Annals of Plant and Soil Research 20(2): 120–124 (2018)

Influence of phosphorus and potassium on performance of green gram (*Vigna radiata* L.) in Inceptisols of Nagaland

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Received: March, 2018; Revised accepted May, 2018

ABSTRACT

A field experiment was conducted in randomized block design with three levels of phosphorus (0, 30, 60 kg P_2O_5 ha^{-1}) and three levels of potassium (0, 30, 60 kg K_2O ha^{-1}) at Medziphema in kharif season of 2016 to study the effect of P and K on performance of green gram. It was observed that 60 kg P_2O_5 ha^{-1} gave significantly higher plant height, number of branches per plant, number of pods per plant, grain yield, stover yield, nutrient content and nutrient uptake as compared to other levels of phosphorus. Application of potassium also significantly enhanced the growth, yield attributes, yields, nutrient content and uptake by green gram. Application of 60 kg P_2O_5 ha^{-1} increased the seed yield by 19.2% and stover yield by 46.2% over control. Application of 60 kg K_2O ha^{-1} increased the seed yield to the extent of 18.4% and stover yield up to 14.6% over control. Application of 60 kg P_2O_5 ha^{-1} increased protein yield to the extent of 27.8% over control and application of potassium also had significant effect on protein content of green gram. Phosphorus and potassium application markedly enhanced the N, P and K contents and their uptake. Total N uptake increased by 47.0 and 24.3%, P uptake by 102.9 and 31.1% and K uptake by 47.4 and 26.2% with application of highest levels of phosphorus and potassium, respectively. Phosphorus application resulted significant increase in protein content. Phosphorus application increased available nitrogen status of the soil from 317.7 to 363.2 kg ha^{-1}, while available phosphorus increased from 10.6 to 22.2 kg ha^{-1}. Available potassium status of the soil increased markedly with potassium application. The pH, organic carbon, CEC and base saturation were not affected significantly with phosphorus and potassium application.

Key words: Green gram, phosphorus, potassium, yield, nutrient uptake

INTRODUCTION

Green gram (*Vigna radiata* L.Wilczek) is one of the most important *zaid* and *kharif* pulse crop of India. 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. Productivity of pulses in the country is much lower (789 kg ha^{-1}) than the average yield of other pulse producing countries of the world (Anonymous, 2015). 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 and it alone accounts for about 65 percent of the world's acreage and 54 percent of the world's production. The area and production of pulses in Nagaland stretches to 34430 hectare and 36460 tons, respectively where green gram contributes 330 hectare of the total pulse area and 510 tons of the total pulse production in Nagaland (Anonymous, 2013-14). There are various reasons for low yield of green gram and balanced nutrient application is one of them. Phosphorus and potassium fertilization to legumes is more important than that of nitrogen. Phosphorus nutrient simulates a greater attention in enhancing the productivity of legumes. Phosphorus plays a vital role in photosynthesis, respiration, energy storage, energy transfer, cell division, cell elongation and several other processes within plant system (Tisdale *et al.* 1997**)**. 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. Potassium status in the soils is uniquely dynamic and elusive and its functions in the plants are complex but not well defined. The trend of crop responses to K in India has undergone changes but still, the present scenario continues to be complex, eluding and anomalous. Pulse crops showed yield benefits

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from potassium application. Improved potassium supply also enhances biological nitrogen fixation and protein content of pulse grains. It maintains turgor pressure of cell which is necessary for cell expansion. It helps in osmotic regulation of plant cell, assists in opening and closing of stomata. It plays a key role in activation of more than 60 enzymes in plant system. Therefore, an attempt was made to study the influence of phosphorus and potassium on performance of green gram under acidic soil condition of Nagaland.

MATERIALS AND METHODS

A field experiment was conducted at research farm of the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland with green gram (cv. Samrat) as the test crop. The experimental soil was sandy clay loam with pH 5.52, organic carbon 14.8 g kg^{-1}, CEC 10.1[cmol (p^{+}) kg^{-1}], base saturation 30.05% and available N, P and K status 301.0, 10.5 and 130.0 kg ha^{-1}, respectively. The experiment was laid out in RBD with three levels of phosphorus viz. control, 30 and 60 kg P_2O_5 ha^{-1} and three levels of potassium viz. control, 30 and 60 kg K_2O ha^{-1}. Treatments were replicated thrice. Recommended doses of nitrogen @ 20 kg ha^{-1} was applied through urea. Phosphorus and potassium levels were developed through single superphosphate and muriate of potash and all fertilizers were incorporated into plots two days prior to sowing of the crop. Seed was treated with *Rhizobium* culture @ 20g per kg of seed. Seeds were sown by line sowing at a depth of 1.5 cm, maintaining plant geometry of 40 cm x 15 cm on 28th July, 2016. Plant to plant spacing was maintained by thinning at 15 DAS. Hand weeding was done at regular interval to check the weed growth. The data on plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$ and grain and stover yield were recorded. Plant samples were analyzed 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, CEC, base saturation and available N & K using standard procedures (Jackson, 1973). For estimation of available P, soil samples were extracted with NH_4F (Bray and Kurtz, 1945). The data were analyzed statistically to compare the treatment effects (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

