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B Bhabai
Dept. of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal, India

D Mukhopadhyay
Dept. of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal, India

B Mitra
Dept. of Agronomy, Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal, India

Correspondence
B Bhabai
Dept. of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal, India

Effect of biofertilizer and phosphorus on green gram (*Vigna radiata*)

B Bhabai, D Mukhopadhyay and B Mitra

Abstract
A pot experiment was conducted during pre-kharif season, 2017 at Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal to investigate the effect of biofertilizer on production potential of greengram. The plants were grown in pots containing soils amended with consortium of Rhizobium + Vasicular Arbascular Micorrhizae + Phosphate Solubilizing Bacteria. Four treatments comprising of P at 0, 20, 40, 60 kg/ha along with the above consortium culture in soil were applied in soil. Growth parameters of the crop at two stages such as after 45 days and after 65 days were recorded. The important agronomic parameters (shoot length, root length, effective root nodule plant-1, plant height, pods/plant and pod length) were significantly influenced by the addition of biofertilizer packages along with graded doses of phosphorus. The maximum pods plant-1 was recorded at P3 suggesting that even at the lower dose of phosphorus @ 40 kg ha-1 (P2) could bring about less variability on yield obtained @ 60 kg ha-1(P3).

Keywords: Mungbean, consortium culture, biofertilizer, phosphorus etc.

Introduction

Plant roots takes up P from soil mostly as the primary orthophosphate (H2PO4-) ion, but it is taken up also in the form of secondary orthophosphate ions from the soil as is found that with the increase in soil pH, the amount of secondary orthophosphate form of P increases in soil (Tiwari, 2012) [17]. About 98% of Indian soil have inadequate supply of Phosphorus (Hasan, 1996; Thiyageshwari and Selvi, 2006) [7, 16] although, the total N content in soils is somewhat high. Because of the P fixation by soil constituents and phosphate runoff in P loaded soil, applied phosphatic fertilizer is not used completely (Goldstein, 1986; Del Campillo *et al.*, 1999) [6, 4]. When phosphatic fertilizer is added to soil in the form of available P2O5, gets fixed in the soil and becomes unavailable for plant growth. The role of micro-organism including PSB (Phosphate Solubilizing Bacteria) and VAM (Vasicular Arbascular Micorrhizae) in solubilizing and mobilizing inorganic phosphate in soil and making them available to plants is important (Pal, 1998; Hilda and Fraza, 1999; Bhattacharya and Jain, 2000) [11, 8, 2]. The PSB convert the insoluble Phosphate into soluble forms by acidification, chelation, exchange reaction and production of gluconic acid (Rashid *et al.*, 2004; Rodriguez *et al.*, 2004; Chung *et al.*, 2005) [13, 15, 3]. Greengram is most important pulse crop in India for grain, forage and greenmanure purpose. However, requirement of pulses is growing due to explosion of population, although, there is limitation in its production maximization. Along with other constituents, fertilizer is one of the most important constraints to reduce the pulse production. Fertilizers are costly for farmers for securing higher yield. Phosphorus is very important mineral element for pulse crops, as it is a major constituent of protein and nucleic acids (Gajera *et al.*, 2014) [5]. The cost of nitrogenous and phospatic fertilizer are increasing day by day. Hence, Proper and effective use of fertilizer is very important. Biofertilizer like Rhizobium and PSB takes an important role in enhancing availability of N and P through increase in biological fixation of atmospheric N and increasing the phosphorus availability to plants (Gajera *et al.* 2014) [5]. The microorganism responsible for P solubilization and mobilization with PSB, VAM and rhizobium for fixation of inorganic N is used to root zone of crop plant as inoculants which partially solublize the insoluble phosphate and fix the atmospheric N respectively and hence, improve the fertilizer use efficiency and the productivity of the given crop. (Gajera *et al.* 2014) [5]. Based on the above perspectives, the present experiments were conducted to understand the behaviour of P in some soils of West Bengal with a view to – Asses the effect of biofertilizer on production potential of Greengram (*Vigna radiata*).

