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Response of Greengram (*Vigna radiata* L. Wilczek) to Nutrients Influencing Yield, Uptake and Soil Fertility in Loamy Sand Soil under Dry Land Condition

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A B S T R A C T

The experiment was conducted during the *Kharif* season of the year 2018 at AICRP for Dry Land, Centre for Natural Resources Management, Sadarkrushinagar Datiwada Agricultural University, Sardarkrushinagr, Gujarat to study the "Effect of phosphorus, sulphur and biofertilizer on yield and available nutrient status of greengram (*Vigna radiata* L. Wilczek) in loamy sand under dry land condition". The results revealed that integrated application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB registered significantly higher seed and stover yield, content of P and S in seed as well as stover and uptake of N, P and S in seed as well as stover of greengram. The highest net realization and benefit : cost ratio (BCR) was obtained with the treatment 30 kg P_2O_5/ha + 20 kg S/ha + PSB. The organic carbon content in soil remained unaffected due to different treatments. Significantly the highest phosphorus and sulphur build up in soil after harvest of the crop was observed under the treatment of 50 kg P_2O_5/ha + 20 kg S/ha + PSB.

Introduction

Greengram (*Vigna radiata* L.) is commonly known as moong or golden gram. It belongs to family *Leguminosae*. The India is the largest producer and consumer of pulses. In India, *kharif* greengram occupies an area of about 40.70 lakh ha with a production of 19.01 lakh tonnes (DE and S, 2018-19). In Gujarat, *kharif* greengram occupies an area of about 63,000 ha with a production of 24,000 tonnes and the productivity is 381 kg/ha, respectively (DOA, 2018-19).

Phosphorus is a second major nutrient for plants because of their high requirement. It is also involved in controlling key enzyme reaction and in the regulation of metabolic pathways (Theodorou and Plaxton, 1993). Since the concentration of phosphorus in the soil solution is normally insufficient to support plant growth, continual replacement of soluble phosphorus from inorganic and organic source is necessary for crop growth (Chauhan *et al.*, 1997). So, to meet the phosphorus requirements of crops phosphatic fertilizer are used. Sulphur is essential for synthesis of vitamins (Biotin and Thiamine), sulphur containing amino acids that are cystine, cysteine and methionine are a requisite for protein synthesis. It is also constituent of glutathione, a compound that plays a part in plant respiration and synthesis of essential oils. It has a number of oxidizing functions in plant nutrition and a constituent of Fe-S proteins called Ferredoxin, responsible for transfer of electrons during the first phase of photosynthesis reaction (Marchner, 1995; Goswami, 1988 and Randall, 1988).

Seed inoculation with proper strain of phosphorus solubilizing bacteria is low cost input for enhancing yield, as it solubilizes the unavailable phosphorus into the available forms, which reduces the high cost of inorganic phosphatic fertilizer (Parveen *et al*. 2002). Phosphorus dissolving microorganisms have capacity to render insoluble form of phosphate more available to plant besides, metabolic product of soil microbes such as organic acids and humic substances form complexes with Fe and Al compounds, thereby reducing further fixation.

Materials and Methods

A field experiment on "Response of greengram (*Vigna radiata* L. Wilczek) to nutrients influencing yield, uptake and soil fertility in loamy sand soil under dry land condition". The field experiment was laid out on Plot No. 9 at AICRP for Dry land Agriculture, Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* season of 2017-18. Total twelve treatments *viz.*, T_1 : 30 kg P_2O_5/ha, T_2 : 40 kg P_2O_5/ha , T_3 : 50 kg P_2O_5/ha, T_4 : 30 kg P_2O_5/ha + 20 kg S/ha, T_5 : 40 kg P_2O_5/ha + 20 kg S/ha, T_6 : 50 kg P_2O_5/ha + 20 kg S/ha, T_7 : 30 kg P_2O_5/ha + PSB, T_8 : 40 kg P_2O_5/ha + PSB, T_9 : 50 kg P_2O_5/ha + PSB, T_{10} : 30 kg P_2O_5/ha + 20 kg S/ha + PSB, T_{11} : 40 kg P_2O_5/ha + 20 kg S/ha + PSB and T_{12} : 50 kg P_2O_5/ha + 20 kg S/ha + PSB were tried in randomized block design with three replications in loamy sand soil. The details of treatments tested in the present investigation are as follows:

