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Response of greengram (*Vigna radiata*) to biofertilizers under different fertility levels*

AMIT KUMAWAT[1], B L PAREEK[2] and R S YADAV[3]

Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan 334 006

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In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated application of alternate sources of nutrients for sustaining the desired crop productivity (Tiwari 2002). In integrated nutrient management supply system, biofertilizers is one of the important components. Further, biofertilizers are low cost and eco-friendly input have tremendous potential of supplying nutrients which can reduce the chemical fertilizer dose by 25–50% (Pattanayak *et al.* 2007). For increased N supply through biofertilizers, there is a need for improving the efficiency of biological nitrogen-fixation system. Phosphorus-solubilizing bacteria species like *Bacillus polymyxa* and *Psuedomonas striata* are also reported to be beneficial in increasing the P availability in soil and thereby seed yield of pulses (Gupta 2006). Hence, there is a need to inoculate the crops with effective strains of these micro-organisms which improve nutritional environment of the soil by applying the deficient nutrients needed for biological N_2-fixation and solubilizing the native and added phosphorus. However, meager information is available on the combined effect of *Rhizobium* and phosphorus-solubilizing bacteria (PSB) inoculation along with fertilizer nutrients in greengram [*Vigna radiata* (L.) Wilczek] for maintaining higher crop productivity and soil fertility.

An attempt was made to study the response of greengram to biofertilizers under different fertility levels. Field experiment on greengram was conducted during rainy *(kharif)* season of 2007 at Agronomy Farm, College of Agriculture, Bikaner, Rajasthan. The soil was loamy sand with *p*H 8.2, available N 78.8 kg/ha, P 16.3 kg/ha and K 180.4 kg/ha. The treatments comprised 4 biofertilizer inoculations treatments (control, *Rhizobium*, phosphate-solubilizing bacteria (PSB) and *Rhizobium* + PSB) and 4 fertility levels (control, 10 kg N + 10 kg P_2O_5, 15 kg N + 20 kg P_2O_5 and 20 kg N + 30 kg P_2O_5/ha) and were laid out in randomized block design (factorial) with 3 replications. The quantity of nitrogen and phosphorous was drilled manually through urea and single superphosphate, respectively as per treatment prior to sowing at a depth of 8–10 cm in furrows. 'RMG 268' greengram was sown in rows spaced 30 cm apart on 17 July 2007 and harvested 65 days after sowing. Crop received 121.7 mm of rainfall in 7 rainy days during the growing season. Evaporation ranged from 5.9 to 12.6 mm/day during the crop growing period.

Dual inoculation of seed with *Rhizobium* + PSB recorded significantly higher plant height, number of branches/plant, root nodules/plant (Table 1) as compared to control and all other treatments. Generally, overall improvement in the crop growth under the influence of microbial fertilization, i e *Rhizobium*, PSB and *Rhizobium* + PSB seems to be on account of their impact on nutritional environment and involvement in various physiological processes in the plant system which are considered to be pre-requisite growth of

Table 1 Effect of biofertilizers and fertility levels on plant height, number of branches and number of root nodules

Treatment	Plant height (cm)	Branches/ plant (at harvest)	Root nodules/plant	
			30 DAS	45 DAS
Biofertilizer				
Control	29.9	4.1	25.4	28.2
Rhizobium	38.5	4.7	29.5	32.3
PSB	43.4	4.5	32.9	34.8
Rhizobium + PSB	46.9	5.3	35.1	36.3
SEm±	1.1	0.1	0.8	0.9
CD (*P* = 0.05)	3.3	0.3	2.5	2.7
Fertility level (kg/ha)				
Control	32.3	3.9	26.4	28.1
10 kg N + 10 kg P_2O_5	38.8	4.6	29.8	32.2
15 kg N + 20 kg P_2O_5	42.7	5.0	32.6	35.0
20 kg N + 30 kg P_2O_5	45.0	5.1	34.1	36.4
SEm±	1.1	0.1	0.8	0.9
CD (*P* = 0.05)	3.3	0.3	2.5	2.7

DAS, Days after sowing

*Short note

[1]Student,Department of Agronomy (amit.skn@rediffmail.com)

[2]Assistant Professor (Agronomy) (pareek_bl@yahoo.co.in)

[3]Associate Professor & Head ((rsy.1961@gmail.com), Department of Agronomy.

Table 2 Effect of biofertilizers and fertility levels on yield attributes and yield

Treatment	Yield attributes			Yield (kg/ha)	
	Pods/ plant	Seeds/ pod	Test weight (g)	Seed	Straw
Biofertilizer					
Control	13.5	8.8	32.4	564	997
Rhizobium	18.1	10.0	34.6	663	1164
PSB	17.4	9.9	33.5	647	1138
Rhizobium + PSB	19.5	10.7	35.7	813	1315
SEm±	0.3	0.3	0.5	22	35
CD (P = 0.05)	1.1	0.8	1.4	63	101
Fertility level (kg/ha)					
Control	11.8	8.3	31.9	448	870
10 kg N + 10 kg P_2O_5	16.7	9.6	33.4	621	1119
15 kg N + 20 kg P_2O_5	18.9	10.6	35.3	778	1265
20 kg N + 30 kg P_2O_5	20.9	10.9	35.4	839	1361
SEm±	0.3	0.3	0.5	22	35
CD (P = 0.05)	1.1	0.8	1.4	63	101

