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Short Communication

INFLUENCE OF PHOSPHORUS AND PHOSPHORUS SOLUBILISING BACTERIA ON PERFORMANCE OF GREEN GRAM AND SOIL PROPERTIES

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Pulses form an integral part of the vegetarian diet of the large population of India, besides being rich source of protein and amino acids; they maintain soil fertility through the process of nitrogen fixation in symbiotic association with *Rhizobium* bacteria which helps in sustaining productivity of agricultural soil. Green gram is one of the most important pulse crop grown in almost all part of the country. India is the largest producer and consumer of green gram. Phosphorus plays a vital role in photosynthesis, respiration, energy storage, energy transfer, cell division, cell elongation and several other processes within plant system. It promotes early root formation, growth and improves harvest index of crops. Phosphorus, when applied to legumes, enhances the activity of *Rhizobia* by increasing nodulation and thereby helps in atmospheric nitrogen fixation. Biofertilizers having the capability to fix atmospheric nitrogen or to transform native soil nutrients such as phosphorus, zinc, copper, iron, sulphur etc., from the non-useable (fixed) to useable form through biological processes. Biofertilizers are the ultimate renewable sources and have played potential role in evolving judicious combinations with chemical fertilisers to further supplement the nutrient requirements of crops. Therefore, an attempt was made to study the influence of phosphorus and phosphorus solubilising bacteria on performance of green gram (*Vigna radiata* L.Wilczek) under acidic soil condition of Nagaland.

A pot experiment was carried out in the pot house of the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland with green gram (cv. K 851) as the test crop. The experimental soil was sandy loam with pH 5.52, organic carbon 15.0 g kg^{-1} and available N, P & K status 301.0, 21.5 & 196.0 kg ha^{-1}, respectively. The experiment was laid out in CRD design with five levels of phosphorus viz. 0, 25, 50, 75 and 100 kg P_2O_5 ha^{-1} and two levels of phosphorus solubilising bacteria viz. uninoculated and inoculated. Earthen pots of 30cm diameter size were filled with 8 kg of soil. Recommended doses of nitrogen and potash @ 20 and 40 kg ha^{-1} respectively were applied through urea and muriate of potash. Phosphorus level was developed through single super phosphate and all fertilisers were incorporated into pots two days prior to sowing of the crop. PSB was applied as seed treatment method. Seeds of all pots were treated with *Rhizobium* culture. Biofertilizers was used @ 200g per 10 kg of seed. Three seeds in each pot were sown on 10th August, 2013 at a depth of 5 cm at optimum soil moisture level to ensure proper germination. Thinning was done ten days after germination and one healthy plant in each pot was allowed to grow.

Table 1: Growth, yield and total uptake of nutrients in green gram as influenced by phosphorus and phosphorus solubilising bacteria

Treatment	Plant height (cm)	Pods $plant^{-1}$	Seeds pod^{-1}	Yield (g pot^{-1})			Nutrient uptake (mg pot^{-1})		
				Seed	Stover	Protein	N	P	K
Phosphorus (kg ha^{-1})									
0	33.50	12.6	8.0	7.77	13.88	1.56	440.6	31.5	267.6
25	37.00	13.3	8.1	8.20	14.33	1.80	481.4	37.2	326.9
50	38.66	16.0	8.4	10.16	15.21	2.35	594.7	48.5	370.2
75	41.50	17.0	8.7	10.65	15.58	2.51	639.4	55.5	407.8
100	39.66	15.1	8.5	9.98	15.25	2.31	596.4	51.0	373.4
SEm±	0.93	0.44	0.11	0.38	0.29	0.10	23.4	1.8	13.3
CD (P=0.05)	2.75	1.30	0.32	1.13	0.87	0.31	69.3	5.3	39.5
PSB									
Uninoculated	35.93	14.3	8.3	8.69	14.57	1.92	513.9	38.0	318.3
Inoculated	40.20	15.3	8.4	10.01	15.13	2.30	587.1	51.4	380.1
SEm±	0.59	0.27	0.07	0.24	0.18	0.06	14.8	1.1	8.4
CD (P=0.05)	1.74	0.82	NS	0.71	0.55	0.19	43.8	3.4	25.0