Greengram cv. GM 4 was sown with spacing 40 cm × 10 cm on 11th July, 2018 and harvesting on 11th September, 2018. Other cultural practices and plant protection measures were taken as per recommendation. The data on seed and stover yield were recorded from net plot and converted on hectare basis. The plant samples (seed and stover) were wet digested using di-acid mixture of HNO_3 and $HClO_4$ in 3:1 ratio. The acid extract prepared after digestion was used for estimation of P and S. The total N content in seed and stover was estimated by Kjeldahl method using N analyzer (KELPLUS model). The observations of the study was to know the nutrient status of soil at harvest, a representative soil samples (0-15 cm depth) from five spots of each plot after harvest of greengram crop were collected, composited and air dried in shade. These samples were then ground using wooden mortar and pestle and passed through 2 mm sieve and were analyzed for organic carbon by Walkley and Black titration and the available phosphorus (kg/ha) of soil was extracted with 0.5 M sodium bicarbonate (1:20) and determined colorimetrically and soil available S was extracted with 0.15 % $CaCl_2$.

The net realization was calculated by deducting the total cost of cultivation from the gross realization for each treatment. The benefit cost ratio (BCR) was calculated on the basis formula given below.

BCR = Net realization (Rs./ha) /cost of cultivation (Rs./ha).

The data related to each parameter of the experiment were statistically analyzed using MSTATC software. The purpose of analysis of variance was to determine the significant effect of treatments on greengram. LSD test at 5 % probability level was applied when analysis of variance showed significant effect of treatment (Panse and Sukhatme 1985).

Results and Discussion

Yields of greengram

The data pertaining to seed and stover yield of greengram are presented in Table 1 showed that the treatment receiving 50 kg P_2O_5/ha + 20 kg S/ha + PSB produced significantly higher seed (761 kg/ha) and stover yield (131kg/ha), but it was remained at par with all the treatments consisting of phosphorus, sulphur and biofertilizer treatments except T_1, T_2, T_3 and T_7 and T_1, T_2, T_9 and T_7 for seed and stover, respectively.

The yield improvement was higher when phosphorous was applied along with sulphur and PSB. The significant increase in yield of greengram due to phosphorous, sulphur and PSB might be due to fact that phosphorus, sulphur and PSB had positive effect on greengram yields as phosphorus is known to play beneficial role in legume by promoting extensive root development and nodulation ensuring better nutritional environment for growth and finally the yield.

Sulphur also played important role in energy transformation and activation of enzymes, carbohydrate metabolism and also due to inoculation with PSB, which increased available phosphorus and favored higher absorption and utilization of P and plant nutrients and ultimately positive resultant effect on growth and yield attributes, which led to increase in seed and stover yield. These results are in the line of those reported by Patel *et al*. (2013), Manju *et al*. (2016), Das (2017), Sipai *et al*. (2016) and Serawat *et al*. (2018).

Nutrient content

Data pertaining to N, P and S content in seed and stover of greengram are represented in Table 2.

N content in seed and stover

The data presented in Table 2 revealed that the differences in N content in seed and stover of greengram were found non significant.

P content in seed and stover

The data pertaining to phosphorous content in seed and stover are given in Table 2 showed that the phosphorous content in seed and stover were significantly influenced due to different treatments. Significantly highest phosphorous content in seed (0.637 %) and stover (0.182 %) were found with treatment of *viz.*, 50 kg P_2O_5/ha + 20 kg S/ha + PSB, but it was at par with the treatments 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha. The lowest phosphorous content in seed and stover was obtained under treatment receiving 30 kg P_2O_5/ha. The significant increase of P content in seed and stover due to application of phosphorous, sulphur and PSB might be attributed to fact that synergistic effect among them had favorable effect on soil properties and makes more P available during crop growing season. These results are in close agreement with those reported by Manju *et al*. (2016) and Raj *et al*. (2017) in greengram crop.

S content in seed and stover

Data pertaining to S content in seed and stover are presented in Table 2.

The sulphur content in seed and stover were significantly influenced due to different treatments. Application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB recorded significantly higher S content in seed (0.247 %) and stover (0.135 %), but it was found at par with the treatments *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha and in the same trend for stover but in addition of it was remained at par with 40 kg P_2O_5/ha + 20 kg S/ha and 30 kg P_2O_5/ha + 20 kg S/ha.

