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Multifunctional rhizobacteria with *Rhizobium* for yield maximization in mungbean

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Abstract

To assess the effect of multifunctional rhizobacteria on yield of mungbean, a trial was laid out using different multifunctional rhizobacteria viz., Kalaburagi (GUR5 & GUR8), Akola (WUR 12-1), Vamban (VUC), and Pantnagar (A-3, P-5 & PUR 34), received from various AICRP centres. A total of four multifunctional rhizobacteria were obtained from three different AICRP centres viz., Pantnagar, Coimbatore and Ludhiana. Multifunctional rhizobacteria promotes plant growth through nutrient mobilization, growth hormone secretion and protects the plants from pest/diseases. Mungbean seeds were treated with all the multifunctional rhizobacteria along with the local best *Rhizobium* BMBS 47. Observations were recorded at 45th DAS to assess their effect on plant growth parameters viz., number of nodules /plants, root length and shoot length and nodule dry weight and yield parameters at harvest. Among rhizobacteria *Methylobacterium* (Coimbatore) recorded a greater number of nodules/plant (53.3/plant) and nodule dry weight (0.069 g/plant) which is higher than other rhizobacteria. This was followed by NE 10 (*Bacillus cereus*) (Pantnagar Ch.) which recorded 44.3 nodules/plant and nodule dry weight (0.057 g/plant). Uninoculated control recorded the least nodulation as 23/plant which is significantly lesser than all the other treatments. Among the different rhizobacteria *Methylobacterium* (Coimbatore) inoculated treatment recorded the higher yield of 1115.3 kg/ha followed by NE 10 (*Bacillus cereus*) (Pantnagar Ch.) (990 kg/ha).

Keywords: Multifunctional rhizobacteria, mungbean, nodules, *Rhizobium* BMBS47

Introduction

Nitrogen (N) fixation through the symbiotic relationship between legumes and *Rhizobium* is essential for enhancing agricultural productivity and carries significant economic importance. Recent studies indicate that other beneficial soil bacteria can positively affect the performance of rhizobia in this symbiosis. Inoculating plants with selected plant growth-promoting rhizobacteria (PGPR) can boost the native populations of rhizobia and help mobilize phosphorus (P) from sources that are not easily available, thereby improving plant nutrition (Richardson *et al.*, 2009) [8].

Notably, *Paenibacillus polymyxa* and *Bacillus megaterium* have proven particularly effective in promoting growth and phosphorus uptake in tomatoes (Ei-Yazeid and Abou-Aly, 2011) [3]. Moreover, the growth and yield of legumes improve significantly with *Rhizobium* inoculation. Research shows that co-inoculating plants with phosphorus-solubilizing bacteria and *Rhizobium* stimulates plant growth more effectively than either treatment alone (Walpole and Yoon, 2013) [12]. For instance, Bai *et al.* (2003) [11] found that co-inoculating soybean plants with *Bacillus* strains and *Bradyrhizobium japonicum* resulted in significant increases in nodule number, nodule weight, shoot weight, root weight, total biomass, total nitrogen, and grain yield. Additionally, non-rhizobial plant growth-promoting bacteria can enhance nodulation and grain yield in legumes when co-inoculated with specific crop rhizobia. Furthermore, Remans *et al.* (2007) [7] observed that the ability of *Rhizobium* isolates to nodulate bean plants increased when phosphate-solubilizing bacteria were applied simultaneously. Silva *et al.* (2007) [10] reported that co-inoculating *Vigna unguiculata* with *Bradyrhizobium* sp., *Paenibacillus polymyxa*, and *Bacillus* sp. led to specific stimulation of nodulation and increased root dry matter. Lastly, endophytic plant growth-promoting bacteria and nitrogen-fixing *Rhizobium* species can work synergistically to enhance nitrogen fixation efficiency in lentils (Saini and Khana, 2012) [9].

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Materials and Methods

To assess the performance of *Rhizobium* strains at various locations, a trial was laid out with *Rhizobium* strains received from various AICRP centres. The experimental details are mentioned below.

The field experiments were conducted during kharif 2022 in red sandy loam soil of pH 7.3 and low in organic C, and available N and medium in available P. The seven treatments consisted of inoculation with different *Rhizobium* strains were tested following Randomized Block Design in three replicates in plot of 4.0 x 3.0 m size.

Treatment details

1. *Rhizobium* (Local best)
2. *Rhizobium* + NE 10 (*Bacillus cereus*) (Pantnagar Ch.)
3. *Rhizobium* + *Pseudomonas* spp. (Coimbatore)
4. *Rhizobium* + LMSR 45 (*Pantoea agglomerans*) (Ludhiana)
5. *Rhizobium* + *Methylobacterium* (Coimbatore)
6. N as per RDF
7. Uninoculated control

Mungbean seeds (VBN8) were treated with the required inoculants (200 g/10 kg seeds) at the time of sowing and crop

was raised as per the recommended agronomic practices. Seven *Rhizobium* isolates were obtained from four AICRP centres viz., Kalaburagi (GUR5 & GUR8), Akola (WUR 12-1), Vamban (VUC), and Pantnagar (A-3, P-5 & PUR 34), along with the local best *Rhizobium* BMBS47 were used for the experiment. Mungbean seeds were treated with the *Rhizobium* isolates and sown. Observations were recorded at 45th DAS, to assess their effect on plant growth parameters viz., number of nodules/plants, root length, shoot length, nodule dry weight and yield parameters were recorded during harvest.



