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Microbial consortia mediated improvement of yield in Green Gram

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Abstract

Microbial consortia offer a sustainable alternative to chemical fertilizers by enhancing crop productivity through synergistic interactions. The present study evaluated the effect of *Rhizobium* and rhizobacterial consortia on yield attributes in two green gram varieties, DGGV-2 and DGG-96. Individual inoculants and different microbial combinations were tested under controlled conditions. Yield parameters such as number of pods per plant, pod length, seed weight, and hundred-seed weight were recorded. The results demonstrated that microbial consortia significantly outperformed single inoculations and control treatments. The consortium comprising HR-73, BR-29, AUDP 203, and AUDP 279 (M7) recorded the highest yield, particularly in variety DGGV-2. The study confirms the potential of microbial consortia in improving green gram productivity while enhancing soil biological functioning.

Keywords: Green gram yield, Microbial consortia, *Rhizobium*, Sustainable agriculture

1. Introduction

Sustainable intensification of pulse production requires strategies that enhance crop yield while maintaining soil health. Microbial inoculants, particularly *Rhizobium* and plant growth promoting rhizobacteria, have emerged as eco-friendly alternatives to chemical fertilizers due to their ability to improve nutrient availability, stimulate plant growth, and enhance soil biological activity. However, the effectiveness of single-strain inoculants is often inconsistent under field conditions due to environmental variability and limited functional scope.

Microbial consortia, comprising compatible strains with complementary functions, offer a promising approach to overcome these limitations. Such consortia can simultaneously promote plant growth, improve nutrient uptake, enhance soil enzyme activities, and increase soil organic matter. Yield parameters such as pod number, pod length, seed weight, and hundred-seed weight serve as reliable indicators of crop response to microbial inoculation.

Green gram varieties differ in their responsiveness to microbial inoculation, necessitating the evaluation of variety and inoculant interactions. Despite growing interest in microbial consortia, limited studies have systematically linked yield enhancement with soil biochemical properties in green gram. Therefore, the present study aimed to evaluate the effect of *Rhizobium* and rhizobacterial consortia on yield attributes in two green gram varieties. The study sought to identify efficient microbial combinations capable of improving both crop productivity.

2. Materials and methodology

The present study was conducted under greenhouse conditions at University of Agricultural sciences, Dharwad. In this study the treatment were formulated after *in vitro* studies for plant growth promoting traits. The microbial inoculum used has characters for in dole acetic acid, ammonium, Siderophore and Hydrogen cyanide production along with in-vivo nitrogen fixation capacity. The present study was aimed for analysis the effect of microbial consortium formulated on plant yield parameters. The yield of plant was measured using various parameters which includes No. of pods per plant, pod length, seed weight per pod, no. of seeds per pod and hundred seed weight. The treatment to pots were given based on lab study results in pervious experiments for plant growth promoting traits. Firstly, pods were harvested from all the treatments of green gram plants present in each pot and were counted and the average of this

was noted as the number of pods per plant. The pod length of each individual pod in each treatment was taken manually with the help of measuring scale and the mean values were expressed in centimeters. The seed weight per pod from respective plants in each treatment was taken with the help of electrical weighting balance and the mean values were expressed in grams. The pods from respective plants in each treatment were removed and a number of seeds per pod were manually counted and the average of this was noted as the number of seeds per pod and hundred seed weight for every treatment is measured using randomly

selected 100 seeds and the mean values were expressed in grams.

3. Results

Yield parameters

Yield parameters like number of pods per plant, pod length, seed weight per pod, number of seeds per pod and hundred seed weight was assessed at harvest and presented. (Table 1 and Plate 1).

