

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. During *Kharif-2019*, a field study entitled effect of water-soluble fertilizers and PGPR on performance of rainfed blackgram 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. The Results 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.

1. Introduction

Agriculture plays a pivotal role in meeting the ever-increasing global food demand, and optimizing crop yield is of paramount importance to ensure food security. Blackgram (*Vigna mungo* L. Hepper), commonly known as urad dal, is an essential leguminous pulse crop grown extensively across various regions, contributing significantly to the protein (24 %) with calorific value of 347 Kcal per 100g. It is extensively grown as a grain legume and guaranteed considerable importance from the point of food and nutritional security (Anon. 2019). In India, black gram contributes about 13 percent of the total pulse area and 10 percent of their total production and it was cultivated over an area of about 4.6 M ha with a production of 3.56 Mt. with a productivity of 654 kg ha⁻¹ and in Karnataka, is cultivated over an area of 1.38 lakh ha with a production of 0.47 lakh tonnes (Anon. 2018). The sustainable production of blackgram is contingent upon several factors, including soil fertility and nutrient management practices (Thriveni *et al.*, 2023). In the pursuit of enhancing crop productivity, modern agriculture has witnessed a surge in the use of water-soluble fertilizers,

which are readily absorbed by plants and can offer precise nutrient delivery. The application of water-soluble fertilizers has gained prominence as a means to address nutrient deficiencies and promote vigorous plant growth during peak nutrient demanding stages like flowering and pod filling. However, the specific impact of these fertilizers on the growth and yield parameters of blackgram warrants comprehensive investigation. PGPR is a group of microbial consortium helps in maintaining the soil biological activity and enhancing plant nutrient availability in the rhizosphere. Besides, it also helps in stress tolerance with the release of plant hormones. The growth parameters under consideration include plant height, branching pattern, number of leaves while yield parameters encompass pod number per plant, pod length, seed count per pod, seed weight, and overall crop yield per unit area. The gap between vegetative phase and reproductive phase is very less as black gram is an indeterminate growth in nature. One of the major reasons for low yield was lower flower to pod ratio in pulses due to poor pod setting. This paper seeks to elucidate the intricate relationship between plant growth and yield parameters of blackgram under water soluble fertilizers and PGPR based nutrient management treatments, with the ultimate goal of optimizing crop maximizing productivity. Understanding the effect application of water-soluble fertilizers and PGPR on the correlation studies between the various growth and yield parameters of blackgram is pivotal for optimum nutrient management practices and ensuring the productivity and profitability of the crop. So, systematic correlation studies between dependent and independent parameters will reveal the at what percent vegetative parameters and yield parameters will contribute the final seed yield at different growth stages.

2. Materials and methods

A field experiment was conducted during *Kharif* season of 2019 at College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga which is come under Southern Transition Zone (Zone-7) of Karnataka. The geographical reference point of the experimental site was 13° 58' to 14° 1' North latitude and 75° 34' to 75° 42' East longitude and at an altitude of 650 m above the mean sea level. The soil was sandy loam in texture, slightly acidic pH (6.19) and normal in electrical conductivity (0.70 dS m⁻¹), low organic carbon 4.56 g kg⁻¹ and low in available nitrogen (242.22 kg ha⁻¹), high in phosphorus (75.08 kg P₂O₅ ha⁻¹) and medium in potassium status (135.63 kg K₂O ha⁻¹) and Nitrogen fixers (20 × 10⁵ CFU g⁻¹ soil), P-solubilizing bacteria (16 × 10⁵ CFU g⁻¹ soil), K-mobilizing bacteria (9 × 10⁵ CFU g⁻¹ soil). During the cropping period, the total actual rainfall received was 1088.8 mm. Randomized Complete Block Design was used for this experiment with

thirteen treatments and three replications. Treatments consisting of different combinations of water soluble fertilizers viz., 19:19:19 (N: P: K) and Mono potassium phosphate (0:52:34) sprayed at 30 and 45 days after sowing with or without liquid plant growth promoting rhizomicrobial consortia application along with the package of practice viz., T₁: package of practice (POP)(6.5 t ha⁻¹ FYM, 13:25:25 kg NPK ha⁻¹ + 4 kg ZnSO₄ as basal dose), T₂: T₁+19:19:19 @1 per cent at 30 DAS, T₃: T₂ + PGPR, T₄: T₁ +19:19:19 @1 per cent at 30 and 45 DAS, T₅: T₄+ PGPR, T₆: T₁+MPP @1 per cent at 30 DAS, T₇: T₆ + PGPR, T₈: T₁+MPP @1 per cent at 30 and 45 DAS, T₉: T₈ + PGPR, T₁₀: T₁+19:19:19@1 per cent + MPP @1 per cent at 30 DAS, T₁₁: T₁₀ + PGPR, T₁₂: T₁+19:19:19 @1 per cent + MPP @1 per cent at 30 and 45 DAS and T₁₃: T₁₂ + PGPR. variety used is Rashmi (LBG-625) it matures in 85 to 90 days with average yield ranging from 8 to 9 q ha⁻¹. The land was ploughed with tractor drawn plough followed by harrowing and levelling. Field layout was made according to the experimental design and as per the plan of layout. The plots of 3.6 m width and 3.0 m length were prepared by making bunds of 30 cm width and 15 cm height. The gross plot size was 3.60 m × 3.0 m and net plot size was 2.40 m × 2.20 m and treatments were allocated randomly in the plots within the blocks. Recommended dose of fertilizers and farm yard manure @ 7.5 t ha⁻¹ was applied at the time of sowing common to all the treatments. Liquid plant growth promoting rhizomicrobial consortia (*Rhizobium leguminosarum*, *Pseudomonas* sp. and *Bacillus* sp.) mixed with farm yard manure at the rate of 750 ml ha⁻¹ incorporated to soil as per treatments at the time of sowing. The 1 per cent solution of water-soluble fertilizers 19:19:19 and mono potassium phosphate was used for foliar spraying at 30, 45 and 60 DAS and at harvest as per the treatments. The plant growth parameters were recorded manually from 5 plants from each plot at 30, 45 DAS and at the time of harvesting. Yield attribute and yield was recorded at harvest time from each plot separately. Data was analysed in analysis of variance (ANOVA) as per Randomized Block Design (Gomez and Gomez, 1984). The significance of the treatments was tested using an F test with a 5% level of significance (P ≤ 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 an important growth parameter that reflects the vegetative growth behaviour of the crop to the applied nutrients. The plant height was progressively increased

