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YIELD AND NUTRIENT UPTAKE OF SUMMER GREEN GRAM [*Vigna radiata* (L) Wilczek] UNDER DIFFERENT LEVELS OF PHOSPHORUS AND SULPHUR FERTILIZATIONS

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ABSTRACT

A field experiment was conducted at Krishi Vigyan Kendra, Dungarpur (Rajasthan) during summer seasons of 2010 and 2011 on sandy clay loam soil to investigate the effect of phosphorus (control, 10, 20, 40 and 60 kg P_2O_5 ha^{-1}) and sulphur (control, 15, 30 and 45 kg S ha^{-1}) application on NPK and S uptake by green gram [*Vigna radiata* (L) Wilczek]. Increasing levels of phosphorus up to 60 kg P_2O_5 ha^{-1} resulted in significantly higher grain (745 kg ha^{-1}) and stover (1245 kg ha^{-1}) yields and uptake of NPK and S by grain, stover and the whole plant over lower levels of phosphorus during both the years of the study as well as on pooled basis. But it was at par with 40 kg P_2O_5 ha^{-1} in respect to S uptake by grain during 2011, S uptake by stover during both the years and total S uptake during 2011. 45 kg S ha^{-1} produced significantly higher grain (743 kg ha^{-1}) and stover (12264 kg ha^{-1}) yields and uptake of NPK and S by grain, stover as well as total uptake over lower levels of sulphur during both the years of the investigation and on pooled basis. Interaction effect was significant in respect to total NPK and S uptake on pooled basis. Combined application of 60 kg P_2O_5 ha^{-1} and 45 kg S ha^{-1} resulted in significantly higher uptake of total NPK and S by summer green gram.

Keywords: Green gram, Nitrogen, Phosphorus, Potassium, Sulphur, Interaction.

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INTRODUCTION

Pulses are the major source of dietary protein in the vegetarian diet of India. Besides being the source of protein, the pulses maintain soil fertility through biological nitrogen fixation and thus play a vital role in furthering sustainable agriculture (Kannaiyan, 1999). In India, pulses are grown in 23.28 million hectare of land area with a production of 14.66 million tonnes and an average productivity of 630 kg ha^{-1} (Economic Survey, 2010-11). Green gram is the third most important pulse crop in India after chickpea and pigeon pea. At the national level, it is grown on 3.10 m ha land area and produces nearly 0.94 m t with an average productivity of 304 kg ha^{-1} (Govt. of India, 2010). In Rajasthan, green gram is cultivated on 1.06 m ha land area with a production of 0.41 MT (Govt. of Rajasthan, 2010).Green gram is generally grown as a rain fed crop during *kharif* season in Rajasthan either as sole crop or mixed crop with cereals. However, with the enhanced irrigation facility in southern Rajasthan, the cropping intensity has increased substantially. In the canal command areas, this crop is now raised in summer season in between winter and rainy seasons. This has opened avenues of intensifying crop production in the tribal dominated belt. Perhaps, because of these distinct features and higher economic returns, farmers have shown renewed interest towards the pulse crop (Chadha, 2010). Among the growth inputs, mineral nutrients play a vital role to get better yields as well as to maintain soil fertility. Judicious use of phosphate fertilizer is supposed to result in better nodulation and efficient functioning of nodule bacteria for fixation of atmospheric nitrogen to be utilized by plants during grain development stage, which in turn leads to increase in grain yield (Sarkar, 1992). Sulphur is best known for its role in the formation of amino acids methionine (21 percent S) and cystine (27 percent S), synthesis of protein, chlorophyll formation, promotes nodulation in legumes thereby increase in nitrogen fixation (Tandon, 1991). Keeping in view the importance of these two factors, the present study was designed to investigate the effect of phosphorus and sulphur on yield and nutrient uptake of summer green gram [*Vigna radiata* (L) Wilczek].

