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Effect of phosphorus and sulphur on nutrient content and uptake by greengram [*Vigna radiata* (L.) Wilczek]

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Abstract
A field experiment was conducted during the *kharif* season of the year 2019 at Agronomy Instructional Farm, Department of Agronomy, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the "Effect of phosphorus and sulphur on growth, yield, quality and nutrient uptake by greengram [*Vigna radiata* (L.) Wilczek]". This experiment was conducted in randomized block design, the treatments comprised of three levels of phosphorus (20, 40 and 60 kg P_2O_5 ha^{-1}) as one factor and three levels of sulphur (20, 40 and 60 kg S ha^{-1}) as another factor. The results revealed that an application of 60 kg P_2O_5 ha^{-1} recorded significantly higher phosphorus content in seed as well as stover and S content in stover, higher uptake of nitrogen, phosphorus, potassium and sulphur by seed as well as stover. An application of 60 kg S ha^{-1} recorded significantly higher sulphur content in seed as well as stover, uptake of nitrogen, phosphorus, potassium and sulphur by seed and stover. Interaction effect of 40 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1} recorded significantly higher phosphorus and sulphur uptake by seed of greengram.

Keywords: Phosphorus and Sulphur application, Interaction, Nutrient content and uptake, Greengram, Loamy sand soil

Introduction
Greengram [*Vigna radiata* (L.) Wilczek*]* is commonly known as mung, mungbean or golden gram. It is self-pollinated crops belong to the *leguminosae* family and origin India and Central Asia. Greengram is a protein rich staple food. It contains about 25 percent protein, which is almost three times that of cereals. It is an excellent source of high quality protein (24.4%) particularly rich in Leucine, Phenylalanine, Lysine, Isoleucine etc. and contains about 1.3% fat, 56.6% carbohydrate, Ca and P are 140 and 280 mg in 100 gm of grain, and calorific value (Cal/100 g) 334 Cal of grain, respectively.

The United Nations, declared in the year 2016 as "International Year of Pulses" (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food security and nutrition. India is the largest producer and consumer of pulses in the world. Pulses account for around 29.99 million ha (23.51%) of the area under total food grain, contributes around 25.23 million tonnes (8.85%) of the total food grain production and 841 kg ha^{-1} (37.66%) of the productivity in the country. In Gujarat, total pulses account for around 9.10 Lakh ha (3.03%) of the area and contributes around 9.26 Lakh tonnes (3.67%) of the production (DES, 2017-2018) [3].

Phosphorus deficiency in the soil is fulfilled by the addition of phosphatic fertilizers but efficiency of utilization of added P by plants is very low. Phosphorus is helps in nitrogen assimilation and it is an indispensable constitute of protein and nucleic acid. Deficiency of sulphur is increasing due to continuous use of S-free fertilizers and increasing cropping intensity with high yielding cultivars and is more conspicuous in coarse textured soils low in organic matter (Sinha *et al.*, 1995) [13].

Material and Methods
A field experiment was conducted on Plot number B-11 during *kharif* season of the year 2019-20 at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). Geographically, Sardarkrushinagar Dantiwada Agricultural University is situated at 24˚-32' North latitude and 72˚-30' East longitude with an elevation of 154.52 meters above the mean sea level. It is situated in the North Gujarat Agro-climatic zone (Zone IV) of the Gujarat state.

The details of the experimental technique employed for the investigation on "Effect of phosphorus and sulphur on growth, yield, quality and nutrient uptake by greengram (*Vigna radiata* (L.) Wilczek)" had total nine treatments *viz*., T_1: 20 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_2: 20 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1}, T_3: 20 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1}, T_4: 40 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_5: 40 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1}, T_6: 40 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1}, T_7: 60 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_8: 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} and T_9: 60 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1} were tried in factorial randomised block design with four replications.

Greengram cv. GM 4 was sown with spacing 40 cm × 15 cm on 9th July, 2019 and harvesting on 25th September, 2019. Other cultural practices and plant protection measures were taken as per recommendation.

The representative dry 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, K and S content and uptake. The N, P, K and S contents were analyzed by micro- Kjeldahl method (KELPLUS model), vandomolybdo phosphoric acid, flame photometric method and turbidimetric method, respectively. The collected data for various parameters were statistically analyzed using Fishers' analysis of variance (ANOVA) technique and the treatments were compared at 5% level of significance.

Results and discussion

Nutrient (N, P, K and S) content in greengram

The data pertaining to the nitrogen, phosphorus, potassium and sulphur content (%) in seed and stover of greengram as influenced by phosphorus and sulphur are presented in Table 1.

Effect of phosphorus

Nitrogen and potassium content (%) in seed and stover was not influenced significantly by phosphorus application. Application of 60 kg P_2O_5 ha^{-1} recorded significantly highest phosphorus content in seed (0.57%) and stover (0.18%) of greengram, which was found at par with 40 kg P_2O_5 ha^{-1}. These results were supported by the findings of Sharma *et al.* (2003) and Niraj *et al.* (2014) [12, 10] in blackgram.