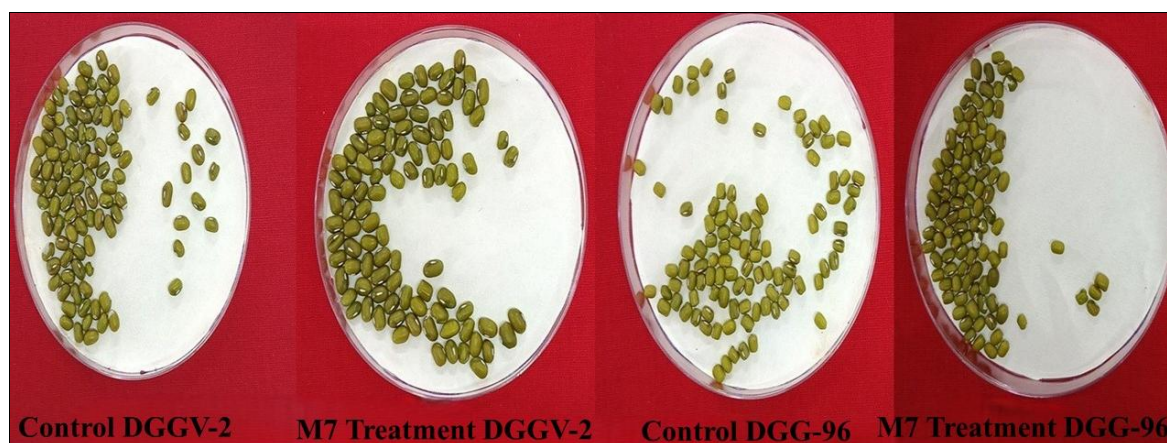


Plate 1: Hundred seed weight compression between control and best performing treatment

a. Number of pods per plant

Number of pods per plants at harvest were counted and presented in Table 1a. Inoculation of consortium for green gram varieties, increased the no. of pods per plants of green gram at harvest when compared to controls.

Among all observation recorded across all treatments, the treatment with M7 inoculum (34.84) shown highest no. of pods per plants when compared to other treatments followed by M5 inoculum (33.25), M6 inoculum (31.06) and least no. of pods per plants among all treatments was shown by M9 inoculum (16.83) whereas, M1 inoculum with NC-92 showed 20.04 pods per plant.

Among the varieties, DGGV-2 with an average of 27.12 shown higher no. of pods per plants when compared to DGG-96 (25.28). The interaction effect of microbial inoculum with varieties DGGV-2 and DGG-96 was found significant in number of pods per plants at harvest with a range of 36.67-15.66. The treatment M7 with DGGV-2 recorded significantly highest no. of pods per plant (36.67) at harvest.

b. Pod length

Pod length of pods was measured in triplicates at harvest using centimeter scale and presented. (Table 1b). Inoculation of consortium for green gram varieties, increased the pod length of green gram at harvest when compared to controls. Among all observation recorded across all treatments, the treatment with M7 inoculum (10.89) shown highest pod length in centimeters when compared to other treatments followed by M5 inoculum (10.54), M6 inoculum (10.40) and least pod length was observed among all treatments was shown by M9 inoculum (08.20) whereas, M1 inoculum with NC-92 showed pod length of 09.10 cm.

Among the varieties, DGGV-2 with an average of 9.68 shown higher pod length in centimeters when compared to DGG-96 (09.51). The interaction effect of microbial inoculum with varieties DGGV-2 and DGG-96 was found significant in pod

length at harvest with a range of 11.17-08.00cm. The treatment M7 with DGGV-2 recorded significantly highest pod length (11.17cm) at harvest.

c. Seed weight per pod

At harvest, seed weight per pod was measured individually using electrical weighting balance and Table 1c present's data obtained. Inoculation of consortium for green gram varieties, increased the seed weight per pod of green gram at harvest when compared to controls. Among all observation recorded across all treatments, the treatment with M7 inoculum (0.76) shown highest seed weight per pod in grams when compared to other treatments followed by M5 inoculum (0.71), M6 inoculum (0.60) and least seed weight per pod among all treatments was shown by M9 inoculum (0.39) whereas, M1 inoculum with NC-92 showed 0.44 grams of seed weight.

