Original Research article

Performance of blackgram as influenced by water soluble fertilizers and PGPR under rainfed situation

Abstract

Lower production potential of blackgram grown under rainfed situation due to lack of proper nutrition during critical crop growth stages. So, investigation was carried out with an objective to study the effect of water-soluble fertilizers and PGPR on performance of blackgram during *Kharif*-2019, a field study was carried out at University of Agricultural and Horticultural Sciences, Shivamogga which comes under Southern Transition Zone of Karnataka. Experimental design was laid out in randomized complete block design with thirteen treatments and replicated thrice. Treatments include combination of 19:19:19, monopotassium phosphate @ different dosage foliar spray with and without PGPR treatment along with package of practices. Water soluble fertilizers *viz.*, 19:19:19 (N: P: K) and mono potassium phosphate (0:52:34) were used in treatment combinations along with PGPR. TheResults revealed that, foliar application of 19:19:19 and mono potassium phosphate @ 1 per cent each at 30 and 45 days after sowing + PGPR along with a package of practice recorded significantly higher plant height, number of branches per plant, leaf and stem dry weight, crude protein (26.54 %), seed yield (1167 kg ha^{-1}) and haulm yield (2019 kg ha^{-1}) over package of practice treatment and also positive correlation was found between growth and yield parameters with seed yield and haulm yield.

Key words: Blackgram, Foliar nutrition, PGPR, Pulses, Water soluble fertilizers

1. Introduction

Agriculture is crucial for addressing the growing global food demand, and optimizing crop yield is essential for ensuring food security. Blackgram (*Vigna mungo* L. Hepper), commonly known as urad dal, is a vital leguminous pulse crop that is widely cultivated in various regions. It plays a significant role in providing protein, accounting for 24% of its content, and offers a calorific value of 347 Kcal per 100 grams. This grain legume is particularly important for food and nutritional security (Anon. 2019). In India, blackgram represents approximately 13% of the total pulse cultivation area and 10% of the total pulse production. It is grown over an area of about 4.6 million hectares, yielding a production of 3.56 million tonnes with a productivity rate of 654 kg per hectare. In Karnataka, blackgram is cultivated on approximately 138,000 hectares, producing around 47,000 tonnes (Anon. 2018).

Blackgram isanimportant source of protein, especially for poorpeople and contribute to nutritional security. However, it is predominantly cultivated by small and marginal farmers under degraded soils and resource-constrained conditions. Many farmers are hesitant to apply a basal dose of fertilizer or less than the recommendation to pulse crops, leading to poor yields (Thakur *et al*., 2017). However, soil application of nutrients as a basal dose often fails to meet the demands of growing crops, especially for short-duration crops like blackgram. Given its indeterminate flowering and fruiting habit, there is continuous competition for available assimilates between vegetative and reproductive sinks throughout the growth period.In this context, foliar application of water-soluble fertilizers presents a promising option to enhance the yield of blackgram while reducing cultivation costs (Das and Jena, 2015). Supplying legume plants with supplementary nitrogen or a balanced dose of nutrients, especially during the pre-flowering stage, has been found to positively impact seed yield. (Das and Jena, 2015). However, there are no regional guidelines for foliar nutrition of water-soluble fertilizers during the crop growth period. Apart from this, flower and fruit drop are the significant factors contributing to low yielddue to poor flower-to-pod ratio and inadequate pod setting.To boost crop productivity, modern agriculture has increasingly adopted water-soluble fertilizers, which plants can easily absorb and allow precise nutrient delivery. These fertilizers are particularly beneficial in correcting nutrient deficiencies and supporting robust plant growth during critical stages such as flowering and pod filling. The sustainable cultivation of blackgram depends on various factors, including soil fertility and effective nutrient management practices (Thriveni *et al*., 2023). Plant Growth-Promoting Rhizobacteria (PGPR) comprise a group of beneficial microbes that support soil biological activity and enhance nutrient availability in the rhizosphere. Additionally, PGPR aids in stress tolerance through the release of plant hormones. Understanding the impact of water-soluble fertilizers and PGPR on the correlation between various growth and yield parameters of blackgram is crucial for optimizing nutrient management practices and ensuring the crop's productivity and profitability. Systematic correlation studies between dependent and independent parameters will reveal the extent to which vegetative and yield parameters contribute to the final seed yield at different growth stages.This paper aims to elucidate the complex relationship between the growth and yield parameters of blackgram when subjected to water-soluble fertilizers and PGPR-based nutrient management treatments, ultimately aiming to optimize crop productivity.Potential use of 19:19:19 and MPP is predominantly used in vegetables and commercial crops but very limitedliterature is available related to use of water-soluble fertilizers and PGPR inrainfed blackgram. Hence, this study was undertaken on priority to see the influence of combined use of water-soluble fertilizers sprays and plant growth promoting rhizomicrobial consortia on performance of black gram in rainfed conditions and to popularize the same in blackgram under rainfed condition.