The sulphur content (%) in seed was not influenced significantly due to phosphorus application while in case of stover was observed that significantly the highest sulphur content (0.138%) was recorded with application of 60 kg P_2O_5 ha^{-1} treatments. Similar results had been reported by Niraj *et al.* (2014) [10] in blackgram.

Effect of sulphur

Nitrogen, phosphorus and potassium content (%) in seed and stover were not influenced significantly by sulphur application.

Significantly the highest sulphur content in seed (0.220%) and stover (0.136%) was recorded with 60 kg S ha^{-1} treatment over 20 kg S ha^{-1} and 40 kg S ha^{-1} treatments. These results were confirmed by the findings of Marko *et al.* (2013) [5] in blackgram.

Interaction of phosphorus and sulphur

The data presented in Table 1 revealed that interaction effect of phosphorus and sulphur levels were not found significant with respect to nitrogen, phosphorus, potassium and sulphur content (%) in seed and stover of greengram.

Nutrient uptake (N, P, K and S) by greengram

The data pertaining to the nitrogen, phosphorus, potassium and sulphur uptake (kg ha^{-1}) by seed and stover of greengram as influenced by phosphorus and sulphur are presented in Table 2.

Effect of phosphorus

Significantly the highest nitrogen uptake by seed (25.98 kg ha^{-1}) and stover (11.19 kg ha^{-1}) was recorded with application of 60 kg P_2O_5 ha^{-1} treatments, which was found at par with 40 kg P_2O_5 ha^{-1}. These results were confirmed by the findings of Mandal *et al.* (2005) [4] in greengram, Thenua and Ravindra (2011) [15] in chickpea and Rani *et al.* (2016) [11] in greengram crop.

Significantly the highest phosphorus uptake by seed (4.34 kg ha^{-1}) was recorded with application of 60 kg P_2O_5 ha^{-1}, which was found at par with 40 kg P_2O_5 ha^{-1} and highest phosphorus uptake by stover (2.56 kg ha^{-1}) was observed due to application of 60 kg P_2O_5 ha^{-1}. These results were confirmed by the findings of Tanwar *et al.* (2003) [14] in blackgram, Murari *et al.* (2013) [7] in chickpea and Rani *et al.* (2016) [11] in greengram crop.

Significantly the highest potassium uptake by seed (8.58 kg ha^{-1}) and stover (34.70 kg ha^{-1}) was recorded with application of 60 kg P_2O_5 ha^{-1} treatments, which was found at par with 40 kg P_2O_5 ha^{-1}. These results were confirmed by the findings of Mandal *et al.* (2005) [4] in greengram, Niraj *et al.* (2014) [10] in blackgram and Bairwa *et al.* (2014) [1] in greengram crop.

Significantly highest sulphur uptake by seed (1.55 kg ha^{-1}) was recorded with application of 60 kg P_2O_5 ha^{-1} treatments, which was found at par with 40 kg P_2O_5 ha^{-1} and the highest sulphur uptake by stover (2.00 kg ha^{-1}) was observed due to application of 60 kg P_2O_5 ha^{-1}. These results were confirmed by the findings of Thenua and Ravindra (2011) [15] in chickpea, Murari *et al.* (2013) [7] in chickpea and Rani *et al.* (2016) [11] in greengram crop.

Effect of sulphur

Significantly the highest nitrogen uptake by seed (25.40 kg ha^{-1}) and stover (11.03 kg ha^{-1}) was recorded with application of 60 kg S ha^{-1}, which was found at par with 40 kg S ha^{-1}. These results were confirmed by the findings of Nagar and Meena (2004) [8] in clusterbean and Meena (2012) [6] in groundnut crop.

Significantly the highest phosphorus uptake by seed (4.22 kg ha^{-1}) and stover (2.37 kg ha^{-1}) was recorded with application of 60 kg S ha^{-1}, which was found at par with 40 kg S ha^{-1}. These results were confirmed by the findings of Nilambari *et al.* (2003) [9] in chickpea and Marko *et al.* (2013) [5] in blackgram crop.

Significantly the highest potassium uptake by seed (8.97 kg ha^{-1}) and stover (34.44 kg ha^{-1}) was recorded with application of 60 kg S ha^{-1}, which was found at par with 40 kg S ha^{-1}. Similar results had been reported by Meena (2012) [6] in groundnut and Marko *et al.* (2013) [5] in blackgram crop.

Significantly the highest sulphur uptake by seed (1.65 kg ha^{-1}) and stover (1.94 kg ha^{-1}) was recorded with application of 60 kg S ha^{-1}. Similar results had been reported by Nagar and Meena (2004) [8] in clusterbean and Marko *et al.* (2013) [5] in blackgram crop.

Interaction of phosphorus and sulphur

The data presented in Table 3 revealed that interaction effect

of phosphorus and sulphur levels was found significant with respect to phosphorus uptake (kg ha^{-1}) by seed of greengram. Significantly the maximum phosphorus uptake by seed (4.97 kg ha^{-1}) was recorded with combined application of 40 kg P_2O_5 ha^{-1} and 60 kg S ha^{-1} treatments, which was found at par with 60 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1}.