Among the varieties, DGGV-2 with an average of 0.55 shown higher seed weight per pod in grams when compared to DGG-96 (0.53). The interaction effect of microbial inoculum with varieties DGGV-2 and DGG-96 was found significant in seed weight per pod at harvest with a range of 0.77-0.36g. The treatment M7 with DGGV-2 recorded significantly highest seed weight per pod (0.77g) at harvest.

d. Number of seeds per pod

Number of seeds per pod were counted in triplicates and presented in Table 1d. Inoculation of consortium for green gram varieties, increased the no. of seeds per pod of green gram at harvest when compared to controls. Among all observation recorded across all treatments, the treatment with M7 inoculum (09.79) shown highest no. of seeds per pod when compared to other treatments followed by M5 inoculum (09.23), M6 inoculum (09.00) and least no. of seeds per pod among all treatments was shown by M9 inoculum (07.03) whereas, M1 inoculum with NC-92 showed 08.17 seeds per pod.

e. Among the varieties, DGGV-2 with an average of 9.64

shown higher no. of seeds per pod when compared to DGG-96 (7.41) the interaction effect of microbial inoculum with varieties DGGV-2 and DGG-96 was found significant in number of seeds per pod at harvest with a range of 10.90-07.00. The treatment M7 with DGGV-2 recorded significantly highest no. of seeds per pod (10.90) at harvest.

f. Hundred seed weight

At harvest, hundred seed weight of all treatments were counted and presented in Table 1e. Inoculation of consortium for green gram varieties, increased the hundred seed weight of green gram at harvest when compared to controls.

Among all observation recorded across all treatments, the treatment with M7 inoculum (6.46) shown highest hundred seed weight in grams when compared to other treatments followed by M5 inoculum (5.49), M6 inoculum (5.14) and least hundred seed weight among all treatments was shown by M9 inoculum (3.59) whereas, M1 inoculum with NC-92 showed hundred seed weight of 3.84 grams. Among the varieties, DGGV-2 with an average of 4.82 shown higher hundred seed weight in grams when compared to DGG-96 (4.24).

The interaction effect of microbial inoculum with varieties DGGV-2 and DGG-96 was found significant in hundreds seed weight at harvest with a range of 6.71-2.98 g. The treatment M7 with DGGV-2 recorded significantly highest hundred seed weight in grams (6.71) at harvest.

4. Discussion

Yield parameter like no. of pods per plant, pod length, seed weight per pod, no. of seeds per pod, hundred seed weight were significantly improved when seeds were treated with consortium

when compared to positive controls (NC-92, HR-73, BR-29) and uninoculated control. Highest values of yield parameters were recorded for plants treated with M7(HR-73+ BR-29+ AUDP 203 + AUDP 279) inoculum then other treatments. Among the varieties DGGV-2 shown better yield then DGG-96 and the interaction effect of *Rhizobium* and rhizobacteria was positively correlated in green gram varieties for parameters like no. of pods per plant, pod length, seed weight per pod, no. of seeds per pod, hundred seed weight. The interaction effect in DGGV-2 with M7 microbial inoculum treatment shown highest value at all stages plant sample analysis when compared to all other treatments. The results are in similar with findings of Ibrahim *et al.* (2022) [2] reported that co inoculation of *Rhizobium* and *Azotobacter* in Egypt increased yield by 24.7% when compared to control in pea. Alam *et al.* (2015) [1] reported that inoculation of *Rhizobium* sps. BARIRGm901 in soyabean crop at Bangladesh has produced greater nodule numbers, nodule weight, shoot and root biomass, and plant height than non-inoculated plants along with enhanced activity of nitrogenase (NA) enzyme, contributing to higher nitrogen fixation and assimilation, compared to non-inoculated soybean plants in both years.

Form the observation significant improvement in yield of varieties with consortium treatment and positive controls over inoculated control was because of plants were provided with PGPR bacteria with ability of fixing N₂, solubilizing and mobilizing major plant nutrients, providing antagonistic activity for pathogenic microbes and improving overall health by providing better micro environment at rhizosphere and phyllosphere for plant growth (Mbaka *et al.*, 2021) [3].

Table 1a: Influence of *Rhizobium* and rhizobacteria on yield parameters in green gram varieties DGGV-2 and DGG-96