2. Materials and methods

A field study was conducted during 2019 *Kharif* season at College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, come under Southern Transition Zone of Karnataka(Zone-7). The geographically experimental site was located between 13° 58' to 14° 1' North latitude and 75° 34' to 75° 42' East longitude and at 650 m above the mean sea level. The experiment site soil texture was sandy loam with slightly acidic pH (6.19) and the soil texture was sandy loam, slightly acidic pH (6.19) and optimum level of in electrical conductivity (0.70 dS m^{-1}), lower organic carbon 4.56 g kg^{-1}. Initial soil waslow in nitrogen availability (242.22 kg ha^{-1}), high in phosphorus availability (75.08 kg P_2O_5 ha^{-1}) and medium potassium availability (135.63 kg K_2O ha^{-1}). The total rainfall received during cropping period was 1088.8 mm. Field experiment was laid out in Randomized Complete Block Design (RCBD) with thirteen treatments and replicated three times. Treatments are allocated randomly b using random number table to reduce the biasness. Treatments materials used in study was water soluble fertilizers(19:19:19 and Mono potassium phosphate (0:52:34)) and liquid plant growth promoting rhizomicrobial consortia application. Treatments combinations are as follows,

Treatment No.	Treatment details
T_1	: Package of practice (POP)
T_2	: T_1+19:19:19 @1% at 30 DAS
T_3	: T_2 + PGPR
T_4	: T_1 +19:19:19 @1% at 30 and 45 DAS
T_5	: T_4+ PGPR
T_6	: T_1+MPP @1% at 30 DAS
T_7	: T_6 + PGPR
T_8	: T_1+MPP @1% at 30 and 45 DAS
T_9	: T_8 + PGPR
T_{10}	: T_1+19:19:19@1% + MPP @1% at 30 DAS
T_{11}	: T_{10} + PGPR
T_{12}	: T_1+19:19:19 @1% + MPP @1% at 30 and 45 DAS
T_{13}	: T_{12} + PGPR

The field was prepared by ploughing with tractor drawn plough and subsequent harrowing and levelling of land for proper seed bed. Pythagoras theorem principle was used to prepare field layout by fixing baseline parallel to bund. Size of gross plot and net plot was 3.6×3 m^2 and 2.4×2.2 m^2, respectively. Blackgram variety LBG-625(Rashmi) was sown at 30m×10m spacing. Short duration variety having 85 to 90 days with average yield ranging from 8 to 9 q ha^{-1}. Package of practices of blackgram 6.5 t ha^{-1} FYM, 13:25:25 kg NPK ha^{-1}+ 4 kg $ZnSO_4$was applied as a basal dose for all the treatments. Liquid PGPR (*Rhizobium leguminosarum*, *Pseodumonas* sp. and *Bacillus* sp.) applied by mixed with FYM at the rate of 750 ml ha^{-1} incorporated in to soil before sowing. One percent spray solution was prepared and sprayed at 30 and 45 DAS according to allocated treatments. The biometric observation was recorded manually from the 5 tagged plants from each plot during 30, 45 DAS and at harvesting stage and expressed as mean value of five plants. Yield attribute and yield was recorded at harvest time from each plot separately.Data was analysed in MS excel for ANOVA as per Randomized Block Design (Gomez and Gomez, 1984). The significance between the treatments was tested using an F test with a 5% level of significance ($P \leq 0.05$). Simple correlation between growth and yield parameters of black gram was estimated to know the correlation between these parameters and seed yield.