MATERIALS AND METHODS

A field experiment was conducted during summer seasons of 2010 and 2011 at Krishi Vigyan Kendra, Dungarpur. The site is situated at 23.83°N latitude, 73.72°E longitude and an altitude of 579.5 m above mean sea level. The region falls under Humid Southern Plain of Rajasthan (Agro climatic Zone IV b). The mean annual rainfall of the region is 729.2 mm, most of which is contributed by south-west monsoon from July to September. The soil was sandy clay loam in texture and alkaline in reaction (pH 8.1), low in organic carbon (0.48 g kg^{-1} soil), available nitrogen (246.75 kg ha^{-1}), medium in available phosphorus (17.89 kg P_2O_5 ha^{-1}), high in available potassium (282.43 kg K_2O ha^{-1}) and low in available sulphur (SO_4^{-2} 8.8 ppm). The treatments comprised four levels of phosphorus (control, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four levels of sulphur (control, 15, 30 and 45 kg S ha^{-1}) replicated four times in factorial randomized block design. The seeds of green gram were sown on 18 March in 2010, and 15 March in 2011. As per treatment, phosphorus and sulphur were applied manually through DAP and mineral gypsum at the time of sowing in the furrow at 5 cm below the seeding depth. A uniform dose of 25 kg nitrogen ha^{-1} was applied through urea. The seeds of green gram variety SML 668 were treated with 2 g of bavistin per kg of seed. It was followed by bacterial culture (*Rhizobium phseoli*) treatment. Furrows were opened manually at 25 cm apart and seeds were placed at a depth of 3 to 4 cm, using a seed rate 15 kg ha^{-1}. Weed control, irrigation and plant protection measure were followed as per zonal package. At harvest, observations were recorded for the growth traits (plant height at 30 days after sowing (DAS), dry matter accumulation at 30 DAS and at harvest, leaf area index at flower initiation stage) grain yield (t ha^{-1}) and stover yield (t ha^{-1}). The plant samples collected at harvest were oven dried. The seeds and stover were separated out, which were ground to pass through 40 mesh sieve and used for determination of nutrient contents by using following methods:

i. Nitrogen: Nesseler's reagent colorimetric method (Lindner, 1944)

ii. Phosphorus: Vanadomolybdo phosphoric yellow colour method (Richards, 1968)

iii. Potassium: Flame photometric method (Richards, 1968)

iv. Sulphur: Barium chloride gelatin reagent turbidimetric method (Tabatabai and Bremner, 1970)

NPK and S uptake at harvest were computed by the following formula:

Nutrient uptake (kg ha^{-1}) = Nutrient content (%) × Seed or stover yield (kg ha^{-1})/100

Total uptake by crop was computed by summing up the uptake by grain and stover.

The data were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Cocharan and Cox (1967). Assuming homogeneity in data over two years of experimentation, pooled analysis was also carried out as per Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of phosphorus on yield and nutrient uptake

The data (Table 1) revealed that grain and stover yields of summer green gram significantly increased with increasing levels of phosphorus up to 60 kg P_2O_5 ha^{-1} in both the years. On pooled basis, 60 kg P_2O_5 ha^{-1} increased grain and stover yields by over 14 % over control (648and 1091kg ha^{-1}, respectively). Increasing phosphorus up to 60 kg P_2O_5 ha^{-1} resulted in significantly higher uptake of NPK and S by grain, stover and whole plant by summer green gram over lower levels of phosphorus during both the years of study as well as on pooled basis. However, 60 kg P_2O_5 ha^{-1} was on par with 40 kg P_2O_5 ha^{-1} with respect to S uptake by grain during 2011, S uptake by stover during both the years and total S uptake during 2011 (Table 3). It is an established fact that photosynthesis together with availability of assimilates (source) and storage organs (sink) exert an important regulative function on the complex process of yield formation. The regulatory functions of phosphorus in photosynthesis and carbohydrate metabolism of leaves can be considered to be one of the major factors limiting plant growth, particularly during reproductive phase. The level of phosphorus during this period regulates starch/sucrose ratio in the source leaves and reproductive organs (Giaquinta and Quebedeaux, 1980). Improvement in yield of summer green gram due to P fertilization was also observed by Ali et al. (2010). Dart (1977) reported that in many leguminous crops, P application enhances root formation and increase the capacity of nodules for fixation of higher atmospheric nitrogen and thereby improves nutritional status of the plant. Nutrient uptake by crop is a function of their concentration and dry matter production of plants. Increased uptakes of NPK and S by summer green gram crop due to P application corroborate the findings of Sharma et al. (2008).