Treatments	Yield parameters								
	a. No. of pod per plant			b. Pod length (cm)			c. Seed weight per pod (gm)		
Microbial inoculants	DGGV-2	DGG-96	Mean values	DGGV-2	DGG-96	Mean values	DGGV-2	DGG-96	Mean values
M1: NC-92 (Reference strain)	20.36	19.71	20.04	09.00	09.20	09.10	0.44	0.44	0.44
M2: HR-73	25.00	23.96	24.48	09.17	09.37	09.27	0.52	0.45	0.49
M3: BR-29	19.83	17.67	18.75	08.67	08.80	08.74	0.43	0.44	0.44
M4: HR-73+ BR-29	27.77	25.63	26.70	09.23	09.40	09.32	0.52	0.53	0.53
M5: HR-73+ AUDP 203+ AUDP 279	34.00	32.50	33.25	10.87	10.20	10.54	0.71	0.70	0.71
M6: BR-29+ AUDP 203 + AUDP 279	31.62	30.50	31.06	10.70	10.10	10.40	0.66	0.54	0.60
M7: HR-73+ BR-29+ AUDP 203 + AUDP 279	36.67	33.00	34.84	11.17	10.60	10.89	0.77	0.74	0.76
M8: NC-92 + AUDP 203 + AUDP 279	29.77	27.28	28.53	10.00	10.00	10.00	0.56	0.54	0.55
M9: UIC	18.00	15.66	16.83	08.40	08.00	08.20	0.41	0.36	0.39
M10: HR-73 + BR-29 + NC-92	28.14	26.85	27.50	09.60	09.40	09.50	0.52	0.52	0.52
Mean of variety	27.12	25.28		09.68	09.51		0.55	0.53	
Comparison of	S. Em. (+)		CD (p=0.01)	S. Em. (+)		CD (p=0.01)	S. Em. (+)		CD (p=0.01)
V (Variety)	0.02		0.07	0.01		0.02	0.01		0.02
R (Isolates and consortia)	0.05		0.15	0.02		0.05	0.01		0.04
Interaction V*R (Variety *Isolates)	0.07		0.21	0.02		0.06	0.02		0.06

Table 1b: Influence of *Rhizobium* and rhizobacteria on yield parameters in green gram varieties DGGV-2 and DGG-96

Treatments	Yield parameters					
	d. No. of seeds per pod			e. Hundred seed weight (gm)		
Microbial inoculants	DGGV-2	DGG-96	Mean values	DGGV-2	DGG-96	Mean values
M1: NC-92 (Reference strain)	09.25	7.08	8.17	3.79	3.89	3.84
M2: HR-73	09.60	7.23	8.42	4.30	3.81	4.06
M3: BR-29	07.28	7.05	7.17	3.70	2.98	3.34
M4: HR-73+ BR-29	10.22	7.30	8.76	4.51	3.91	4.21
M5: HR-73+ AUDP 203+ AUDP 279	10.90	7.55	9.23	5.78	5.20	5.49
M6: BR-29+ AUDP 203 + AUDP 279	10.40	7.60	9.00	5.60	4.68	5.14
M7: HR-73+ BR-29+ AUDP 203 + AUDP 279	10.90	8.67	9.79	6.71	6.20	6.46
M8: NC-92 + AUDP 203 + AUDP 279	10.40	7.27	8.84	5.03	4.07	4.55
M9: UIC	07.06	7.00	7.03	3.56	3.62	3.59
M10: HR-73 + BR-29 + NC-92	10.38	7.39	8.89	5.20	4.00	4.60
Mean of variety	09.64	07.41		4.82	4.24	
Comparison of	S. Em. (+)		CD (p=0.01)	S. Em. (+)		CD (p=0.01)
V (Variety)	0.01		0.01	0.02		0.05
R (Isolates and consortia)	0.01		0.03	0.04		0.12
Interaction V*R (Variety *Isolates)	0.02		0.05	0.06		0.17

5. Conclusion

The results of the study clearly demonstrated that microbial consortia significantly enhanced yield parameters in green gram compared to single inoculants and uninoculated controls. Among the treatments, the consortium comprising HR-73, BR-29, and rhizobacterial isolates AUDP 203 and AUDP 279 consistently outperformed other treatments across both varieties. Significant improvements were recorded in number of pods per plant, pod length, seed weight per pod, number of seeds per pod, and hundred-seed weight, with DGGV-2 showing greater responsiveness than DGG-96.

These findings confirm that synergistic interactions among compatible microbial strains can effectively enhance crop yield. The use of *Rhizobium*-rhizobacteria consortia represents a sustainable and biologically sound approach for green gram cultivation. Further multilocation field trials and formulation studies are recommended to facilitate large-scale adoption of these consortia in pulse-based farming systems.

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