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Effect of phosphorus and sulphur on nutrient content and uptake in Mungbean (*Vigna radiate* L.)

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Abstract
A study was carried out at Agronomy Farm, college of agriculture, SKRAU, Bikaner during *kharif* season of 2016 to evaluate the effect of different levels of phosphorus and sulphur and their interactions on growth, yield attributes and nutrient concentration of mungbean. The experiment was laid out with twelve treatments combinations consisting of four levels of phosphorus (control, 15, 30 and 45 kg P_2O_5 ha^{-1}) and three levels of sulphur (control, 20 and 40 kg S ha^{-1}). The results revealed that uptake and content of nutrients increased significantly with increasing levels of phosphorus and sulphur. Application of 30 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1} significantly increased the nitrogen, potassium, sulphur content and their uptake by seed and straw but highest was found with 45 kg P_2O_5 and 40 kg S. Whereas, the phosphorus content in seed and straw significantly increased with increasing levels of phosphorus up to 45 kg P_2O_5.

Keywords: Phosphorus sulphur, nutrient content mungbean agronomy farm

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the most extensively grown leguminous crops of India. It occupies 3.4 million ha area with a production of 1.4 million tonnes with the average yield 475 kg per ha (2014-15). Rajasthan is the largest producer of green gram. It is a short duration crop and rich in protein & vitamin B. Proper fertilization is essential to improve the productivity of Mungbean. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur (Thakur and Negi, 1985) [29]. Mungbean, being a pulse crop requires high amount of phosphorus. Phosphorus is among the essential macro-nutrients required for plant growth and development. It plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, root growth, nodulation and nitrogen fixation in plants. Mungbean also responds well to sulphur fertilization in S deficient soils. Sulphur has a profound influence on protein synthesis for pulses and is a part of amino acids such as cystein, cystine and methionine. Kour *et al.* (2010) [10] reported that the total sulphur, available sulphur and organic sulphur content in soils of Rajasthan region is below the critical limit.

Both phosphorus and sulphur can improve the quality and quantity of the crop. Sulphur interacts with phosphorus as phosphate ion is more strongly bound than sulphate (Hedge and Murthy, 2005) [7]. Application of P influences the absorption and assimilation of a number of other essential as well as non- essential elements present in the soil. Its addition may have favourable (synergistic) or depressing (antagonsitc) effect on the availability of other nutrients. Generally, P x S interaction was found to be synergistic on dry matter yields of different crops at their lower levels of application but at their higher levels of application, there was antagonistic interaction (Aulakh *et al.*, 1990 and Islam *et al.*, 2006) [1, 8]. The interaction of these nutrient elements may affect the critical levels of available P and S below which response to their application could be observed.

Materials and methods

A field experiment on mungbean crop was conducted at the Agronomy farm, College of

Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2016. The experimental site is located under Agro-ecological region No. 2 (M9E1) under Arid ecosystem (Hot Arid Eco-region. The soil of experimental field was loamy sand in texture having pH-8.38, EC-0.22 dS m^{-1}, available N – 89.25 kg ha^{-1}, available P_2O_5-19.50 kg ha^{-1}, available K_2O-190.35 kg ha^{-1} and available S-7.30 mg kg^{-1} and organic carbon-0.07%. The experiment was laid out in a factorial randomized block design with three replications and the 12 treatment combinations randomized with the help of random number table as advocated by Fisher (1950) [6]. The treatment details are follows:

(A) Phosphorus levels
P_0 = Control, P_{15} = 15 Kg ha^{-1}, P_{30} = 30 Kg ha^{-1} and P_{45} = 45 Kg ha^{-1}
(B) Sulphur levels
S_0 = Control, S_{20} = 20 Kg ha^{-1}, S_{40} = 40 Kg ha^{-1}

The Nitrogen and phosphorus was applied as per treatments through DAP and Urea. Sulphur was applied through elemental sulphur as per treatments.

Representative samples of seed and straw from individual plot was taken at the time of threshing for estimation of nutrients concentrations. Further the samples were oven dried and ground separately in fine powder with Willey Mill and N, P, K and S contents were determined by using standard methods given below:

Estimation of nitrogen was done by colorimetric method using spectrophotometer (Snell and Snell, 1939) [25]. Phosphorus was estimated by digesting plant samples with tri-acid mixture and was determined by Vanadomolybdo phosphoric yellow colour method (Jackson, 1973) [9]. Potassium content in samples was determined in tri-acid digested materials by using Flame photometer (Jackson, 1973) [9]. Sulphur was determined by turbidimetric method (Tabatabi and Bremner, 1970) [27] and turbidity was measured by colorimeter.