the crop. Better nodulation in combined inoculation might be due to increased P availability through PSB and enhanced biological N_2-fixation in greengram (Gupta 2006). Synergism in *Rhizobium* and PSB might have also resulted in better nodulation with their dual inoculation as against single inoculation (Kumar and Chandra 2003). Dual inoculation of greengram seed with *Rhizobium* + PSB recorded maximum and significantly higher number of pods/plant, seeds/pod, test weight, seed and straw yield over control (Table 2). However, seed and straw yields obtained with *Rhizobium* and PSB alone were remained at par with each other but proved superiority over control. Such increases in yield and yield-attributing characters might be due to the fact that *Rhizobium* inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield (Sardana *et al*. 2006). The combined application of *Rhizobium* + PSB significantly improved the N and P uptake and the magnitude of significant increase in N uptake was 72.8, 33.7 and 39.6% in seed and 66.3, 25.1 and 33.2% in straw, whereas P uptake was 83.1, 36.8 and 29.1% in seed and 59.1, 22.2 and 17.9% in straw by greengram, respectively over the control, *Rhizobium* and PSB alone. The uptake of N and P might have increased due to increased content and biological yield with the use of biofertilizers. Similar findings were reported by Govindan and Thirumurgan (2005) in soybean. Dual inoculation with *Rhizobium* + PSB also recorded maximum net returns and B: C ratio (Table 3).

Application of 15 kg N + 20 kg P_2O_5/ha significantly increased the plant height, number of branches/plant, root nodules/plant and statistically at par with the treatment of 20 kg N + 30 kg P_2O_5. Since phosphorus has a specific role in nodule formation and microbial activities in the soil, the adequate supply of this nutrient might have increased the utilization of smaller dose of nitrogen thus the higher fertility level of 20 kg N + 30 kg P_2O_5/ha could not prove beneficial in enhancing growth attributes significantly than application at lower dose of 15 kg N + 20 kg P_2O_5/ha. similar results were also reported by Mishra (2003). Application of 15 kg N + 20 kg P_2O_5/ha significantly increased the number of pods/plant, seeds/pod, test weight, seed and straw yield over lower levels and control. The application of 15 kg N + 20 kg P_2O_5/ha was found at par with 20 kg N + 30 kg P_2O_5/ha and increased the seed yield by 73.6 and 25.2% and straw yield by 45.4 and 13.0% over the control and 10 kg N + 10 kg P_2O_5/ha, respectively. It is well established fact that seed yield of a crop is a function of yield attributes such as number

Table 3 Effect of biofertilizers and fertility levels on nutrient uptake, quality, net returns and B:C ratio of greengram

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		Protein content (%)	Net returns (Rs/ha)	B : C ratio
	Seed	Straw	Seed	Straw			
Biofertilizer							
Control	18.80	13.21	2.01	1.69	20.47	5 598	1.83
Rhizobium	24.30	17.55	2.69	2.20	22.55	7 711	2.13
PSB	23.27	16.49	2.85	2.28	22.13	7 365	2.08
Rhizobium + PSB	32.49	21.97	3.68	2.69	24.34	10 832	2.57
SEm±	1.20	0.76	0.12	0.10	0.49	461	
CD (P = 0.05)	3.45	2.18	0.35	0.27	1.40	1 329	
Fertility level (kg/ha)							
Control	14.22	11.00	1.58	1.49	19.80	3 804	1.63
10 kg N + 10 kg P_2O_5	21.89	16.36	2.53	2.09	21.77	6 852	2.02
15 kg N + 20 kg P_2O_5	29.77	19.83	3.40	2.52	23.58	9 891	2.43
20 kg N + 30 kg P_2O_5	32.98	22.02	3.73	2.75	24.34	10 960	2.53
SEm±	1.20	0.76	0.12	0.10	0.49	461	
CD (P = 0.05)	3.45	2.18	0.35	0.27	1.40	1 329	

of pods/plant, seeds/pod and test weight. The increase in these yield attributes due to fertilization might have increased seed yield of greengram. The increase in seed yield with these treatments was also largely due to high harvest indices that show high partitioning of the plant assimilates towards the sink. Significant increase in straw yield could be attributed to the increased vegetative growth possibly a result of effective utilization of nutrients absorbed through extensive root system developed under phosphate fertilization (Kumar and Kushwaha 2006). Application of 15 kg N + 20 kg P_2O_5/ha being at par with 20 kg N + 30 kg P_2O_5/ha significantly enhanced N and P uptake in seed and straw of greengram crop over the control and 10 kg N + 10 kg P_2O_5/ha. The seed protein content also increased significantly up to application of 15 kg N + 20 kg P_2O_5/ha. This might be due to improved nutritional environment in the rhizosphere as well as its utilization in the plant system leading to enhanced translocation to reproductive structure, viz pods, seeds and other plant parts. The nitrogen fertilization to greengram crop increases the cation exchange capacity of roots, thereby enabling them to absorb more phosphorus from the soil thus, N and P might have been utilized in greater quantities due to their abundant availability (Nadeem *et al*. 2004). Since uptake of nutrient is a function of their content and yield. Increase in seed and straw yield along with higher content of N and P might have resulted in higher uptake of these nutrients by the crop. Application of 15 kg N + 20 kg P_2O_5/ha also fetched significantly higher net returns over control and 10 kg N + 10 kg P_2O_5/ha.

SUMMARY

An experiment was conducted during rainy *(kharif)* season of 2007 to study the response of greengram [*Vigna radiata* (L.) Wilczek] to biofertilizers under different fertility levels. Inoculation of *Rhizobium* + PSB and application of 15 kg N + 20 Kg P_2O_5/ha significantly increased the growth, i e number of branches/plant and root nodules/plant and yield-attributing characters, i e pods/plant, seeds/pod, test weight and consequently seed and straw yield. Dual inoculation of *Rhizobium* + PSB and 15 kg N + 20 kg P_2O_5/ha significantly increased the N and P uptake by seed and straw, protein content of seed, net returns and had higher B: C ratio also.

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