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Weeding was done at regular interval to check the weed growth. The data on plant height, number of pods plant^{-1}, number of seeds per pod and grain and stover yield were recorded. Plant samples were analysed for N by Kjeldahl method. Phosphorus and potassium in plant samples were determined in diacid (HNO_3, $HClO_4$) extract by advocating standard procedure (Jackson 1973). Post crop harvest soil samples were collected and analyzed for pH, organic carbon and available N, P & K using standard procedures (Jackson 1973).

A perusal of data (Table 1) indicates that significantly taller plants were produced with phosphorus and PSB application over control and maximum plant height was recorded with 75 kg P_2O_5 ha^{-1} which was at par with 50 kg P_2O_5 ha^{-1}. This might be due to involvement of phosphorus in energy transformation and cell division. Furthermore, phosphorus also help in better root growth resulted plant extract more nutrient and moisture from deeper soil layer leading to better growth and development. These results are in accordance with those of Kanwar *et al.* (2013). PSB increased availability of phosphorus in the soil and favoured higher absorption and utilization of phosphorus as well as other nutrients resulted positive effect on plant growth (Walpola and Yoon 2013). Number of pods per plant was affected significantly with phosphorus and PSB application and maximum value was recorded with 75 kg P_2O_5 ha^{-1}. Application of phosphorus @ 50, 75 and 100 kg P_2O_5 ha^{-1} increased seeds per pod significantly over control. Highest number of seeds pod^{-1} was recorded at 75 kg P_2O_5 ha^{-1}. It might be due to involvement of phosphorus in flowering and fruiting including seed development. PSB inoculation could not produce significant effect on number of seeds per pod. Phosphorus and PSB application had significant beneficial effect on seed, stover and protein yield of green gram. Seed, stover and protein yield increased with application of phosphorus up to 75 kg P_2O_5 ha^{-1} and beyond this level yield was decreased. However, 50 kg P_2O_5 ha^{-1} was at par to 75 kg P_2O_5 ha^{-1} in this regard and proved optimum level. Application of 50 kg P_2O_5 ha^{-1} increased seed, stover and protein yield to the extent of 30.7, 9.6 and 50.6 % respectively over control. While the 75 kg P_2O_5 ha^{-1} increased seed, stover and protein yield by 37.1, 12.2 and 60.9%, respectively over control. Inoculation by PSB enhanced the seed, stover and protein yield by 15.2, 3.8 and 19.8%, respectively over control. Variation in the yield of green gram with different treatments might be due to variations in the yield components. Phosphorus and PSB application improved the root growth resulted plant absorbed more nutrients from soil for effective dry matter production and translocation of photosynthates from leaves to reproductive parts for better development of seeds (Kumawat *et al.* 2009 and Patel *et al.* 2013). Furthermore, probably sufficient nutrient supply is helpful in more assimilate production at certain stages of development than needed for growth and development and excess assimilate is stored in storage compounds (Kanwar *et al.* 2013). Total N uptake by green gram enhanced significantly with increasing levels of phosphorus and PSB inoculation. Increase in nitrogen uptake by green gram due to 25, 50, 75 and 100 kg P_2O_5 ha^{-1} was 9.2, 34.9, 45.1 and 35.3%, respectively over control. PSB inoculation increased N uptake by 14.2% over uninoculated. Higher N uptake with phosphorus and PSB application could be attributed to enhanced crop growth with increased N translocation and utilization into the plant system resulting in the enhancement of yield. The P uptake by green gram increased significantly with P and PSB application. Phosphorus uptake by green gram enhanced from 31.59 mg pot^{-1} in control to 55.52 mg pot^{-1} at 75 kg P_2O_5 ha^{-1}. PSB inoculation enhanced P uptake from 38.05 mg pot^{-1} to 51.49 mg pot^{-1}. Phosphorus uptake enhanced by 17.9, 53.6, 75.7 and 61.5% over control with application of 25, 50, 75 and 100 kg P_2O_5 ha^{-1}, respectively. PSB inoculation increased P uptake by 35.3% over uninoculated. The K uptake by green gram increased significantly with the application of phosphorus and PSB. Maximum K uptake (407.8 mg pot^{-1}) was recorded at 75 kg P_2O_5 ha^{-1}. Increase in potassium uptake by green gram due to application of 25, 50, 75 and 100 kg P_2O_5 ha^{-1} was 22.1, 38.3, 52.4, and 39.5%, respectively over control. PSB inoculation increased P uptake by 19.4% over uninoculated. Similar results were obtained by Vikram and Hamzehzarghani (2008) and Hojjat and Taherzadeh (2013).

