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Effect of phosphorus and sulphur on the yield & nutrient content of green gram

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Abstract
The field experiment was carried out at Agriculture experimental field (Department of Soil Science & Agricultural Chemistry), Nehru P. G. College, Lalitpur (U. P.) during 2015. Lalitpur, district is a part of Bundelkhand plateau. Betwa River is the boundary between Jhansi and Lalitpur in the north. Its latitudinal extension is from $24^0$10' N to $25^0$15' N and longitudinal extension is from 78.10' E to 79^0 00' E. the experimental station is situated at 1.5-2.00 km in the Southern of center of Lalitpur city on Sager-Road. The Pot experiment was conducted to study Effect of Phosphorus and Sulphur on Yield and Nutrient Uptake by Moong Bean (*Vigna radiata* L.) at Agriculture experimental field, Nehru PG collage Lalitpur (U.P.) during 2014-15. The Results revealed that application of 40 kg Sulphur ha-^{1} and Phosphorus 90kg ha-^{1} to the summer green gram crop significantly increased the sulphur and Phosphorus content in seed and straw yield. The interaction effect of P×S on seed and straw production of summer green gram was found also significant and yield was improved by the application of both of these two (90 kg P_2O_5/ha and 40 kg S/ha) nutrients as compared to control and but statistically at par with 40 kg sulphur ha-^{1}. The percent enhancement were 6.74, 15.92 and 19.48 in seed and 31.60, 54.50 and 69.71 in straw of green gram due to 10, 20 and 40kg S/ha over control respectively. Interaction effect was also significant.

Keywords: Mungbean, P×S Interaction Effect, Nutrient Content and Yield)

Introduction
The mung bean (*Vigna radiata* L.) is under cultivation since prehistoric time in India. It is also known as green gram and serve are a major source of dietary protein for the vast majority of people. The food legumes, particularly the grain or pulses are important food stuff in all tropical and subtropical countries Mohbe, *et al.* 2015 and 2017 [10, 9]. Pulses deal with those species of the plant which belong to the family and subfamily faboide. They constitute on integral part of human diet as mature dry seeds and may also be used as immature green seeds or as green pods with immature seeds in it. They can be used for animals in the form of hay and straw. The pulses have high protein contents (average 20-25%). In addition to their value as food stuff, they are also important in cropping system. India is the world largest homeland of vegetarian and world leader in pulses production and import to provide protein supplement (Singh *et al*., 2012) [20]. Rapid population growth and low production especially to pulses have enhanced the problem of food security. Indian pulses production has been stuck in between 14 and 15 MT since mid-nineties, resulting in poor consumption (33g/capita/day) during 2010 (Ali and Gupta, 2012) [1]. Chemical fertilizers have deleterious effect on soil fertility, while integration of chemical fertilizers with organic manures and bio-fertilizers would be able to maintain soil fertility and sustain crop productivity (Dotaniya *et al.* 2017 and Jeyabal *et al.*, 2000). In India especially rice-wheat is the prevalent cropping system and the area and resultantly the production of pulses have been marginalized (Singh *et al*, 2013) [21].
Phosphorus is an essential both as a part of several key plant structure compound and as catalysis in the conversion of key biochemical reaction in plants. Phosphorus is also involved in controlling key enzyme reactions and in the regulation of metabolic pathways (Theodorau and Plaxton, 1993) [23]. Phosphorus is an important plant nutrient and it effects seed germination, cell division, flowering, fruiting, synthesis of fat, starch and in fact most biochemical activities. Judicious use of phosphate fertilizer is supposed to result in better nodulation and efficient functioning of nodules bacteria for fixation of atmospheric nitrogen to be utilized by plant during grain development stage, which in turn leads to increase in grain yield (Sarkar, 1992) [16].
Sulphur is an essential element for plant growth, ranks in importance with N and P in the formation of plant proteins.

Sulphur deficiency have been reported over 70 countries worldwide of which India is one **(**Balasubramanian *et al.* 1990). In generally, sulphur is also essential for synthesis of vitamin (biotin and thiamine), sulphur containing amino acids (cystine, cysteine and methionine) and promotes nodulation in legumes. According to Pandey and Singh (2001) reported that highest grain and straw yield of green gram was obtained by application of sulphur.