The uptake of N, P, K and S by seed and straw was estimated by using the following formula.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{NC x Seed or straw yield}}{100}$$

Where NC= % nutrient content in seed or straw and Yield in kg ha^{-1}

Results and discussion

Effect of phosphorus and Sulphur application

a) Nitrogen content and uptake in seed and straw

Nitrogen concentration in seed and straw was significantly improved due to phosphorus fertilization (Table 1). Significant increase in N concentration in seed and straw was observed up to 30 kg P_2O_5 ha^{-1}. Application of phosphorus at 30 kg ha^{-1} resulted in the uptake of 39.89 Kg N ha^{-1} in seed and 28.98 kg N ha^{-1} in straw of mungbean that was significantly higher over rest of levels except 45 kg ha^{-1}. The maximum concentration and uptake of N in seed and straw were obtained with 45 kg P_20_5 ha^{-1}. Bhalu *et. al.* (1995) observed that N and P uptake and content of urdbean increased significantly with increasing levels of phosphorus. Trivedi (1996) [30] observed significant increase in N, P and S content in grain of blackgram with increasing levels of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Similarly application of sulphur in mungbean significantly enhanced the N concentration and uptake in seed and straw up to 20 kg S ha^{-1}. The maximum concentration and uptake of N in seed and straw were obtained with 40 kg S ha^{-1} which represented 21.73 per cent increase in N concentration in seed and 42.25 per cent in straw over control respectively and 138.98 per cent increase in N uptake in seed and 176.24 per cent in straw over control respectively. Singh (2003) [24] reported that successive addition in level of sulphur upto 30 kg/ha significantly increased N and P content and uptake by grain and straw in urdbean.

Table 1: Effect of phosphorus and sulphur on nitrogen content and uptake in seed and straw of mungbean after harvest

Treatments	N content (%)		N Uptake (kg ha^{-1})	
	Seed	Straw	Seed	Straw
A. Phosphorus (kg P_2O_5 ha^{-1})				
P_0	2.96	0.71	15.00	10.16
P_{15}	3.30	0.86	27.12	19.71
P_{30}	3.84	1.00	39.89	28.98
P_{45}	4.05	1.03	43.20	30.40
SEm±	0.09	0.02	1.54	0.90
CD (p= 0.05)	0.26	0.07	4.52	2.65
B. Sulphur (kg S ha^{-1})				
S_0	3.13	0.71	16.75	10.52
S_{20}	3.67	0.97	37.12	27.36
S_{40}	3.81	1.01	40.03	29.06
SEm±	0.08	0.02	1.33	0.78
CD (p= 0.05)	0.22	0.06	3.91	2.30

b) Phosphorus content and uptake in seed and straw

Effect of phosphorus application

Phosphorus concentration in seed and straw was significantly improved due to phosphorus fertilization (Table 2). Significant increase in phosphorus concentration in seed and straw was observed up to 30 kg P_2O_5 ha^{-1}. The maximum concentration of P_2O_5 in seed and straw were obtained with 45 kg P_20_5 ha^{-1}. Lai *et. al.* (2013) [13] observed that application of increasing levels of phosphorus significantly increased the phosphorus content and uptake up to 40 kg P_2O_5 ha^{-1} of chickpea.

Total uptake of P_2O_5 by crop registered profound increase due to phosphorus fertilization. Application of phosphorus at 30 kg ha^{-1} resulted in the phosphorus uptake of 6.49 Kg ha^{-1} by seed that was significantly higher over rest of levels except 45 kg ha^{-1}. The maximum uptake of Phosphorus by seed and straw were obtained with 45 kg P_2O_5 ha^{-1} which represented 164.64, 45.0 and 7.24 per cent increase by seed and 150, 43.72 and 5.87 per cent by straw over control, 15 kg P_2O_5 ha^{-1} and 30 kg P_2O_5 ha^{-1}, respectively. Bhakre and Sonar (2000) [4] observed significantly higher uptake of phosphorus by grain and straw of soybean under 100 kg P_2O_5 ha^{-1} in comparison to 25, 50 and 75 kg P_2O_5 ha^{-1} and control. Shankaralaingappa *et. al.* (2000) [23] also reported that application of phosphorus up to 50 kg P_2O_5 ha^{-1} significantly increased the uptake of N, P, K and S by pigeon pea.