Materials and Methods

A pot culture study was conducted during pre-kharif season to study the effect of biofertilizer on production potential of greengram on Uttar Banga Krishi Viswavidyalaya. Seeds of greengram (*Vigna radiata*) were sown (Cv. Pusa baishakhi) in circular earthen pots containing 5kg soil, which was collected from instructional farm of University. The experiment were laid out in factorial CRD with three replications.

Nitrogen and Potassium was applied @20 kgha-1 as basal in the form of urea and Muriate of Potash (MOP) respectively and Phosphorus was applied in Single Super Phosphate (SSP). Biofertilizer were applied in crop as consortium of Rhizobium +Vasicular Arbascular Micorrhizae (VAM) + Phosphate Solubilizing Bacteria (PSB) and was applied in soil @12.5 kgha-1 and by seed biopriming @10gkg-1 of seeds. Strain of the Rhizobium sp. and PSB were URH-3 and UBPS-9 respectively. The Rhizobium sp. and PSB were taken from Bio-control Agent Production and Service Centre, Department of Plant Pathology, Uttar Baga Krishi Viswavidyalaya and the VAM was taken from Agro Bio-tech Research Centre Ltd., Kottayam, Kerala.

Instruments used

Spectrophotometer: During the study of the visible spectroscopic characteristic of phosphorus of the experimental soils, a systronics make digital spectrophotometer (Model: Systronics Visiscan 167) was used.

Details about treatment

Uninoculated	
Treatment	Doses
P0	Control
P1	20 kgha-1
P2	40 kgha-1
P3	60 kgha-1
Inoculated	
Treatment	Doses
P0	Control +Biofertilizer
P1	20 kgha-1 + Bio-fertilizer
P2	40 kgha-1 + Bio-fertilizer
P3	60 kgha-1 + Bio-fertilizer

Methods of Bio-priming

- Seeds were pre-soaked in water for 12 hours.
- Consortium culture of biofertilizers were mixed with the pre-soaked seeds @ 10gkg-1 of seeds.
- Treated seeds were put in small heap and covered with a moist jute sack to maintain high humidity.
- Seeds were incubated under high humidity for about 48 hours at approximately 25-32°C.
- Biofertilizers adhered to the seeds grew on the seed surface under moist condition to form a protective layer all around the seed coat.
- Seeds were sown in the pots.

Growth parameters of the crop at two stages (after 45 days and 65 days) were recorded. Plant parts were washed, oven dried and weighed. Estimation of Phosphorus In plant sample was carried out by Vanadomolybdo-phosphoric yellow colour method as described by (Jackson, 1967) [9].