Experimental field

Table 1: Effect of different multifunctional rhizobacteria on the growth and nodulation of mungbean

S. No.	Treatments	Root length (cm)	Shoot length (cm)	Nodule number (no./plant)	Nodule dry weight (g/plant)
1	T ₁ - <i>Rhizobium</i> (Local best)	12.40	32.60	31.30	0.043
2	T ₂ - <i>Rhizobium</i> + NE 10 (<i>Bacillus cereus</i>) (Pantnagar Ch.)	11.93	36.46	44.33	0.057
3	T ₃ - <i>Rhizobium</i> + <i>Pseudomonas</i> spp. (Coimbatore)	13.00	31.53	41.60	0.052
4	T ₄ - <i>Rhizobium</i> + LMSR 45 (<i>Pantoea agglomerans</i>) (Ludhiana)	12.20	34.60	43.66	0.053
5	T ₅ - <i>Rhizobium</i> + <i>Methylobacterium</i> (Coimbatore)	12.26	41.46	53.30	0.069
6	T ₆ - N as per RDF	11.73	33.53	26.30	0.04
7	T ₇ - Uninoculated control	12.46	30.00	23.00	0.032
	SE(d)	0.70	2.67	5.27	0.008
	CD (@ 5%)	1.53	5.82	11.48	0.017

Among rhizobacteria *Methylobacterium* (Coimbatore) recorded more number of nodules/plant (53.3/plant) and nodule dry weight (0.069 g/plant) which is higher than other rhizobacteria. This was followed by NE 10 (*Bacillus cereus*) (Pantnagar Ch.) which recorded 44.3 nodules/plant and nodule dry weight (0.057 g/plant). Uninoculated control recorded the least nodulation as 23/plant which is significantly lesser than all the other treatments (Table 6). The results corroborated with the findings of Korir *et al.*, 2017^[4], concluded that co-inoculation of the rhizobia strains with the PGPR generally enhanced the nodulation of common bean compared to single rhizobial inoculation. *Bacillus megaterium* + IITA-PAU 987 and *B. megaterium* + CIAT 899 resulted in extra abundant nodulation of the common bean. This was followed by IITA-PAU 983 + *Bacillus megaterium* and IITA-PAU 983 + *P. polymyxa* that recorded abundant nodulation. However, inoculation with CIAT 899 alone recorded a higher nodulation compared to CIAT 899 + *P. polymyxa* and IITA-PAU 987 + *P. polymyxa*. This implies that different PGPR

vary in their ability to increase nodulation when co-inoculated with the rhizobia strains with co-inoculation with *B. megaterium* showing higher response than *P. polymyxa*. Inoculation of common beans with rhizobial strains significantly increased the number of nodules of common bean over the control. The rhizobia inoculated treatment had abundant nodulation with the control having moderate nodulation. Application of mineral nitrogen recorded the least (Few) number of nodules. Co-inoculation of rhizobia strains with the PGPR increased the nodule fresh weight as compared to single rhizobia inoculation. Root nodules accommodate various non-nodulating bacteria having definite influence on the survival, nodulation, and grain yield of crop (Mishra *et al.*, 2009)^[5] reported the isolation of *Paenibacillus polymyxa* HKA-15, a Gram-positive bacterium from root nodules of soybean. A total of 75 endophytic bacteria isolated from nodules of field pea and 88 from nodules of chickpea showed that 93.4% in were Gram positive (Narula *et al.*, 2013)^[6]. Diep *et al.* (2016)^[2] also isolated endophytic bacteria in soybean root nodules.

Table 2: Effect of different multifunctional rhizobacteria on biomass & yield in mungbean

S. No.	Treatments	Pods per plant (no/plant)	Plant dry weight (g/plant)	Yield (kg/ha)
1	T ₁ - <i>Rhizobium</i> (Local best)	26.06	19.00	880.0
2	T ₂ - <i>Rhizobium</i> + NE 10 (<i>Bacillus cereus</i>) (Pantnagar Ch.)	30.06	20.26	990.0
3	T ₃ - <i>Rhizobium</i> + <i>Pseudomonas</i> spp. (Coimbatore)	29.73	18.86	960.0
4	T ₄ - <i>Rhizobium</i> + LMSR 45 (<i>Pantoea agglomerans</i>) (Ludhiana)	30.46	19.20	893.3
5	T ₅ - <i>Rhizobium</i> + <i>Methylobacterium</i> (Coimbatore)	38.33	26.86	1115.3
6	T ₆ - N as per RDF	23.53	20.83	838.6
7	T ₇ - Uninoculated control	19.53	16.20	708.0
	SE(d)	2.14	2.51	42.03
	CD (@ 5%)	4.65	5.47	92.43

Crop was harvested at 65 DAS and yield parameters viz., number of pods per plant, plant dry weight and yield were recorded and tabulated (Table 2). The inoculated treatments recorded higher values for number of pods/plant and plant dry weight when compared to the uninoculated control. Among the different rhizobacteria *Methylobacterium* (Coimbatore) inoculated treatment recorded the higher yield of 1115.3 kg/ha followed by NE 10 (*Bacillus cereus*) (Pantnagar Ch.) (990 kg/ha). The results agreed with the yield parameters of Verma *et al.* (2012) [11] suggested that the plants grown with combination showed increased root and shoot weight suggesting a promising way for enhancing the growth of legume crops. aswellas showed significant results with the combination of *Mesorhizobium* sp. BHURC02 with *B. megaterium*, to be superior over uninoculated control. Results from the contrast analysis showed that co-inoculation of common bean with rhizobia strain and the two PGPR strains were comparable to mineral nitrogen addition. Therefore, these strains can be used in the formulation of agricultural product and provide cheaper alternative to farmers in production of common bean in such soils.

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Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical Issues: None

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