Effect of sulphur on yield and nutrient uptake

Application of 45 kg S ha^{-1} resulted in significantly higher grain and stover yields of green gram. The increase in grain and stover output was 14.41 and 13.07 per cent over control (649 and1084 kg ha^{-1}), respectively. Application of 45 kg S ha^{-1} significantly increased the NPK and S uptake by green gram in grain, stover as well as total uptake over lower levels of sulphur (control and 15 kg S ha^{-1}) during both the years. It was on par with 30 kg S ha^{-1} with respect to N uptake by stover during both the years, and S uptake by stover during 2011 (Tables 1 & 3). Wareing and Patrick (1975) reported that improvement in yield of green gram was due to diversion of greater proportion of assimilates to the developing pods. Findings of Patel et al. (2010) are similar to the present investigation. Reviewing the work done on effect of gypsum on a variety of crops, it was inferred that its application promoted root growth (Shainberg et al., 1989). Better root development can therefore, be reasoned for greater extraction of nutrients from the soil. Souza and Ritchey (1986) found that improved root development following use of gypsum resulted in enhanced nitrate recovery from soil. Burghardt (1962) opined that as a consequence of lower hydration of SO_4^{-2} ions, the cell colloids get swollen and result in reduction of osmotic pressure which increase transpiration and thereby higher uptake of nutrients. Therefore, the efficient uptake of nutrients by plants under the influence of S fertilization could partly be ascribed to the role of SO_4^{-2} ions in maintaining turgor pressure in plant cells. The results obtained in the present investigation are in conformity with the findings of Kumar and Singh (2009) and Shamsuddoha et al., (2011).

Phosphorus × Sulphur interaction effect

The interaction effect between P and S was significant for total uptake of N, P, K and S (Table 4). On pooled basis, combined application of 60 kg P_2O_5 ha^{-1} and 45 kg S ha^{-1} resulted in significantly higher uptake of N, P, K and S by summer green gram over the rest of the treatment combinations. Researchers have reported that the P x S interaction is synergistic at low to medium levels of P, and antagonistic at higher levels, usually at 60 kg or more P_2O_5 ha^{-1} for field crops (Tandon, 1991). In the present study, experimental field was medium in available phosphorus and low in available S status. This positive interaction may be attributed to the promotion of root development and proliferation in soil. These results are in agreement with those of Aulakh et al. (1990) and Sharma and Singh (1997).

CONCLUSION

Application of 60 kg P_2O_5 ha^{-1} and 45 kg S ha^{-1} alone gave significantly higher grain and stover yields. Whereas combined application of P and S could not bring any significant improvement in grain and stover yields. In respect to uptake of nutrients, application of 60 kg P_2O_5 ha^{-1} and 45 kg S ha^{-1} individually or in combination resulted in significantly higher uptake of NPK and S by summer green gram crop. Interaction among different phosphorus and sulphur levels has no significant effect upon grain yield, stover yields and nutrient content.

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Table 1. Effect of phosphorus and sulphur on grain and stover yield, nitrogen uptake in grain and stover and total nitrogen uptake of summer green gram at harvest.