Table 2: Post harvest soil properties as influenced by phosphorus and phosphorus solubilising bacteria

Treatment	**pH**	**Org. C (g kg^{-1})**	**Avail. nutrient status (kg ha^{-1})**		
			N	**pH**	**K**
Phosphorus(kg ha^{-1})					
0	5.51	15.8	352.5	18.3	205.8
25	5.48	16.0	356.1	21.1	203.4
50	5.40	16.5	364.1	22.4	203.5
75	5.46	16.6	370.8	23.6	204.7
100	5.32	16.3	370.1	24.5	204.9
SEm±	0.06	0.39	1.43	1.02	0.26
CD (P=0.05)	NS	NS	4.23	3.19	NS
PSB					
Uninoculated	5.49	16.2	361.5	20.1	203.2
Inoculated	5.44	16.3	363.9	22.3	203.7
SEm±	0.04	0.25	0.90	0.47	0.17
CD (P=0.05)	NS	NS	NS	1.25	NS

The pH of the post harvest soil ranged from 5.32 to 5.51 (Table 2). The pH of the soil was not affected significantly with the application of phosphorus and PSB. However, a slight reduction in soil pH was recorded with P application as compared to control (Muhammad and Gaibore 2012). Organic carbon content of soil varied from 15.8 to 16.6 g kg^{-1} and was not affected significantly with various treatments. Irrespective of treatments the available N status ranged from 352.5 to 370.8 kg ha^{-1}. Available N enhanced remarkably with P application, but PSB inoculation could not produced significantly effect on it. The increase in available nitrogen in the soil under phosphorus treated pots as compared to control indicated that phosphorus fertilization enhanced nitrogen fixation as well as nitrogen secretion by green gram which improved nitrogen status of the soil. These effects are in concordance with those of Yakubu *et al.* (2010). Available P ranged from 18.3 to 24.5 kg ha^{-1}. A significant increase in available P status was reported with phosphorus and PSB application over control. Low available P in control pots might be due to no addition of any external input and its mining from the soil by crop. Use of PSB also increased the available P of the soil might be due to secretion of some organic acid which solubilised the fixed phosphorus and convert it to plant available form (Chen *et al.* 2006). Available K content of the soil was not affected significantly. Hence P and PSB application may be helpful in improving the soil health in terms of available phosphorus and nitrogen. Similar findings have been also reported by Das *et al.* (2008). The results of the present study lead to a conclusion that application of 75 kg P_2O_5 ha^{-1} produced higher plant height, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed, stover and protein yield of green gram, but 50 kg P_2O_5 ha^{-1} was at par regarding these parameters. The N, P & K uptake improved remarkably by phosphorus and PSB application. Available P status of the post crop harvest soil also improved with the use of P and PSB. Hence, 50 kg P_2O_5 ha^{-1} and PSB application are recommended for better yield of green gram in Nagaland.

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