Growth and yield

A perusal of data (Table 1) indicates that significantly taller plants were produced with phosphorus and potassium application over control and maximum plant height was recorded with 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} which was at par with 30 kg P_2O_5 and 30 kg K_2O_5 ha^{-1}. Application of 30 kg P_2O_5 ha^{-1} also increased plant growth significantly over control. Number of branches also enhanced significantly with phosphorus and potassium application. This might be due to involvement of phosphorus in energy transformation and cell division. Furthermore, phosphorus also helps in better root growth which resulted more nutrient and moisture uptake by plants from deeper soil layer leading to better growth and development. These results are in accordance with those of Kanwar *et al.* (2013). Potassium application improved the growth of green gram which might be due to enhanced metabolic activities within plant system resulted increased the cell division which in turn to better plant growth. Number of pods per plant was affected significantly with phosphorus and potassium application. Maximum pods per plant were recorded at 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}. It might be due to involvement of phosphorus in flowering and fruiting including seed development. Potassium application might be improved the metabolic activities within plant system resulted more pod formation. A critical analysis of the data revealed that phosphorus and potassium application had significant beneficial effect on seed, stover and protein yield of green gram. Maximum seed, stover and protein yield was recorded at 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}. However, 30 kg ha^{-1} level of P_2O_5 and K_2O was at par to 60 level kg ha^{-1} level of P_2O_5 and K_2O with regard to seed and protein yields. The 30 kg ha^{-1} level of P_2O_5 and K_2O increased seed, stover and protein yield to the extent of 13.3 and 16.9, 44.8 and 5.1 and 21.1 and 28.5 percent, respectively over control. While the 60 kg ha^{-1} level of P_2O_5 and K_2O increased seed, stover and protein yield by 19.2 and 18.4, 46.2 and 14.6 and 27.8 and 39.7

percent, respectively over control. Variation in the yield of green gram with different treatments might be due to variations in the yield attributes. Phosphorus 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 (Patel *et al.* 2013 and Singh *et al.* 2017).

Table 1: Effect of phosphorus and potassium on growth and yield of green gram

Treatment	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Yield (kg ha^{-1})		
				Seed	Stover	Protein
Phosphorus (kg ha^{-1})						
0	44.6	4.5	14.1	945.8	1209.4	199.4
30	46.7	5.4	16.1	1071.2	1750.9	241.4
60	48.2	5.9	16.2	1127.3	1768.0	254.9
SEm±	0.51	0.18	0.11	34.6	33.2	6.7
CD(P=0.05)	1.81	0.64	0.39	120.5	116.2	23.7
Potassium (kg ha^{-1})						
0	45.2	4.6	14.4	937.8	1479.2	188.9
30	46.7	5.4	15.9	1096.6	1554.4	242.8
60	47.3	5.9	16.0	1109.9	1694.7	263.9
SEm±	0.51	0.18	0.11	34.4	33.2	6.7
CD(P=0.05)	1.81	0.64	0.39	120.5	116.2	23.7

Nutrients content and their uptake

Nitrogen content in grain and stover of green gram increased significantly by phosphorus and potassium application (Table 2). Irrespective of treatments, the nitrogen content ranged from 3.14 to 3.74 percent in seed and 1.23 to 1.43 percent in stover. Maximum N content in seed and stover was recorded at 60 kg ha^{-1} level of P_2O_5 and K_2O. Total N uptake by green gram enhanced significantly with increasing levels of phosphorus and potassium. Increases in nitrogen uptake by green gram with 30 and 60 kg P_2O_5 ha^{-1} were 36.6 and 47.0%, respectively over control. Same levels of potassium increased N uptake by 14.8 and 24.3% over control. Higher N uptake with phosphorus and potassium application could be attributed to enhanced crop growth with increased N translocation and utilization into the plant system resulting in the enhancement of yield. Phosphorus content of seed and stover improved significantly with phosphorus application. The P content in seed and stover ranged from 0.21 to 0.31% and 0.12 to 0.19%, respectively.