as the age of crop advanced up to harvest, significantly higher plant height (45.58, 59.30 and 67.16 cm was recorded at 45, 60 DAS and at harvest, respectively). However, the rate of increase in plant height was more from the date of sowing to 60 DAS than 60 DAS to harvest stage of the crop. Increased plant height in black gram may be due to increase in the meristematic cell activity, increased rate of cell division and rapid cell elongation with the application of nutrients through foliar spray directly to the foliage through water soluble fertilizers and maintaining the favourable soil condition through the application of PGPR to the soil as they are known to have favourable effects on metabolic process and better vegetative growth of the plant. PGPR show synergistic interactions with microorganisms within the rhizosphere and beyond in bulk soil, which indirectly boosts plant growth rate. These results are akin with results of Basim and Raghu (2015) with application of Farm Yard Manure and PGPR (*Rhizobium sp.*, *Bacillus sp.* and *Pseudomonas sp.* and) recorded significantly higher plant height (71.025).

3.2 Number of branches per plant

Branching is the important growth parameter in pulse crops like black gram, as tillering in cereals, number of branches per plant decides the number flowers and pods in the black gram. Significantly maximum number of branches (8.72, 9.96 and 10.63 plant⁻¹ at 45, 60 DAS and at harvest, respectively) was noticed in the treatment T₁₃. The higher number of branches might be due to hastening various metabolic process viz., photosynthesis, symbiotic biological N₂ fixation process and higher nutrient availability at the initial stage of the crop because of PGPR application this increases the sprouting of auxillary 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 DAS and at harvest 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 (T₁₁) 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 application of 19:19:19 and Mono potassium phosphate each @ 1 per cent at 30 and 45 DAS + PGPR along with a package of practice (26.54 %) and which showed on par to the T₁₁ (24.54 %) and T₁₂ (24.35 %) as compared to remaining treatments. This 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 (Kaleeswarriet *al.*, 2022)

3.5 Grain and haulm yield

In the present investigation, grain yield and haulm yield was varied significantly among the different treatments of water-soluble fertilizers and PGPR (Table 2). Application of 19:19:19 and Mono potassium phosphate each @ 1 per cent at 30 and 45 DAS + PGPR along with a package of practice was recorded significantly higher seed and haulm yield (1067 and 2019 kg ha⁻¹, respectively) as compared to other treatments except T₁₁:T₁+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 in T₁₃ about 45.43 and 25.43 % seed and haulm yield respectively as compared to T₁. This may be due to foliar nutrition of water soluble fertilizers during 30 and 45 DAS favours proper absorption of nutrients applied through foliar nutrition and PGPR application which reflected on the better activity of effective root nodules resulted in increased nutrient mobilization and absorption from the root zone which reflected on more assimilatory leaf area which might have caused efficient translocation of photosynthates from source to sink this reflects on the production of better yield attributing parameters. Due to increase in yield attributing characters, which finally increased the seed yield and haulm yield. Increased grain yield increased the harvest index (0.37) might be due to the increased mobilization of metabolites to reproductive sinks. These results are in similar to the results of Jadhav *et al.* (2017) in black gram and Meena *et al.* (2016) in green gram who also reported that foliar spray of water-soluble fertilizers improves seed yield.

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.

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 between seed 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

Application of 19:19:19 and mono potassium phosphate each @ 1 per cent at 30 and 45 DAS + PGPR along with a package of practice 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

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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

T₁: package of practice (POP)(6.5 t ha⁻¹ FYM, 13:25:25 kg NPK ha⁻¹ + 4 kg ZnSO₄ as basal dose); T₂: T₁+19:19:19 @1 per cent at 30 DAS; T₃: T₂ + PGPR; T₄: T₁ +19:19:19 @1 per cent at 30 and 45 DAS; T₅: T₄+ PGPR; T₆: T₁+MPP @1 per cent at 30 DAS; T₇: T₆ + PGPR; T₈: T₁+MPP @1 per cent at 30 and 45 DAS; T₉: T₈ + PGPR; T₁₀: T₁+19:19:19@1 per cent + MPP @1 per cent at 30 DAS; T₁₁: T₁₀ + PGPR; T₁₂: T₁+19:19:19 @1 per cent + MPP @1 per cent at 30 and 45 DAS and T₁₃: T₁₂ + 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			
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest
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			
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest
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