Results and Discussion

Biofertilizer are microbial inoculants as cost effective, eco-friendly and renewable source of plant nutrients in sustainable agriculture system in India, which increase crop production through improving the nutrient supplier and their availability (Wani and Lee, 2002) [18]. The biofertilizers being the kingpin of modern agriculture boosted not only the food production but also shows the positive effects on physicochemical properties of soil, nitrogen transformation, macro and micro nutrients uptake and nutritional composition (Mahesh and Hosmani, 2004) [10]. In this experiment, inoculation of bioferilizer (Rhizobium+PSB+VAM) significantly increased the dry matter accumulation at different days after sowing (Table 1 and Table 2). The maximum biomass production 3.03 g/plant was observed at (P3 + Biofertilizer) at 45 days (Table 1) and about 4.90 g at 65 days (Table 2). The use of biofertilizer alone with graded doses of phosphorus significantly increased the total P uptake by mungbean (Table 3). The uptake of P (g plant-1) were 0.87 at after 45 days and 0.77 at after 65 days under uninoculated condition, while the same were 1.41 at after 45 days and 1.63 at after 65 days respectively at the inoculated condition at P3. Significant interactions effect between the biofertilizer and P was observed for the total uptake of P, both at after 45 days and 65 days. This is supported by (Zaidi *et al.*, 2006) [20] in their experiment which was conducted to evaluate the effects of nitrogen fixing bacteria [*Bradyrhizobium* sp. (*Vigna*)], phosphate solubilising bacterium (*Bacillus subtilis*), phosphate solubilizing fungus (*Aspergillus awamori*) and AM fungus (*Glomus fasciculatum*). Triple inoculation of AM fungus, *Bradyrhizobium* sp. (*Vigna*) and *B. subtilis* significantly increased dry matter yield, chlorophyll content in foliage and N and P uptake of green gram plants. Also triple inoculation of *Bradyrhizobium* + *G. fasciculatum* + *B. subtilis* increased seed yield by 24%, than control (Zaidi *et al*, 2006) [20]. The important agronomic parameters (shoot length, root length, effective root nodule plant-1, plant height and pod length) were significantly influenced by the addition of biofertilizer packages along with graded doses of phosphorus (Table 1 and Table 2). The maximum pods plant-1 was recorded at P3 (60 kg ha-1) mixed with biofertilizer (Table 2) which was close to the pod yield plant-1 at P2 (40 kg ha-1) mixed with biofertilizer suggesting that, lower dose of phosphorus @ 40 kg ha-1 mixed with biofertilizer could bring about significant yield increase of mungbean over that of high dose of P, i.e, 60 kg ha-1 and the phosphorus use efficiency might be increased by proper management practices. Bansal (2009) [1] found that seed inoculation of mungbean with *Rhizobium* + PGPR + PSB, gave significantly increase the number of nodules per plant and dry weight of nodules per plant over control. Pir *et al.* (2009) [12] conducted an experiment on greengram and revealed that greengram crop with 5t FYM ha-1 conjugated with 40 kg P2O5 ha-1 through rock phosphate + seed inoculation with PSB gave highest values of plant height, pods per plant, nodule count and test weight. Yadav *et al.* (2010) [19] reported that the number of nodules, nodule dry weight, dry weight of root and shoot at flowering stage were increased significantly by seed inoculation of mungbean with PGPR combination of *Rhizobium* + *Azotobacter* + *Pseudomonas* +*Aspergillus* + *Trichoderma* overcontrol. The increase of seed yield may be owing to increase in P availability by solubilization of phosphate rich compound. A number of organic acids is secreted by PSB which may form chelates resulting in effective solubilization of phosphate, helped higher nitrogen fixation, dry matter accumulation, rapid plant growth, higher absorption and utilization of P and other plant nutrients and ultimately positive resultant effect on growth and finely yield attributes (Rathour *et al.*, 2015) [14]. The available phosphorus in soils (Table- 4) was increased significantly both at after 45 days and after 65 days of the mungbean over control, irrespective of the inoculation and the build-up was increased with increasing doses of P in soils. The maximum available ‘P’ was kg ha-1 at 45 days when applied with P @ 40 kg ha-1 under inoculated condition. The available P in soil was relatively lower at 65 days over that of at 45 days, might be due to the increasing ‘P’ utilization by the plants for uptake and dry matter production by the crop during 45 days of mungbean. The results indicated a positive role of biofertilizers in general and phosphate solublizer and VAM in association with rhizobium, in productivity improvement of mungbean under *Terai* agro-ecological region of West Bengal.

Conclusion

The use of biofertilizer alone with graded doses of phosphorus significantly increased the total P uptake by mungbean. Significant interactions between the biofertilizer and P was observed for the total uptake of P. The important agronomic parameters were significantly influenced by the addition of biofertilizer packages along with graded doses of phosphorus. The lower dose of phosphorus @ 40 kg ha-1 mixed with biofertilizer could bring about significant yield increase of mungbean over that of high dose of P, i.e, 60 kg ha-1. The available phosphorus in soils was increased significantly irrespective of the inoculation. The maximum available ‘P’ was 33.27 kg ha-1 at 45 days when applied with P @ 40 kg ha-1 under inoculated condition. Hence, use of biofertilizer in consortium mode will be useful tool to sustain the biomass production in acidic situation under judicious application of phosphatic fertilizers, where the biomass thus produced, might be a source of organic matter on decomposition, besides supplying nutrients like N and P for the succeeding cereal crops.