3. Results and discussion

3.1 Plant height

Plant height is a crucial growth parameter that indicates the vegetative growth response of the crop to the applied nutrients.Considerablymaximum plant height (45.58, 59.30 and 67.16 cm was obtainedat 45 DAS, 60 DAS and at harvest stage, respectively). The plant height was increases with advancing crop stage up to harvest, However, rapid increase in plant hight was noticed during 60 DAS to harvest than sowing to 60 DAS. Foliar application of water-soluble fertilizers directly on foliage facilitates rapid absorption, translocation of nutrients leading to increased activity of meristematic cells, rate of cell division and cell elongation attribute to enhanced plant height. PGPR application mobilizes the unavailable nutrients makes easy uptake and improved metabolic processes and better vegetative growth of plant. PGPR show positive interactions with soil microorganisms in the rhizosphere and beyond in bulk soil, which ultimatelyincreases plant growth rate.Greater plant height was noted with application of FYM and PGPR(Basim and Raghu, 2015).

3.2 Number of branches per plant

Branching serves as a significant growth parameter in pulse crops such as black gram, like tillering in cereals. The number of branches per plant determines the quantity of flowers and pods produced in black gram.Statisticallygreater number of branches 8.72 at 45 DAS, 9.96 at 60 DAS and 10.63 at harvest stagewas found inT_{13}treatment. The rise in branches per plant could be attributed to the acceleration of various metabolic processes such as photosynthesis and symbiotic biological N_2 fixation. This increase may also be influenced by higher nutrient availability during the initial stages of the crop, potentially facilitated by PGPR application, leading to enhanced sprouting of auxiliary buds.This might also due to greater absorption, mobilization and translocation of major nutrients by foliar nutrition of water soluble fertilizers.

3.3 Leaf and stem dry weight per plant

Significantly higher leaf dry weight (4.12, 7.19, 1.94g plant^{-1}) and stem dry weight (1.52, 2.75 and 4.36 g plant^{-1}) at 45, 60 days after sowingand at harvest stage was noticed in the treatment receiving 19:19:19 @ 1 per cent + mono potassium phosphate @ 1 % at 30 and 45 DAS + PGPR along with package of practices when compared to rest of the treatments except (T_{11}) with POP+19:19:19 @ 1 per cent + Mono potassium phosphate @ 1 per cent at 30 DAS+ PGPR (3.69, 6.86 and 1.71; 1.36, 2.37 and 3.93 g plant^{-1} leaf and stem dry weight, respectively) at 45, 60 DAS and at harvest, respectively. Leaf dry weight was highest at peak vegetative stage when crop has better foliage cover as crop advances to harvest stage the leaves become dry and withers from the plant, only skeleton stem will remain at harvesting time.

3.4 Crude protein

Significantly superior crude protein content was found in foliar application of 19:19:19 and MPP each @ 1 % at 30 and 45 DAS + PGPR with package of practices (26.54 %) and which showed on par to the T_{11} (24.54 %) and T_{12} (24.35 %) as compared to remaining treatments. This is may be due to soil application of PGPR increases the nutrient mobilization and nutrient availability and foliar application of 19:19:19 and MPP at flowering and pod setting stage results in effective absorption of nitrogen and its assimilation as amino acids and biosynthesis of proteins in sink. Increased nitrogen content in seeds results in higher protein content (Kaleeswari*et al*., 2022)