Effect of Sulphur application

It is further evident from the data (Table 2) that application of sulphur in mungbean significantly enhanced the phosphorus concentration in seed and straw up to 20 kg S ha^{-1}. The maximum concentration of P_2O_5 in seed and straw were obtained with 40 kg S ha^{-1} which represented 12.61 and 0.81 per cent increase in seed and 16.86 and 3.60 per cent in straw over control and 20 kg S ha^{-1} respectively. The increased photosynthetic efficiency, which favoured dry matter production and nutrient concentration in plant, seems to be the major factor responsible for higher nutrient content and uptake under the influence of sulphur application. This was in agreement with Teotia *et. al.* (2000) [28], Mali *et. al.* (2003) [14], Kumawat *et. al.* (2007) [11], Bahadur *et. al.* (2009) [2] in mungbean.

Application of sulphur in mungbean significantly enhanced the phosphorus uptake in seed and straw up to 20 kg S ha^{-1} (Table 2). The maximum uptake of phosphorus in seed and straw were obtained with 40 kg S ha^{-1} which represented 119.92 and 5.0 per cent increase by seed and 128 and 6.34 per cent by straw over control and 20 kg S ha^{-1} respectively. Naagar and Meena (2004) [17] observed that total uptake of N, P, and S significantly increased up to 60 kg S ha^{-1}.

Table 2: Effect of phosphorus and sulphur on phosphorus content and uptake in seed and straw of mungbean

Treatments	P content (%)		P Uptake (kg ha^{-1})	
	Seed	Straw	Seed	Straw
A. Phosphorus (kg P_2O_5 ha^{-1})				
P_0	0.522	0.170	2.63	2.38
P_{15}	0.582	0.182	4.80	4.14
P_{30}	0.633	0.198	6.49	5.62
P_{45}	0.663	0.207	6.96	5.95
SEm±	0.009	0.003	0.18	0.17
CD (p= 0.05)	0.026	0.008	0.53	0.51
B. Sulphur (kg S ha^{-1})				
S_0	0.555	0.172	2.96	2.50
S_{20}	0.620	0.194	6.20	5.36
S_{40}	0.625	0.201	6.51	5.70
SEm±	0.008	0.002	0.16	0.15
CD (p= 0.05)	0.023	0.007	0.46	0.44

c) Potassium content and uptake
Effect of phosphorus

Potassium concentration in seed and straw was significantly improved due to phosphorus fertilization (Table 3). Significant increase In K concentration in seed and straw was observed up to 30 kg P_2O_5 ha^{-1}. The maximum concentration of potassium in seed and straw were obtained with 45 kg P_20_5 ha^{-1} which represented 20.68, 9.12 and 0.62 per cent increase in seed and 36.02, 14.28 and 1.78 per cent in straw over control, 15 kg P_2O_5 ha^{-1} and 30 kg P_2O_5 ha^{-1}, respectively.

Total uptake of potassium by crop registered profound increase due to phosphorus fertilization. Application of phosphorus at 30 kg ha^{-1} resulted in the potassium uptake of 5.0 Kg ha^{-1} by seed that was significantly higher over rest of levels except 45 kg ha^{-1}. The maximum uptake of Potassium in seed and straw were obtained with 45 kg P_2O_5 ha^{-1} which represented 153.91, 38.50 and 3.60 per cent increase by seed and 184.68, 46.07 and 3.92 per cent by straw over control, 15 kg P_2O_5 ha^{-1} 30 kg P_2O_5 ha^{-1}, respectively. Rathore *et. al.* (2010) [19] from MPUAT, Udaipur reported that every increase in level of phosphorus from 0 to 40 kg/ha significantly increased the uptake of N, P and K in urdbean over lower levels and control.

Effect of Sulphur

It is further evident from the data (Table 3) that application of sulphur in mungbean significantly enhanced the K concentration in seed and straw up to 20 kg S ha^{-1}. The maximum concentration of potassium in seed and straw were obtained with 40 kg S ha^{-1} which represented 16.91 and 1.47 per cent increase in seed and 31.82 and 3.18 per cent in straw over control and 20 kg S ha^{-1} respectively. It is further evident from the data that application of sulphur in mungbean significantly enhanced the K uptake in seed and straw up to 20 kg S ha^{-1}. The maximum uptake of potassium in seed and straw were obtained with 40 kg S ha^{-1} which represented 130.14 and 6.11 per cent increase by seed and 160.21 and 6.37 per cent by straw over control and 20 kg S ha^{-1} respectively. The positive influence of sulphur fertilization on N, P, K and S content of the crop seems to be due to improved nutritional availability both in rhizosphere and the plant system as well as discussed in preceding paragraphs.