Table 2: Effect of phosphorus and potassium on nutrient content and nutrient uptake of green gram

Treatment	Nutrient content (%)							Total nutrient uptake (kg ha^{-1})		
	N		P		K		Protein	N	P	K
	Seed	Stover	Seed	Stover	Seed	Stover	Seed			
Phosphorus (kg ha^{-1})										
0	3.32	1.29	0.21	0.12	1.22	1.39	20.7	46.2	3.4	28.5
30	3.53	1.35	0.27	0.13	1.32	1.45	22.0	63.1	5.7	39.9
60	3.67	1.41	0.31	0.19	1.35	1.53	22.9	67.9	6.9	42.0
SEm±	0.07	0.02	0.010	0.009	0.04	0.01	0.4	2.5	0.21	0.78
CD(P=0.05)	0.25	0.09	0.034	0.031	NS	0.06	1.6	8.9	0.74	2.73
Potassium (kg ha^{-1})										
0	3.14	1.23	0.25	0.12	1.20	1.40	19.6	51.9	4.5	32.5
30	3.62	1.38	0.27	0.15	1.32	1.45	22.6	59.6	5.4	36.8
60	3.74	1.43	0.27	0.17	1.37	1.50	23.4	64.5	5.9	41.0
SEm±	0.07	0.02	0.010	0.009	0.04	0.01	0.4	2.5	0.21	0.78
CD(P=0.05)	0.25	0.09	NS	NS	0.13	0.06	1.6	8.9	0.74	2.73

Phosphorus content in seed and stover was not affected significantly with potassium application. The P uptake by green gram increased significantly with P and K application. Phosphorus uptake by green gram enhanced from 3.4 kg ha^{-1} in control to 6.9 kg ha^{-1} at 60 kg P_2O_5 ha^{-1}. Potassium application enhanced P uptake from 4.5 kg ha^{-1} to 5.9 kg ha^{-1}. Phosphorus uptake enhanced by 67.6 and 102.9% over control with 30 and 60 kg P_2O_5 ha^{-1}, respectively. The 30 and 60 kg K_2O ha^{-1} increased P uptake by 20.0 and 31.1%, respectively over control. The K content in seed and stover of green gram improved markedly with phosphorus and potassium application. Potassium content in seed was not affected significantly by phosphorus application. The K content in seed and stover varied from 1.20 to 1.37 and 1.39 to 1.53%, respectively. The K uptake by green gram increased significantly with phosphorus and potassium. Maximum K uptake was recorded at 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}. Increases in potassium uptake by green gram due to application of 30 and 60 kg P_2O_5 ha^{-1} were 40.0 and 47.4%, respectively over control. Highest level of potassium increased K uptake by 26.2% over control. Similar results were reported by Singh (2017).

Soil properties

The pH of the post crop harvest soil ranged from 5.30 to 5.40 (Table 3). The pH of the soil was not affected significantly with the application of phosphorus and potassium. Organic carbon content, CEC and base saturation of soil were not affected significantly with phosphorus and potassium application. Irrespective of treatments, the available N status ranged from 317.7 to 363.2 kg ha^{-1}. Available N enhanced remarkably with P application. 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 in post harvest soil ranged from 10.6 to 22.2 kg ha^{-1}. A significant increase in available P status was reported with phosphorus 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. However, potassium application could not produce significantly effect on available nitrogen and phosphorus status of the soil. Available K content of the soil was not affected significantly by phosphorus application. But it increased significantly with potassium application. Hence, P and potassium application may be helpful in improving the soil health in terms of available nitrogen, phosphorus and potassium. Similar findings have been also reported by Nyekha (2015).

Table 3: Effect of phosphorus and potassium on soil properties

Treatment	pH	CEC [cmol (p^+)kg^{-1}]	BS (%)	Organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})		
					N	P	K
Phosphorus (kg ha^{-1})							
0	5.3	11.40	31.72	14.9	317.7	10.6	136.1
30	5.2	11.34		15.4	353.3	15.4	143.5
60	5.3	11.74	32.93	16.3	363.2	22.2	147.4
SEm±	0.32	0.49	33.16	0.34	11.2	0.4	3.0
CD(P=0.05)	NS	NS	0.88 NS	NS	39.4	1.5	NS
Potassium (kg ha^{-1})							
0	5.4	10.58	31.79	14.9	321.1	15.4	131.4
30	5.1	11.46	32.65	15.6	355.5	16.0	143.6
60	5.3	12.42	33.36	15.9	357.6	16.8	152.0
SEm±	0.32	0.49	0.88	0.34	11.2	0.45	3.0
CD(P=0.05)	NS	NS	NS	NS	NS	NS	9.7

The results of the present study lead to a conclusion that application of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} produced higher plant height, branches $plant^{-1}$, pods $plant^{-1}$, seed, stover and protein yield of green gram. The N, P and K contents and their uptake improved remarkably by phosphorus and potassium application. Available N, P and K status of the post harvest soil also improved with the use of phosphorus and potassium. Hence, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} are recommended for better yield of green gram in Nagaland.

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