3.5 Grain and haulm yield

In the present study,seed yield and haulm yield was varied significantly among the applied treatments of water-soluble fertilizers and PGPR (Table 2).Application of 19:19:19 and MPP each @ 1 % at 30 and 45 DAS + PGPR + package of practice was recorded substantially higher seed and haulm yield (1067 and 2019 kg ha^{-1}, respectively) as compared to other treatments except T_{11}:T_1+19:19:19@1%+ MPP @1% at 30 DAS+ PGPR (1085 and 1861 kg ha^{-1}) was showed on par results with respect of seed and haulm yield, respectively. The percent increment of seed and haulm yield in $T_{13}$was about 45.43 and 25.43 %, respectively as compared to T_1.Increase in yield, might be due to foliar spraying of water-soluble fertilizers (19:19:19 and MPP) during 30 and 45 DAS, thisfacilitatesrapid absorption and translocation of nutrients. The application of PGPR enhances the activity of effective root nodules, leading to increased mobilization and absorption of nutrients from the root zone (Babu *et al*. 2023). This, in turn, results in a greater assimilatory leaf area, facilitating efficient translocation of photosynthates from source to sink. These improvements are reflected in the production of better yield-attributing parameters. Greater number of yield attributing parameters enhances the yield of blackgram. The similar results are reported by Jadhav *et al*. (2017); Das and Jena (2015) in black gram and Meena *et al*. (2016) in green gram.

3.6 Correlation between growth parameters and seed, haulm yield

From the tabulated data presented in table 3, significant and positive relationship was noticed between seed yield and haulm yield with plant height (0.947 and 0.918), number of branches (0.753 and 0.681), leaves number (0.960 and 0.976), leaf area (0.836 and 0.811), LAI (0.868 and 0.881), leaf dry matter (0.898 and 0.823), stem dry matter (0.875 and 0.769) and number of nodules (0.694 and 0.647) at 30 DAS.Significant and positive relationship was observed between seed yield with plant height (0.966 and 0.892), number of branches (0.902 and 0.841), leaves number (0.963 and 0.919), leaf area (0.969 and 0.945), LAI (0.971 and 0.945), leaf dry matter (0.991 and 0.965), stem dry matter (0.934 and 0.842) and number of nodules (0.681 and 0.655) at 45 DAS.

Significant and positive relationship was witnessed between seed yield and haulm yield with plant height (0.964 and 0.889), number of branches (0.889 and 0.863), leaves number (0.941 and 0.913), leaf area (0.942 and 0.930), LAI (0.941 and 0.927), leaf dry matter (0.975 and 0.894) and stem dry matter (0.969 and 917) at 60 DAS.Significant and positive relationship was noticed between seed yield and haulm yield with plant height (0.970 and 0.889), number of branches (0.903 and 0.901), leaves number (0.918 and 0.901), leaf area (0.956 and 0.911), LAI (0.956 and 0.917), leaf dry matter (0.968 and 0.942) and stem dry matter (0.889 and 0.827) at harvest stage. Growth parameters have positive relationship with crop productivity (Surendar*et al.*, 2013)

3.7 Correlation between yield parameters and seed yield

From the correlation studies data in the table 4 revealed that there is a significantly positive relationship was observed betweenseed yield with number of pods (0.935), number of seeds (0.962), pod length (0.901), test weight (0.957), pod dry weight (0.934) and haulm yield (0.950).Correlation studies showed that, more than 90 % of seed yield is contributed by the yield parameters such as number of pods, number of seeds, pod length, pod weight and test weight. Similar results are reported by Bhavya *et al*. (2019)

4. Conclusion

Foliar application of 19:19:19 and mono potassium phosphate each @ 1% at 30 and 45 DAS + PGPR with a package of practices will be better option for higher growth, yield and crude protein content in blackgram. Further, Correlation studies concluded that all the growth and yield parameters are positively correlated with seed yield and haulm yield.

5. References

Anonymous. 3rd Annual report. *Ministry of agriculture and farmers welfare, Government of India,* 2018.

Anonymous. Basic report: Mungo beans, mature seeds, raw. *National Nutrient Database for Standard Reference*. *US Department of Agriculture*, 2019.

Babu RTC, Mavarkar NS, Praveen BR, Singh M and Dileep R. Effect of Water-Soluble Fertilizers and PGPR on Soil Microbial Population, Nodule Count and Economics of Black Gram. *Ind. J of Ecol.* 2023; **50**(1): 95-98.