Table 3: Effect of phosphorus and sulphur on potassium content and uptake in seed and straw of mungbean

Treatments	K content (%)		K uptake (kg ha^{-1})	
	Seed	Straw	Seed	Straw
A. Phosphorus (kg P_2O_5 ha^{-1})				
P_0	0.406	1.088	2.04	15.27
P_{15}	0.449	1.295	3.74	29.76
P_{30}	0.487	1.454	5.00	41.83
P_{45}	0.490	1.480	5.18	43.47
SEm±	0.007	0.034	0.14	1.12
CD (p= 0.05)	0.020	0.100	0.42	3.28
B. Sulphur (kg S ha^{-1})				
S_0	0.414	1.109	2.19	16.16
S_{20}	0.477	1.417	4.75	39.53
S_{40}	0.484	1.462	5.04	42.05
SEm±	0.006	0.029	0.13	0.97
CD (p= 0.05)	0.017	0.086	0.37	2.84

d) Sulphur content and uptake
Effect of phosphorus

Sulphur concentration and uptake of sulphur in seed and straw was significantly improved due to phosphorus fertilization. Significant increase in S concentration in seed and straw was observed up to 30 kg P_2O_5 $ha^{-1}$and significantly higher sulphur uptake of 3.62 Kg ha^{-1} was observed at 30 kg P_2O_5 ha^{-1}. The maximum concentration and uptake of sulphur in seed and straw were obtained with 45 kg P_20_5 ha^{-1} which represented 14.14 per cent increase in S content & 14.15 per cent increase in S uptake in seed and 32.55 per cent increase in S content & 168 per cent increase in S uptake in straw over control. Sepat and Yadav (2008) [22] reported that increasing levels of phosphorus upto 30 kg/ha significantly increased the N, P and S concentration in seed and straw as well as uptake of these nutrients in mothbean.

Effect of Sulphur

Application of sulphur in mungbean significantly enhanced the S concentration in seed and straw up to 20 kg S ha^{-1}. The maximum concentration of sulphur in seed and straw were obtained with 40 kg S ha^{-1} which represented 11.29 and 4.41 per cent increase in seed and 50 and 6.36 per cent in straw over control and 20 kg S ha^{-1} respectively. Kumawat *et. al.* (2007) [11] from Bikaner reported that application of sulphur at 40 kg/ha resulted in marked increase in S content in dry matter at branching, flowering and maturity by 31.7, 25.2 and 91.0 per cent over control.

It is further observed that application of sulphur in mungbean significantly enhanced the S uptake in seed and straw up to 20 kg S ha^{-1}. The maximum uptake of sulphur in seed and straw were obtained with 40 kg S ha^{-1} which represented 11.29 and 4.41 per cent increase by seed and 191.30 and 9.84 per cent by straw over control and 20 kg S ha^{-1} respectively. Teotia *et. al.* (2000) [28] reported that every increase in level of sulphur upto 80 kg/ha brought about significant improvement in S concentration both in grain and straw of mungbean and their uptake.

Interaction effect between Phosphorus and Sulphur levels on N, P, K and S content and uptake in seed and straw

Nutrient content and uptake in seed as well as in straw was found to increased with increasing levels of sulphur up to 40 kg S ha^{-1} at same level of phosphorus and with increasing levels of phosphorus up to 45 kg P_2O_5 ha^{-1} at same level of sulphur. Significantly higher N content and nitrogen uptake was recorded with treatment combination 30 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} which was statistically at par with treatment combination 45 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} and 30 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1}. Minimum nutrient content was recorded when neither phosphorus nor sulphur was applied. Applied phosphorus increases phosphorus availability in rhizosphere promoting root growth and increase the nutrient uptake resulting into increase in nutrient content. Thus the influence of the nutrient with phosphorus application may ascribe to their synergistic effect in term of crop growth, yield, quality and economics. Adequate supply of phosphorus and sulphur play a vital role in various metabolic processes which resulted in increased flowering and fruiting thereby improving pods per plant due to favourable effect of these nutrient on growth parameters. The findings were in agreement with those of Saxena *et al.* (2003) [21], Patil *et al.* (2011) [18], Yadav *et al.* (2012) [31] Muhammd *et al.* (2013) [15], Bairwa *et al.* (2014) and Kumawat *et al.* (2014) [12].

Srinivasrao and Ali (2006) observed that application of 20 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha significantly increased N and P content in grain and straw and their uptake in urdbean and mungbean over lower doses of fertilizers or control. Sasode (2008) reported that application of 37.5 kg N + 90 kg P_2O_5 + 5 kg Zn/ha significantly increased protein content and uptake of N, P, K, S and Zn in seed of greengram over lower levels of fertility. Murari *et. al.* (2013) [16] also reported that combined application of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and sulfur (0, 15, 30 and 45 kg S ha^{-1}) increased the nutrient content and nutrient uptake up to 40 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}.

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