Material and methods

Experimental site & Climate

The field experiment was carried out at Agriculture experimental field (Department of Soil Science & Agricultural Chemistry), Nehru P. G. College, Lalitpur (U. P.) during 2015. Lalitpur district is a part of Bundelkhand plateau. Betwa River is the boundary between Jhansi and Lalitpur in the north. Most of the area in under the average elevation of 300m–450m from the See level. Its latitudinal extension is from $24^0$10' N to $25^0$15' N and longitudinal extension is from 78.10' E to 79^0 00' E. Geographically, Lalitpur district falls in the zone of sub-tropical climate and may be characterized by a very hot dry summer and cold winter. The summer (May-June) temperature of goes up 40-45 ^{0}C and winter (Dec-Jan) with minimum temperature 3-5 ^{0}C.

Soil Properties, Collection of Soil & Characteristics

The experiment was conducted on clay-loamy soil is heavy soil and is distributed in upland and lowland area of Lalitpur. A composite soil sample representing 0-15cm depth by "V" shaped method was taken from the experimental field. The collected soil sample was air dried, crushed and sieved through 2mm sieve.

Table 1: Initial characteristics of experimental soil

S. No.	Major characteristics	Value	Method of Determination
1.	pH (1:2.5 soil water suspension)	7.9	Method No.21, USDA Handbook No.60 (Richards, 1954)
2.	EC (d/Sm)	0.20	Method No.21, USDA Handbook No.60 (Richards, 1954)
3.	Organic Carbon(g/kg)	4.68	Walkley and Blacks method (Jackson, 1954)
4.	$CaCO_3$ (g/kg)	5.23	Rapid titration method (Piper, 1966)
5.	Available N (mg/kg)	84.67	Alkaline Permanga-nate Method **(**Subbia AndAsiza, 1956)
6.	Available P (mg/kg)	5.13	Olsens method**(** Olsen *et al.*, 1954**)**
7.	Available K (mg/kg)	96.45	Hanway and Heidal (1954)
8.	Available S (0.14% $CaCl_2$)	8.78	Chesnin and Yien (1951)

Chemical analysis of plant samples

The plant samples were collected from each pot and were dried in sun-light and after followed by in oven at 70 ^{0}C. These samples were analyzed for different elements by adopting standard procedures.

Nitrogen was estimated as quoted in Colorimetric Methods, 0.1gm plant material was taken 50 ml. of conical flask and to this 2 ml of con. H_2SO_4 were added. The content was gently heated on a hot plate. When volume was reduced about half of the original volume then 1.5 ml. of 30% H_2O_2 were added. The concentrate contains were heated again till a clear extract were obtained. The contents were transferred in a 10 ml. volumetric flask and volume was made up to the mark with distilled water. After the preparation of acid extract of plant material, nitrogen was estimated with rapid titration method. The phosphorus was estimated 1.0 gram finely grind plant material was taken in 50 ml. conical flask and to this 10 ml. of nitric acid (HNO_3) AR was added and the contents were put for a night. Then the conical flasks were placed in not plate and wet digestion was done with 2.0 ml. of 60% per-chloric acid ($HClO_4$) following the method of outlined by Johnson and Ulrich (1959). Potassium was estimated in the same extract otter making suitable dilution and the concentration was measured with the help of flame photometer. The standard curve was prepared with the help of test solution and amount of K was calculated.

Experimental details & design

The performance of phosphorus and sulphur treatment were tested the pot experiment using summer green gram and other pulses crop. The experimental comprising four levels of phosphorus and four levels of sulphur was conducted in the factorial randomized block design with three replications in 48 pots.

The details are as below treatments: -

Levels of P_2O_5 - 4 (0, 30, 60, 90 kg/ha)

Levels of S - 4 (0, 10, 20, 40 kg/ha)

Replication - 3

The experiment was laid out in randomized block design. There were in all 16 treatment combinations (4×4) and three replications. The allocation of the treatments in to the pots was done randomly in each replication.

Result and discussion

1. Yield Attribute

The data on seed and straw yield of summer green gram are summarized in the table 2 The data given in that sulphur application have a marked effect on seed yield and straw yield of summer green gram (Dharwe *et al.* 2017). All the higher doses of sulphur clearly significantly superior over control enhancing the seed and straw yield production of summer green gram. The lowest average value of seed yield and straw yield were recorded in control treatment. The seed yield 2.47 8.11, and 7.52% and straw yield 13.93, 26.59 and 22.09% increased of summer green gram due to 10, 20 and 40kg S/ha (Surendra Ram and Katiyar, 2013) [22] The higher level of S (40 kg S/ha) tended to decreased 0.54% and 0.43% in seed and straw yield of summer green gram over 20kg S/ha level. However, this reduction in seed yield and straw yield of summer green gram were statistically non-significant. These findings are similarly to those of Ram and Dwivedi, 1992) [14], Shekhawat *et al*. (1996) [18], Sharma and Singh, 1997) [17].