Treatment	Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})			N uptake by grain (kg ha^{-1})			N uptake by stover (kg ha^{-1})			Total N uptake (kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Phosphorus (P_2O_5 kg ha^{-1}))															
0	616.00	680.89	648.34	988.38	1194.13	1091.25	20.62	23.09	21.86	20.41	24.54	22.48	41.04	47.63	44.34
20	624.81	694.56	659.69	1002.69	1214.38	1108.53	21.01	23.78	22.39	21.86	26.42	24.14	42.88	48.95	45.91
40	664.69	740.81	702.75	1066.19	1316.81	1191.50	23.02	25.64	24.33	24.30	30.21	27.25	47.32	55.84	51.58
60	714.69	775.63	745.16	1139.13	1350.75	1244.94	25.31	28.07	26.69	27.72	33.16	30.44	53.03	61.21	57.12
S.Em.±	15.12	17.40	11.10	25.81	26.88	17.61	0.31	0.39	0.20	0.43	0.45	0.25	0.70	0.87	0.46
C.D. (P=0.05)	42.99	49.46	32.25	73.35	76.40	49.56	0.89	1.09	0.57	1.23	1.26	0.69	1.99	2.49	1.26
Sulphur (S kg ha^{-1})															
0	617.00	682.13	649.56	987.06	1181.25	1084.16	20.56	22.91	21.73	22.33	26.72	24.53	42.88	48.38	45.63
15	644.19	715.94	680.06	1021.75	1264.56	1143.16	21.81	24.44	23.13	23.18	28.39	25.79	44.99	52.81	48.90
30	666.13	718.19	692.16	1074.44	1291.56	1183.00	22.98	24.96	23.97	23.92	28.91	26.41	46.90	53.86	50.38
45	692.88	775.44	743.16	1113.13	1338.69	1225.91	24.61	28.28	26.45	24.87	30.29	27.59	49.49	58.57	54.03
S.Em.±	15.12	17.40	11.10	25.81	26.88	17.61	0.31	0.39	0.20	0.43	0.45	0.25	0.70	0.87	0.46
C.D. (P=0.05)	42.99	49.46	32.25	73.35	76.40	49.56	0.89	1.09	0.57	1.23	1.26	0.69	1.99	2.49	1.26

Table 2. Effect of phosphorus and sulphur on phosphorus and potassium uptake by grain, stover and total uptake of phosphorus by summer green gram at harvest

Treatment	Phosphorus uptake by grain (kg ha^{-1})			Phosphorus uptake by stover (kg ha^{-1})			Total Phosphorus uptake (kg ha^{-1})			Potassium uptake by grain (kg ha^{-1})			Potassium uptake by stover (kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Phosphorus (P_2O_5 kg ha^{-1})															
0	3.08	3.45	3.26	2.45	2.88	2.66	5.46	6.33	5.89	9.46	10.56	10.01	7.55	9.27	8.41
20	3.26	3.63	3.44	2.52	2.99	2.76	5.78	6.63	6.20	9.76	10.95	10.35	7.89	9.64	8.77
40	3.53	3.99	3.76	2.71	3.34	3.03	6.24	7.34	6.79	10.63	11.89	11.26	8.53	10.69	9.61
60	4.04	4.38	4.21	3.00	3.54	3.27	7.04	7.92	7.48	11.47	12.67	12.07	9.29	11.43	10.36
S.Em.±	0.045	0.052	0.029	0.032	0.038	0.018	0.068	0.070	0.034	0.17	0.18	0.11	0.12	0.19	0.096
C.D. (P=0.05)	0.129	0.146	0.082	0.091	0.109	0.053	0.194	0.199	0.098	0.48	0.50	0.31	0.34	0.55	0.27
Sulphur (S kg ha^{-1})															
0	3.26	3.65	3.46	2.51	2.98	2.74	5.77	6.63	6.19	9.37	10.63	10.00	7.49	9.22	8.36
15	3.43	3.81	3.62	2.60	3.17	2.89	6.03	6.98	6.51	9.96	11.26	10.61	8.14	9.91	9.03
30	3.52	3.83	3.68	2.74	3.25	2.99	6.26	7.08	6.67	10.56	11.53	11.05	8.42	10.65	9.53
45	3.69	4.16	3.93	2.84	3.36	3.10	6.47	7.52	6.99	11.43	12.66	12.04	9.21	11.27	10.24
S.Em.±	0.045	0.052	0.029	0.032	0.038	0.018	0.068	0.070	0.034	0.17	0.18	0.11	0.12	0.19	0.096
C.D. (P=0.05)	0.129	0.146	0.082	0.091	0.109	0.053	0.194	0.199	0.098	0.48	0.50	0.31	0.34	0.55	0.27