The significant increase of S content in seed and stover was found due to application of phosphorous, sulphur and PSB over no application. This might be attributed to the beneficial effect of phosphorous, sulphur and S addition to the soil. These results are in close agreement with those reported by Serawat *et al*. (2018) and Raj *et al*. (2017) in greengram.

Nutrient uptake

Data pertaining to N, P and S uptake by seed and straw are presented in Table 2.

N, P and S uptake by seed and stover

The N uptake by seed and stover (Table 2) were significantly influenced due to different treatments. Significantly the highest N uptake by seed (26.69 kg/ha) was obtained under treatment *i.e.* 50 kg P_2O_5/ha + 20 kg S/ha + PSB, but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB (25.70 kg/ha), 30 kg P_2O_5/ha + 20 kg S/ha + PSB (25.54 kg/ha), 50 kg P_2O_5/ha + 20 kg S/ha (24.05 kg/ha) and 40 kg P_2O_5/ha + 20 kg S/ha (23.26 kg/ha). Treatment 30 kg P_2O_5/ha recorded minimum N uptake (15.30 kg/ha) by seed. Similarly, significantly higher N uptake by stover (10.34 kg/ha) was obtained under treatment 50 kg P_2O_5/ha + 20 kg S/ha + PSB, but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB (10.17 kg/ha), 30 kg P_2O_5/ha + 20 kg S/ha + PSB (9.86 kg/ha), 50 kg P_2O_5/ha + 20 kg S/ha (8.87 kg/ha), 40 kg P_2O_5/ha + 20 kg S/ha (8.44 kg/ha) and 30 kg P_2O_5/ha + 20 kg S/ha (8.95 kg/ha). Treatment of 30 kg P_2O_5/ha recorded minimum N uptake (7.10 kg/ha) by stover.

Significantly highest P uptake by seed (4.86 kg/ha) and stover (2.39 kg/ha) was recorded under treatment 50 kg P_2O_5/ha + 20 kg S/ha + PSB, but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB (4.63 kg/ha), 30 kg P_2O_5/ha + 20 kg S/ha + PSB (4.54 kg/ha), 50 kg P_2O_5/ha + 20 kg S/ha (4.45 kg/ha) and 40 kg P_2O_5/ha + 20 kg S/ha (4.13 kg/ha) and in the same trend but in addition it was remained at par with 30 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} for P uptake in stover. Treatment 30 kg P_2O_5/ha recorded minimum P uptake by seed (2.35 kg/ha) and stover (1.51 %).

The significantly highest S uptake by seed (1.88 kg/ha) and stover (1.76 kg/ha) was recorded under treatment 50 kg P_2O_5/ha + 20 kg S/ha + PSB (Table 2), but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha and the same trend was also found for stover, but in addition, it was remained at par with 40 kg P_2O_5/ha + 20 kg S/ha and 30 kg P_2O_5/ha + 20 kg S/ha for S uptake. Treatment of 30 kg P_2O_5/ha recorded minimum S uptake by seed (0.68 kg/ha) and stover (0.82 kg/ha).

The synergetic effect among phosphorous, sulphur and PSB might have favored the better utilization of nutrients.

The higher uptake of P might be attributed to the favorable influence of PSB in solubilization of native soil to make P readily available to roots during crop growing season. The higher uptake of these nutrients (N, P and S) might be the outcome of increases in the seed and stover yield of greengram.

Table.1 Effect of phosphorous, sulphur and PSB on yield and monetary returns of kharif greengram