Table 1: Mean value of agronomic parameters of green gram at after 45 days

	Treatment	Shoot length (cm)	Root length (cm)	Plant height (cm)	wt./Plant (g)
Uninoculated	P_0	18.87	5.50	24.37	1.20
	P_1	30.67	6.90	37.57	1.83
	P_2	32.40	7.70	40.10	2.27
	P_3	38.77	8.70	47.47	3.00
Inoculated	P_0	18.87	5.50	24.37	1.20
	P_1	34.83	9.50	44.33	1.93
	P_2	39.73	11.60	51.33	2.80
	P_3	42.83	14.07	56.90	3.03
Biofertilizer	SE(m)±	2.42	0.19	0.30	0.041
	LSD (*P*=0.05)	5.13	0.41	0.63	0.124
Phosphorus	SE(m)±	3.42	0.27	0.42	0.058
	LSD (*P*=0.05)	7.25	0.57	0.89	0.175
Biofertilizer X Phosphorus	SE(m)±	4.84	0.38	0.59	0.082
	LSD (*P*=0.05)	10.25	0.81	1.26	0.247

Table 2: Mean value of agronomic parameters of greengram at 65 days

	Treatment	Shoot length (cm)	Root length (cm)	Effective root nodule/plant	Plant height (cm)	Pod length (cm)	Dry wt./Plant (g)	Pods/ plant
Uninoculated	P_0	21.60	7.17	18.67	28.77	6.33	1.73	14.67
	P_1	33.10	8.60	24.33	41.70	7.00	2.57	17.67
	P_2	34.97	9.63	27.67	44.60	8.33	3.43	20.33
	P_3	39.83	11.67	30.33	51.50	10.00	4.10	21.33
Inoculated	P_0	21.60	7.17	18.67	28.77	5.33	1.73	14.67
	P_1	37.10	12.10	30.33	49.20	7.00	3.23	19.33
	P_2	40.10	14.77	32.67	54.87	8.67	4.37	21.67
	P_3	44.00	16.50	34.33	60.50	10.33	4.90	22.67
Biofertilizer	SE(m)±	0.227	0.265	1.648	0.387	0.344	0.041	0.449
	LSD (*P*=0.05)	0.482	0.561	1.457	0.820	0.728	0.122	0.951
Phosphorus	SE(m)±	0.321	0.375	0.687	0.547	0.486	0.058	0.635
	LSD (*P*=0.05)	0.681	0.794	2.060	1.160	1.030	0.173	1.345
Biofertilizer X Phosphorus	SE(m)±	0.454	0.530	0.972	0.774	0.687	0.082	0.898
	LSD (*P*=0.05)	0.963	1.123	2.914	1.641	1.457	0.245	1.903

Table 3: Effect of phosphorus and biofertilizers on P content of green gram

	Treatment	Plant phosphorus: Total uptake (g plant^{-1}) 45 days	65 days	Grain (%)
Uninoculated	P0	0.16	0.12	0.320
	P1	0.47	0.42	0.364
	P2	0.61	0.67	0.392
	P3	0.87	0.77	0.428
Inoculated	P0	0.23	0.18	0.320
	P1	0.81	0.95	0.439
	P2	1.15	1.40	0.479
	P3	1.41	1.63	0.499
Biofertilizer	SE(m)±	0.013	0.010	0.001
	LSD (*P*=0.05)	0.039	0.030	0.002
Phosphorus	SE(m)±	0.018	0.014	0.001
	LSD (*P*=0.05)	0.054	0.043	0.003
Biofertilizer X Phosphorus	SE(m)±	0.026	0.020	0.001
	LSD (*P*=0.05)	0.077	0.060	0.004

Table 4: Effect of phosphorus and biofertilizers on available phosphorus in soil at 45 and 65 days

	Available phosphorus (kg ha^{-1})		
	Treatment	45 days	65 daysf
Uninoculated	P0	13.74	12.29
	P1	20.61	18.26
	P2	25.31	22.06
	P3	30.37	28.57
Inoculated	P0	13.74	12.29
	P1	22.24	19.89
	P2	27.30	25.67
	P3	33.27	30.55
Biofertilizer	SE(m)±	0.54	0.27
	LSD (*P*=0.05)	1.15	0.82
Phosphorus	SE(m)±	0.76	0.39
	LSD (*P*=0.05)	1.62	1.17
Biofertilizer X Phosphorus	SE(m)±	1.08	0.55
	LSD (*P*=0.05)	2.29	1.65

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