Table 3. Effect of phosphorus and sulphur on total potassium uptake, sulphur uptake by grain and stover, total sulphur uptake by summer green gram at harvest

Treatment	Total Potassium uptake (kg ha^{-1})			sulphur uptake by grain (kg ha^{-1})			sulphur uptake by stover (kg ha^{-1})			Total sulphur uptake (kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Phosphorus (P_2O_5 kg ha^{-1})												
0	17.01	19.84	18.42	1.05	1.13	1.09	0.68	0.85	0.77	1.74	1.98	1.86
20	17.65	20.58	19.11	1.11	1.24	1.17	0.70	0.87	0.79	1.82	2.11	1.96
40	19.15	22.59	20.87	1.24	1.37	1.32	0.74	0.95	0.85	2.00	2.33	2.16
60	20.75	24.09	22.43	1.45	1.39	1.43	0.79	0.94	0.86	2.23	2.33	2.28
S.Em.±	0.25	0.28	0.16	0.019	0.035	0.0014	0.021	0.017	0.0011	0.068	0.047	0.029
C.D. (P=0.05)	0.71	0.80	0.45	0.054	0.101	0.021	0.061	0.048	0.0032	0.193	0.132	0.083
Sulphur (S kg ha^{-1})												
0	16.87	19.85	18.36	0.88	0.92	0.90	0.41	0.44	0.42	1.29	1.36	1.33
15	18.06	21.16	19.62	1.11	1.19	1.15	0.67	0.84	0.75	1.78	2.03	1.90
30	18.98	22.18	20.58	1.25	1.26	1.25	0.79	1.03	0.91	2.04	2.29	2.16
45	20.64	23.91	22.72	1.62	1.75	1.69	1.04	1.31	1.18	2.69	3.05	2.87
S.Em.±	0.25	0.28	0.16	0.019	0.035	0.0014	0.021	0.017	0.0011	0.068	0.047	0.029
C.D. (P=0.05)	0.71	0.80	0.45	0.054	0.101	0.021	0.061	0.048	0.0032	0.193	0.132	0.083

Table 4. Interaction effect of phosphorus and sulphur on total nitrogen, total phosphorus, total potassium and total sulphur uptake by summer green gram at harvest

Phosphorus (P_2O_5 kg ha^{-1})	Total nitrogen uptake (kg ha^{-1})				Total phosphorus uptake (kg ha^{-1})				Total potassium uptake (kg ha^{-1})				Total sulphur uptake (kg ha^{-1})			
	Sulphur (S kg ha^{-1})				Sulphur (S kg ha^{-1})				Sulphur (S kg ha^{-1})				Sulphur (S kg ha^{-1})			
	0	15	30	45	0	15	30	45	0	15	30	45	0	15	30	45
0	40.52	43.18	46.47	47.17	5.48	5.82	6.15	6.12	16.54	17.87	19.26	20.02	1.18	1.70	2.13	2.42
20	40.81	46.09	44.89	51.86	5.86	6.23	6.05	6.68	17.42	18.71	18.72	21.61	1.28	1.80	1.93	2.84
40	49.91	50.51	51.32	54.59	6.64	6.65	6.80	7.08	19.75	20.14	21.03	22.58	1.47	2.06	2.22	2.91
60	51.29	55.84	58.85	62.51	6.82	7.32	7.67	8.09	19.73	21.78	23.31	24.88	1.37	2.05	2.37	3.32
S.Em.±	0.92				0.069				0.32				0.058			
C.D. (P = 0.05)	2.58				0.195				0.91				0.165			