Treatments			Yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross realization (Rs/ha)	Net realization (Rs/ha)	BCR
			Seed	Stover				
T_1	:	30 kg P_2O_5/ha	488	933	18183	31505	13322	1.73
T_2	:	40 kg P_2O_5/ha	527	907	18638	33520	14882	1.80
T_3	:	50 kg P_2O_5/ha	583	1042	19093	37275	18182	1.95
T_4	:	30 kg P_2O_5/ha + 20 kg S/ha	627	1128	18783	40125	21342	2.14
T_5	:	40 kg P_2O_5/ha + 20 kg S/ha	715	1124	19238	44945	25707	2.34
T_6	:	50 kg P_2O_5/ha + 20 kg S/ha	738	1144	19693	46310	26617	2.35
T_7	:	30 kg P_2O_5/ha + PSB	592	1012	18198	37620	19422	2.07
T_8	:	40 kg P_2O_5/ha + PSB	598	1058	18653	38180	19527	2.05
T_9	:	50 kg P_2O_5/ha + PSB	601	709	19108	36600	17492	2.07
T_{10}	:	30 kg P_2O_5/ha + 20 kg S/ha + PSB	739	1294	18798	47115	28317	2.51
T_{11}	:	40 kg P_2O_5/ha + 20 kg S/ha + PSB	743	1249	47110	47110	19253	2.45
T_{12}	:	50 kg P_2O_5/ha + 20 kg S/ha + PSB	761	1317	48440	48440	19708	2.46
S.Em.±			56	56				
C.D. (P = 0.05)			164	164				
C.V. (%)			15.12	15.24				

Table.2 Effect of phosphorus, sulphur and biofertilizer on nutrients content and uptake by seed and stover of *kharif* greengram

Treatments			Nutrients content (%)						Nutrients uptake (kg/ha)					
			Nitrogen		Phosphorus		Sulphur		Nitrogen		Phosphorus		Sulphur	
			Seed	Stover	seed	stover	seed	stovr	seed	stover	seed	stover	seed	Stover
T_1	:	30 kg P_2O_5/ha	3.14	0.76	0.483	0.162	0.140	0.088	15.30	7.10	2.35	1.51	0.68	0.82
T_2	:	40 kg P_2O_5/ha	3.17	0.76	0.526	0.163	0.162	0.091	16.66	6.88	2.78	1.47	0.85	0.83
T_3	:	50 kg P_2O_5/ha	3.19	0.76	0.541	0.163	0.178	0.113	18.59	7.92	3.15	1.69	1.03	1.17
T_4	:	30 kg P_2O_5/ha + 20 kg S/ha	3.23	0.79	0.576	0.161	0.205	0.127	20.34	8.95	3.61	1.82	1.27	1.43
T_5	:	40 kg P_2O_5/ha + 20 kg S/ha	3.23	0.75	0.579	0.167	0.206	0.128	23.26	8.44	4.13	1.89	1.46	1.44
T_6	:	50 kg P_2O_5/ha + 20 kg S/ha	3.27	0.77	0.605	0.175	0.233	0.129	24.05	8.87	4.45	2.00	1.72	1.49
T_7	:	30 kg P_2O_5/ha + PSB	3.20	0.76	0.555	0.166	0.189	0.114	18.97	7.72	3.30	1.67	1.12	1.16
T_8	:	40 kg P_2O_5/ha + PSB	3.21	0.76	0.561	0.168	0.198	0.115	19.17	8.08	3.35	1.78	1.18	1.22
T_9	:	50 kg P_2O_5/ha + PSB	3.21	0.77	0.575	0.169	0.199	0.117	19.31	5.43	3.46	1.20	1.20	0.83
T_{10}	:	30 kg P_2O_5/ha + 20 kg S/ha + PSB	3.45	0.77	0.611	0.177	0.236	0.130	25.54	9.86	4.54	2.30	1.76	1.69
T_{11}	:	40 kg P_2O_5/ha + 20 kg S/ha + PSB	3.45	0.81	0.622	0.177	0.239	0.131	25.70	10.17	4.63	2.22	1.77	1.63
T_{12}	:	50 kg P_2O_5/ha + 20 kg S/ha + PSB	3.51	0.79	0.637	0.182	0.247	0.135	26.69	10.34	4.86	2.39	1.88	1.76
S.Em.±			0.08	0.02	0.016	0.005	0.006	0.003	2.10	0.71	0.37	0.18	0.12	0.13
C.D. (P = 0.05)			NS	NS	0.048	0.01	0.018	0.009	6.15	2.10	1.08	0.52	0.35	0.38
C.V. (%)			4.45	5.13	4.92	4.73	5.17	4.65	17.19	14.89	17.1	16.66	15.7	17.40

Table.3 Effect of phosphorus, sulphur and biofertilizer on organic carbon, available P_2O_5 and S content in soil after harvest of *kharif* greengram