Table 2: Effect of Phosphorus and Sulphur level on yield attribute seed & straw of summer green gram (g/pot)

Sulphur Level (kg/ha)	Seed Yield					Straw Yield				
	Phosphorus level (kg/ha)					Phosphorus level (kg/ha)				
	P_0	P_{30}	P_{60}	P_{90}	Mean	P_0	P_{30}	P_{60}	P_{90}	Mean
S_0	11.64	11.82	11.97	12.42	11.96	13.85	18.12	20.28	20.70	18.24
S_{10}	12.15	12.13	12.28	12.33	12.28	19.20	20.38	21.97	21.55	20.78
S_{20}	12.74	12.89	13.00	13.12	12.93	21.37	22.57	23.95	24.46	23.09
S_{40}	12.69	12.75	12.97	13.04	12.86	21.29	22.43	23.86	24.38	22.99
Mean	12.30	12.43	12.56	12.74	12.75	18.93	20.88	22.52	22.77	21.27
	P		S		P×S	P		S		P×S
SEM+	0.12		0.12		0.24	0.48		0.48		0.96
CD at 5 %	0.25		0.25		0.50	0.98		0.98		1.96

P application had a significant response on seed yield and straw yield production of summer green gram. All the higher doses of P significantly enhanced the seed yield and straw yield production. The percent enhancement were 1.05, 2.11 and 3.58 (seed yield) and 10.31, 18.97 and 20.34 (straw yield) over control (due to 30, 60 and 90 kg P_2O_5/ha) of summer green gram, respectively. A similar effect of P application on green gram and other pulses crop production have also been reported /showed by Singh *et al*. 1985) [19], Sarkar and Banik, (1991) [16] Dotaniya *et al.* (2014) [6], Muhammad *et al*, 1999. The interaction effect PXS on seed and straw yield production of summer green gram were found significant. Highest yield in seed and straw was found with 40 kg S/ha and 90 kg P_2O_5/ha. The same result also observed by Kumar *et al.* (2007) and Kumar & Kumar, 2013).

2. Chemical composition of green gram

2.1 Effect on nitrogen content

The data given in table 3 clearly indicate that S application have a significant effect on nitrogen content in seed and straw of green gram plant. All higher doses of S application were found significantly increased N content 3.93, 3.37 and 11.2% in seed and 15.33, 22.59 and 35.49% in straw of green gram over control respectively Singh and Ram (1992) [14]**.** The result obtained in present investigation indicated a synergetic effect of applied S on tissue N content hence on protein synthesis. These findings are similar to those of Singh and Singh (2012) who also observed a positive effect in N content in field crop with higher level of S application. P applications have a significant effect on the N content in seed and straw yield of summer green gram crop. P application caused a significant enhancement in N content 0.53, 1.07 and 2.95% in seed and 4.28, 6.42 and 8.57% in straw due to 30, 60 and 90 kg P_2O_5/ha. All the higher doses of Phosphorus 30, 60 and 90 kg/ha application were found significantly superior over control in enhancing the N content in seed and straw of summer green gram.

Table 3: Effect of P and S levels on N content in seed and straw of green gram (%).

Sulphur Level (kg/ha)	Seed					straw				
	Phosphorus level (kg/ha)					Phosphorus level (kg/ha)				
	P_0	P_{30}	P_{60}	P_{90}	Mean	P_0	P_{30}	P_{60}	P_{90}	Mean
S_0	3.59	3.64	3.45	3.59	3.56	1.23	1.20	1.29	1.26	1.24
S_{10}	3.63	3.70	3.67	3.83	3.70	1.31	1.42	1.49	1.53	1.43
S_{20}	3.76	3.72	3.93	3.89	3.82	1.44	1.51	1.53	1.60	1.52
S_{40}	3.91	3.92	4.02	4.01	3.96	1.62	1.73	1.66	1.71	1.68
Mean	3.72	3.74	3.76	3.83	3.76	1.40	1.46	1.49	1.52	1.46
	P	S	P×S			P		S		P×S
SEM+	0.03	0.03	0.6			0.02		0.02		0.4
CD at 5 %	0.06	0.06	0.13			0.04		0.04		0.8

The interaction effect P×S on N content in seed and straw yield of summer green gram were found significant. The highest N content was found with 40 kg S/ha and 90kg P_2O_5/ha.

