertilizer sources and concentrations with the highest pod weight of 20.19 g and 21.45 g was recorded with the application of PSAP (s_2) and 0.4 % concentrations (c_3). Compared to control (KAU POP), treatments were observed to be increased by 57.88 % in enhancing number of seeds per pod of black gram are presented in Tables 2. This might be due to phosphorus is essential for energy transfer (ATP) and efficient nutrient uptake, supporting pod formation and filling stages. It 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. Such that application of phosphorus and potassium in the form of PSAP increased in pod weight. 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). The treatments were significantly increased by 21.16 % 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 to phosphorus enhancing vegetative growth and reproductive characteristics when adequately available. Additionally, potassium contributes to the formation of robust cell walls, which collectively improves the number of pods and seeds per pod so that 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 considerably 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}) than s_1 and c_1. The comparison made between treatments and control proved to be significant and the treatments increased by 44.07 % 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, 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.

3.6 Seed Yield

Fertilizer sources and concentrations had significant effect on the seed yield of black gram. Application of PSAP (s_2) and 0.4 % (c_3) was observed to significantly enhance seed yield (1464 and 1550 kg ha^{-1}). Compared to control (KAU POP), treatments were increased by 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 study concluded that application of 100 per cent RDN (20:30: 30 kg NPK ha^{-1}) supplemented with foliar application of PSAP at the rate of 0.4 % at vegetative, flowering and pod filling stages in blackgram resulted in higher production and productivity.

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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				
$s_1c_1l_1$ - nano-DAP @ 0.1 % + 100 % RDN	42.90	36.84	4.43	16.54
$s_1c_1l_2$ - nano-DAP @ 0.1 % + 75 % RDN	40.40	39.40	4.52	17.02
$s_1c_2l_1$ - nano-DAP @ 0.2 % + 100 % RDN	38.90	39.98	4.63	17.72
$s_1c_2l_2$ - nano-DAP @ 0.2 % + 75 % RDN	41.60	38.67	4.49	16.98
$s_1c_3l_1$ - nano-DAP @ 0.4 % + 100 % RDN	35.70	46.78	5.03	20.65
$s_1c_3l_2$ - nano-DAP @ 0.4 % + 100 % RDN	36.20	44.19	4.75	19.94
$s_2c_1l_1$ - PSAP @ 0.1 % + 100 % RDN	38.50	42.56	4.68	18.43
$s_2c_1l_2$ - PSAP @ 0.1 % + 75 % RDN	39.60	39.87	4.57	17.43
$s_2c_2l_1$ - PSAP @ 0.2 % + 100 % RDN	36.90	46.12	4.89	20.43
$s_2c_2l_2$ - PSAP @ 0.2 % + 75 % RDN	37.70	43.78	4.72	19.63
$s_2c_3l_1$ - PSAP @ 0.4 % + 100 % RDN	33.50	52.10	5.56	22.83
$s_2c_3l_2$ - 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

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			
$s_1c_1l_1$ - nano-DAP @ 0.1 % + 100 % RDN	7.16	1518	1207
$s_1c_1l_2$ - nano-DAP @ 0.1 % + 75 % RDN	7.48	1589	1256
$s_1c_2l_1$ - nano-DAP @ 0.2 % + 100 % RDN	7.51	1675	1334
$s_1c_2l_2$ - nano-DAP @ 0.2 % + 75 % RDN	7.37	1530	1195
$s_1c_3l_1$ - nano-DAP @ 0.4 % + 100 % RDN	7.94	1970	1550
$s_1c_3l_2$ - nano-DAP @ 0.4 % + 100 % RDN	7.84	1786	1390
$s_2c_1l_1$ - PSAP @ 0.1 % + 100 % RDN	7.70	1690	1367
$s_2c_1l_2$ - PSAP @ 0.1 % + 75 % RDN	7.62	1635	1299
$s_2c_2l_1$ - PSAP @ 0.2 % + 100 % RDN	7.91	1840	1480
$s_2c_2l_2$ - PSAP @ 0.2 % + 75 % RDN	7.80	1743	1376
$s_2c_3l_1$ - PSAP @ 0.4 % + 100 % RDN	8.53	2138	1648
$s_2c_3l_2$ - 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

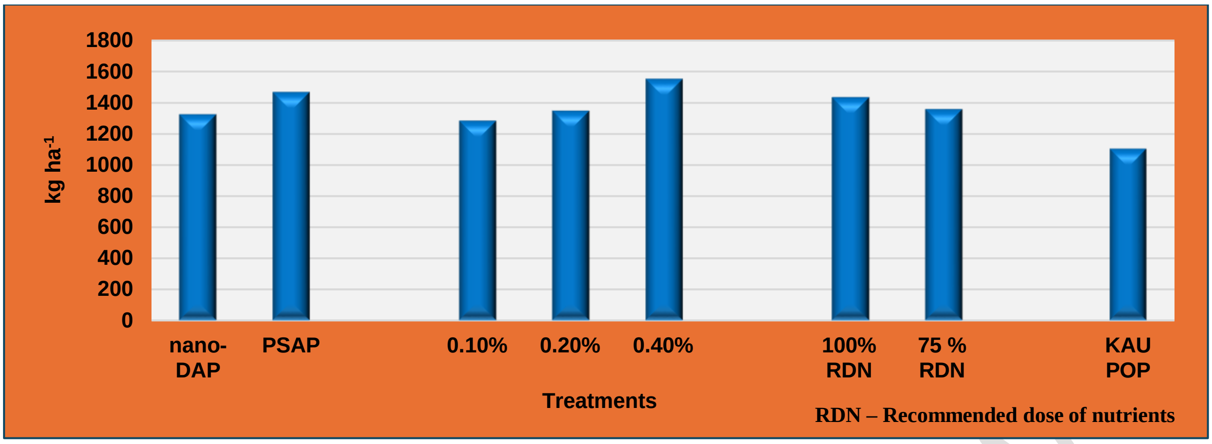

Fig. 1: Effect of sources, concentrations and nutrient levels on seed yield (kg ha^{-1}) of blackgram