Basim KH and Raghu RM. Evaluation of PGPR and organic manure applications on soil fertility, growth, nodulation and yield of black gram. *Int. J. Agric. Sci. Res*. 2015; **5**(2):183-192.

Bhavya M.Influence of foliar application of water-soluble fertilizers on growth and yield of green gram (*Vigna radiata* L.). *M.Sc. (Agri.) Thesis*, University of Agricultural and Horticultural Sciences, Shivamogga, 2019.

Das S K, Jana K. Effect of foliar spray of water-soluble fertilizer at pre flowering stage on yield of pulses. *Agril. Sci. Digest.* 2015;**35**(4), 275-279.

Gomez KA and Gomez AA.*Statistical procedures for agricultural research*. John wiley and sons, USA, 1984.

Jadhav SM, TakankharVG and Kumbhar S. Studies on foliar nutrition in black gram (*Vigna mungo* L.) under rainfed condition. *Trend Biosci*. 2017;**10**(27): 5842-5847.

Kaleeswari RK, Vijayakumar M and Kannan P. Nitrogen Utilization Potential of Prominent Blackgram Genotypes. *Ind. J. of Agril. Res.* 2022; 1, 5.

Meena S, Swaroop N and Dawson J. Effect of integrated nutrient management on growth and yield of green gram (*Vigna radiata* L.). *Agric. Sci. Digest*. 2016;**36**(1): 63-65.

Surendar KK, Vincent S, Wanagamundi M and Vijayaraghavan, H. Physiological effects of nitrogen and growth regulators on crop growth attributes and yield of black gram (*Vigna mungo* L.). *Bull. Env. Pharmacol. Life Sci.* 2013; **2**(4): 70-76.

Thakur V, Patil RP, Patil JR, Suma TC and Umesh MR. Influence of foliar nutrition on growth and yield of blackgram under rainfed condition. *J Pharmacogn. and phytochem*. 2017;**6**(6): 33-37.

Thriveni P, Rani BS, Sunitha N, MohanMM and Sagar GK. Enhancing the Productivity and Quality of Black gram (*Vigna mungo* L.) with Potassium Fertilization. *Legume Res.* 2023; **1**:pp 5.

Table 1: Effect of water-soluble fertilizers and liquid PGPR on growth parameters and crude protein content in blackgram

Treatment No.	Plant height (cm)			No. of branches $plant^{-1}$			Leaf dry weight (g $plant^{-1}$)			Stem dry weight (g $plant^{-1}$)			CP %
	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest	
T_1	27.27	35.32	37.15	4.71	6.47	6.87	2.53	3.15	1.24	0.53	1.56	1.96	20.15
T_2	32.83	38.59	42.02	5.35	7.68	7.89	2.63	4.31	1.28	0.66	1.64	3.16	22.45
T_3	35.07	42.02	46.67	5.80	8.42	8.64	2.72	4.35	1.31	0.70	1.68	3.21	22.67
T_4	32.80	40.99	45.71	6.20	8.36	8.81	2.78	4.50	1.42	0.72	1.73	3.24	22.54
T_5	35.07	50.66	56.37	7.73	8.63	8.79	3.11	5.41	1.61	0.90	2.13	3.57	22.76
T_6	32.53	39.95	45.54	5.30	7.85	7.87	2.62	4.38	1.34	0.65	1.66	3.15	22.74
T_7	33.70	42.22	47.38	5.94	8.47	8.58	2.70	4.42	1.39	0.71	1.71	3.26	23.74
T_8	32.53	41.11	45.35	6.23	8.44	8.74	2.76	4.56	1.43	0.73	1.76	3.30	23.64
T_9	37.93	50.85	56.55	8.23	8.60	8.73	3.12	5.84	1.62	1.26	2.29	3.66	23.98
T_{10}	36.20	44.16	51.30	6.20	8.41	8.75	3.02	5.65	1.58	1.21	2.01	3.51	23.92
T_{11}	41.12	57.36	64.49	8.30	9.63	9.76	3.69	6.86	1.71	1.36	2.37	3.93	24.54
T_{12}	38.40	51.22	57.27	7.83	8.60	8.76	3.21	5.85	1.61	1.23	2.23	3.65	24.35
T_{13}	45.58	59.30	67.16	8.72	9.96	10.63	4.12	7.18	1.94	1.52	2.75	4.36	26.54
S. Em.±	2.4	2.66	3.2	0.50	0.4	0.6	0.24	0.45	0.10	0.06	0.15	0.23	0.8
CD @ 5%	6.9	7.77	9.3	1.47	1.3	1.8	0.71	1.33	0.30	0.19	0.43	0.68	2.3