2.2 Effect on P content

The data given in table 4 clearly indicate that S application have a significant effect on phosphorus content in seed and straw of green gram plant. All higher doses of S application were found significantly increased P content 2.0, 42.5 and 16.6% in seed and 9.88, 16.05 and 22.84% in straw of green gram over control Dharwe *et al.* (2017) [3], Surendra and Katiyar, T.P.S. (2013) [22]. The P content in seed and straw of green gram with increasing levels of S and maximum values were recorded at 40 kg S/ha.

P application has a significant effect on the P content in seed and straw yield of summer green gram crop. P application caused a significant enhancement in P content 8.34, 14.59 and 18.75% in seed and 1.70, 3.96 and 5.09% in straw due to 30, 60 and 90 kg P_2O_5/ha. All the higher doses of phosphorus 30, 60 and 90 kg/ha application were found significantly superior over control in enhancing the P content in seed and straw of summer green gram. The favorable effect of S on N content was also reported by Singh and Kalra (1985) [19] & Sarkar and Banik (1991) [16]. The interaction effect P×S on P content in seed and straw yield of summer green gram were found significant. The highest P content was showed with 40 kg S/ha and 90kg P_2O_5/ha.

Table 4: Effect of P and S levels on P content in seed and straw of green gram (%).

Sulphur Level (kg/ha)	Seed					Straw				
	Phosphorus level (kg/ha)					Phosphorus level (kg/ha)				
	P_0	P_{30}	P_{60}	P_{90}	Mean	P_0	P_{30}	P_{60}	P_{90}	Mean
S_0	0.36	0.39	0.34	0.45	0.40	0.162	0.159	0.168	0.160	0.162
S_{10}	0.45	0.48	0.51	0.51	0.48	0.171	0.176	0.181	0.186	0.178
S_{20}	0.50	0.57	0.59	0.63	0.57	0.180	0.188	0.190	0.196	0.188
S_{40}	0.63	0.66	0.67	0.69	0.66	0.197	0.198	0.199	0.202	0.199
Mean	0.48	0.52	0.55	0.57	0.52	0.177	0.180	0.184	0.186	0.181
	P	S	P×S			P	S	P×S		
SEM+	0.007	0.007	0.01			0.001	0.001	0.003		
CD at 5 %	0.015	0.015	0.03			0.003	0.003	0.006		

2.3 Effect of Phosphorus and Sulphur on K content

A reference to table 5 indicates that the application of S increased the K content 1.56, 2.60 and 4.15% in seed and 5.33, 7.91 and 11.25% straw of summer green gram significantly over control. However, the lower level of S (10 kg S/ha) did not prove significantly superior over control in respect of K content in seed and straw of green gram. The higher levels (20 and 40 kg S/ha) of S registered a significant increase K content in seed and straw of green gram. The maximum value of concentration of K in green gram crop was recorded at 40 kg S/ha. The same result found by Dharwe *et al.* (2017) [3], Singh and Singh (2012), Pandey *et al.* (2000), Ram and Katiyar, T.P.S. (2013) [22].

A perusal of the data given in table 4.2-3 reveals that the K content in seed and straw of green gram increased with P application over control. All the levels of P proved significantly superior over control. P application caused a significant enhancement in K content 1.04, 2.59 and 4.14% in seed and 2.28, 2.56 and 3.13% in straw due to 30, 60 and 90 kg P_2O_5/ha. All the higher doses of phosphorus 30, 60 and 90 kg/ha application were found significantly superior over control in enhancing the K content in seed and straw of summer green gram. These findings are similar to those of Singh and Ram (1992) [14], Dotaniya *et al.* (2013, 2014a) [4, 5] Muhammad *et al.* (2001).

Table 5: Effect of P and S levels on K content in seed and straw of green gram (%)

Sulphur Level (kg/ha)	Seed					Straw				
	Phosphorus level (kg/ha)					Phosphorus level (kg/ha)				
	P_0	P_{30}	P_{60}	P_{90}	Mean	P_0	P_{30}	P_{60}	P_{90}	Mean
S_0	1.89	1.91	1.94	1.98	1.93	3.35	3.42	3.38	3.40	3.38
S_{10}	1.92	1.94	1.97	1.99	1.96	3.51	3.58	3.55	3.60	3.56
S_{20}	1.94	1.96	1.99	2.02	1.98	3.57	3.64	3.69	3.71	3.65
S_{40}	1.97	1.99	2.01	2.05	2.00	3.67	3.76	3.80	3.83	3.76
Mean	1.93	1.95	1.97	2.01	1.96	3.52	3.60	3.61	3.63	3.58
	P	S	P×S			P	S	P×S		
SEM+	0.01	0.01	0.02			0.006	0.006	0.012		
CD at 5 %	0.02	0.02	0.04			0.013	0.013	0.026		

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