The data presented in Table 4 revealed that interaction effect of phosphorus and sulphur levels was significant with respect to sulphur uptake (kg ha^{-1}) by seed of greengram. Significantly the maximum sulphur uptake by seed (1.74 kg ha^{-1}) was recorded with combined application of 40 kg P_2O_5 ha^{-1} and 60 kg S ha^{-1}, which was found at par with treatments *viz*., 60 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1}, 40 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1}, 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} and 60 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}. Similar results had been reported by Das (2017) in greengram crop.

The data presented in Table 2 revealed that interaction effect of phosphorus and sulphur levels was not significant with respect to nitrogen and potassium uptake (kg ha^{-1}) by greengram.

Table 1: Effect of phosphorus and sulphur on nutrient content of greengram

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Sulphur content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
(A) Phosphorus levels (P)								
P_1: 20 kg ha^{-1}	3.25	0.75	0.52	0.14	1.09	2.37	0.200	0.119
P_2: 40 kg ha^{-1}	3.27	0.77	0.55	0.17	1.13	2.38	0.210	0.133
P_3: 60 kg ha^{-1}	3.42	0.77	0.57	0.18	1.13	2.39	0.200	0.138
S.Em ±	0.05	0.01	0.007	0.002	0.02	0.03	0.003	0.002
CD (P= 0.05)	NS	NS	0.02	0.01	NS	NS	NS	0.007
(B) Sulphur levels (S)								
S_1: 20 kg ha^{-1}	3.28	0.75	0.54	0.16	1.10	2.36	0.190	0.126
S_2: 40 kg ha^{-1}	3.32	0.76	0.55	0.16	1.11	2.38	0.200	0.129
S_3: 60 kg ha^{-1}	3.34	0.77	0.56	0.17	1.14	2.41	0.220	0.136
S.Em ±	0.05	0.01	0.007	0.002	0.02	0.03	0.003	0.002
CD(P= 0.05)	NS	NS	NS	NS	NS	NS	0.008	0.007
Interaction effect								
P × S	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.62	3.16	4.13	5.00	7.37	5.03	4.87	6.63

Table 2: Effect of phosphorus and sulphur on nutrient uptake by greengram

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})		Sulphur uptake (kg ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
(C) Phosphorus levels (P)								
P_1: 20 kg ha^{-1}	19.67	8.26	3.15	1.52	6.60	26.36	1.21	1.33
P_2: 40 kg ha^{-1}	23.41	10.38	3.94	2.29	8.43	32.30	1.48	1.80
P_3: 60 kg ha^{-1}	25.98	11.19	4.34	2.56	8.58	34.70	1.55	2.00
S.Em ±	0.97	0.36	0.13	0.06	0.35	1.25	0.06	0.06
CD (P= 0.05)	2.84	1.05	0.40	0.19	1.02	3.64	0.18	0.16
(D) Sulphur levels (S)								
S_1: 20 kg ha^{-1}	19.73	8.45	3.25	1.79	6.65	26.72	1.15	1.44
S_2: 40 kg ha^{-1}	23.92	10.35	3.95	2.21	7.98	32.21	1.45	1.76
S_3: 60 kg ha^{-1}	25.40	11.03	4.22	2.37	8.97	34.44	1.65	1.94
S.Em ±	0.97	0.36	0.13	0.06	0.35	1.25	0.06	0.06
CD (P= 0.05)	2.84	1.05	0.40	0.19	1.02	3.64	0.18	0.16
Interaction effect								
P × S	NS	NS	0.68	NS	NS	NS	0.31	NS
CV (%)	14.66	12.48	12.32	10.47	15.41	13.88	14.94	11.24

Table 3: Interaction effect of phosphorus and sulphur on phosphorus uptake by seed of greengram

Treatments	Phosphorus uptake by seed (kg ha^{-1})		
Phosphorus levels (P)	Sulphur levels (S)		
	S_1 (20 kg ha^{-1})	S_2 (40 kg ha^{-1})	S_3 (60 kg ha^{-1})
P_1 (20 kg ha^{-1})	2.48	3.72	3.55
P_2 (40 kg ha^{-1})	2.90	3.97	4.97
P_3 (60 kg ha^{-1})	4.05	4.12	4.49
S.Em ±	0.24		
CD (P= 0.05)	0.68		
CV (%)	12.32		

Table 4: Interaction effect of phosphorus and sulphur on sulphur uptake by seed of greengram

Treatments	Sulphur uptake by seed (kg ha^{-1})		
Phosphorus levels (P)	**Sulphur levels (S)**		
	S_1 (20 kg ha^{-1})	**S_2 (40 kg ha^{-1})**	**S_3 (60 kg ha^{-1})**
P_1 (20 kg ha^{-1})	0.88	1.34	1.23
P_2 (40 kg ha^{-1})	1.10	1.50	1.74
P_3 (60 kg ha^{-1})	1.65	1.62	1.67
S.Em ±	0.11		
CD (P= 0.05)	0.31		
CV (%)	14.94		

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