T_1: package of practice (POP)(6.5 t ha^{-1} FYM, 13:25:25 kg NPK ha^{-1} + 4 kg $ZnSo_4$ as basal dose); T_2: T_1+19:19:19 @1 per cent at 30 DAS; T_3: T_2 + PGPR; T_4: T_1 +19:19:19 @1 per cent at 30 and 45 DAS; T_5: T_4+ PGPR; T_6: T_1+MPP @1 per cent at 30 DAS; T_7: T_6 + PGPR; T_8: T_1+MPP @1 per cent at 30 and 45 DAS; T_9: T_8 + PGPR; T_{10}: T_1+19:19:19@1 per cent + MPP @1 per cent at 30 DAS; T_{11}: T_{10} + PGPR; T_{12}: T_1+19:19:19 @1 per cent + MPP @1 per cent at 30 and 45 DAS and T_{13}: T_{12} + PGPR

Table 2: Effect of water soluble fertilizers and liquid PGPR on seed yield, haulm yield and harvest index of blackgram

Treatment No.	Grain yield	Haulm yield	Harvest index
T_1	802	1603	0.33
T_2	869	1640	0.35
T_3	876	1653	0.35
T_4	883	1708	0.34
T_5	965	1767	0.35
T_6	868	1624	0.35
T_7	877	1657	0.35
T_8	886	1715	0.34
T_9	967	1753	0.36
T_{10}	955	1733	0.36
T_{11}	1085	1861	0.37
T_{12}	994	1706	0.36
T_{13}	1167	2019	0.37
S. Em.±	44.69	72.20	0.02
CD @ 5%	130.46	210.81	NS

*Refer table 1 for treatment details

Table 3: Correlation between seed yield, haulm yield of blackgram and different growth parameters at different growth stages as influenced by water soluble fertilizers and PGPR

	Plant height				**Number of branches per plant**			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**	**30 DAS**	**45 DAS**	**60 DAS**	**At harvest**
Seed yield	0.94	0.96	0.96	0.97	0.75	0.90	0.88	0.90
Haulm yield	0.91	0.89	0.88	0.88	0.68	0.84	0.86	0.91
	Number of leaves per plant				**Leaf area**			
Seed yield	0.96	0.96	0.94	0.91	0.83	0.96	0.94	0.95
Haulm yield	0.97	0.91	0.91	0.90	0.81	0.94	0.93	0.91
	LAI				**Leaf dry matter**			
Seed yield	0.86	0.97	0.94	0.95	0.89	0.99	0.97	0.96
Haulm yield	0.88	0.94	0.92	0.91	0.82	0.96	0.89	0.94
	Stem dry matter				**Number of nodules per plant**			
					30 DAS		**45 DAS**	
Seed yield	0.87	0.93	0.96	0.88	0.69		0.68	
Haulm yield	0.76	0.84	0.91	0.82	0.64		0.65	

Table 4: correlation studies between yield and yield attribute as influenced by water soluble fertilizers and PGPR

	No. of Pods plant^{-1}	**No. of Seeds Plant^{-1}**	**Pod length**	**TW**	**Pod dry weight**	**Seed yield**	**Haulm Yield**
No. of Pods plant^{-1}	1						
Seeds plant^{-1}	0.94	1					
Pod length	0.94	0.88	1				
TW	0.90	0.92	0.91	1			
Pod dry weight	0.92	0.95	0.89	0.95	1		
Seed yield	0.93	0.96	0.90	0.95	0.93	1	
Haulm Yield	0.93	0.95	0.86	0.86	0.86	0.95	1