Treatments			**Organic carbon (%)**	**Available nutrients**	
				P_2O_5 (kg/ha)	**S (mg/kg)**
T_1	**:**	30 kg P_2O_5/ha	0.267	41.63	8.04
T_2	**:**	40 kg P_2O_5/ha	0.267	41.76	8.97
T_3	**:**	50 kg P_2O_5/ha	0.280	41.77	9.13
T_4	**:**	30 kg P_2O_5/ha + 20 kg S/ha	0.300	45.62	11.18
T_5	**:**	40 kg P_2O_5/ha + 20 kg S/ha	0.303	45.92	11.24
T_6	**:**	50 kg P_2O_5/ha + 20 kg S/ha	0.287	45.94	11.98
T_7	**:**	30 kg P_2O_5/ha + PSB	0.297	41.95	8.17
T_8	**:**	40 kg P_2O_5/ha + PSB	0.297	42.34	9.07
T_9	**:**	50 kg P_2O_5/ha + PSB	0.303	42.39	9.03
T_{10}	**:**	30 kg P_2O_5/ha + 20 kg S/ha + PSB	0.310	43.33	12.11
T_{11}	**:**	40 kg P_2O_5/ha + 20 kg S/ha + PSB	0.323	44.51	12.79
T_{12}	**:**	50 kg P_2O_5/ha + 20 kg S/ha + PSB	0.293	46.63	12.94
S.Em.±			0.014	44.51	0.49
C.D. (P = 0.05)			NS	3.53	1.43
C.V. (%)			7.96	4.78	8.15
Initial			0.26	37.40	9.52

The positive effect of phosphorous, sulphur and PSB on N, P and S uptake has also been reported by Serawat *et al*. (2018) and Raj *et al*. (2017) in greengram.

Nutrient status of soil after harvest

Organic carbon

The perusal of the data present in Table 3 revealed that the differences in organic carbon content in soil after harvest of greengram crop were found non significant due to different treatments.

Available phosphorus

A perusal of data presented in Table 3 indicated that available P_2O_5 content in soil after harvest of greengram crop differed significantly due to different treatments. The results revealed that an application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB registered significantly higher available phosphorus content in soil (46.63 kg/ha) as compared to other treatments except T_1, T_2, T_3, T_7, T_8 and T_9. The lowest available phosphorus content in soil (41.63 kg/ha) was recorded under treatment 30 kg P_2O_5/ha. It might be due to supply of phosphorous and better mineralization of organic P under the influence of PSB. Similar findings had been reported by Sipai *et al*. (2016) in greengram crop.

Available sulphur

The data pertaining to available sulphur in soil after harvest of greengram crop are presented in Table 2.

The data revealed that the available S in soil after harvest of greengram crop was significantly influenced due to different treatments. The data narrated in Table 2 indicated that significantly higher S (12.94 ppm) content in soil after harvest of crop was noticed with application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB, but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha. The lower S (8.04 mg/kg) content in soil after harvest of crop was found under the treatment 30 kg P_2O_5 /ha. The significant improvement in available sulphur status of soil was found in treatments which had received sulphur nutrition. This was might be due to beneficial effect of sulphur fertilizer on available S content in soil and S addition to the soil. The results are in accordance with those reported by Patel *et al*. (2014) in greengram.

Economics

The data on cost of cultivation, gross and net realization as well as benefit : cost ratio (B : C ratio) for different treatments are presented in Table 1.

A perusal of data on gross realization as influenced by different treatments revealed that the maximum gross realization of ` 48440/ha was accrued under the treatment 50 kg $P_2O_5$/ha + 20 kg S/ha + PSB followed by treatment 30 kg $P_2O_5$/ha + 20 kg S/ha + PSB (` 47115/ha). The highest net realization of ` 28317/ha and benefit : cost ratio (BCR) of 2.51 were obtained with the treatment 30 kg P_2O_5/ha + 20 kg S/ha + PSB.

In view of the results obtained from the present investigation, it could be concluded that for securing higher seed yield and net realization of greengram (cv. Gujarat Mungbean 4) raised on loamy sand under dry land conditions, the crop should be fertilized with phosphorus @ 30 kg/ha, sulphur @ 20 kg/ha with PSB (phosphorus solubilizing bacteria) liquid biofertilizer along with recommended dose of N @ 20 kg/ha along with sustaining soil fertility.

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