

Original Research Article

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## Effect of Phosphorus and Sulphur on Growth attributes and Yield of Mungbean (*Vigna radiate* L.) in Sandy Soils of Hyper Arid Western Plains of Rajasthan

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### ABSTRACT

A field experiment was conducted at Agronomy Farm, college of agriculture, Bikaner during *kharif* season of 2016 to evaluate the effect of different levels of phosphorus and sulphur on, growth, yield attributes and nutrient concentration of mungbean. The experiment was laid out in factorial randomized block design with three replications, assigning twelve treatments combinations consisting of four levels of phosphorus (control, 15, 30 and 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) and three levels of sulphur (control, 20 and 40 kg S ha<sup>-1</sup>). The results revealed that application of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 20 kg S ha<sup>-1</sup> significantly increased the total leaf chlorophyll content, total and effective root nodules per plant, number of pods per plant, number of seeds per pod, seed and straw yield, nitrogen, potassium, sulphur content and their uptake by seed and straw and protein content in seed. Whereas, the phosphorus content in seed and straw significantly increased with increasing levels of phosphorus up to 45 kg P<sub>2</sub>O<sub>5</sub>. The available N, K and S content of soil increased with increasing levels of phosphorus up to 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> but not reached at level of significance. Application of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> significantly increased the available phosphorus content of soil. Application of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> significantly increased net returns and B: C ratio of mungbean over control and 15 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>.

### Keywords

Mungbean,  
Phosphorus,  
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### Introduction

Pulse crops play an important role in Indian agriculture and India is the largest producer and consumer of pulses in the world. Pulses

are included in cropping systems to improve soil health and fertility status. The productivity of pulses mainly depends on proper nutrient management practices. Pulses are generally grown in soils with low fertility

status or with application of low quantities of organic and inorganic sources of plant nutrients, which in turn resulted in deterioration of soil health and productivity (Kumpawat, 2010).

Mungbean (*Vignaradiate* L. Wilczek) is one of the most ancient and extensively grown leguminous crops of India. It is a short duration crop and rich in protein and vitamin B. In India it is cultivated in Maharashtra, Andhra Pradesh, Rajasthan, Orissa and Karnataka. It can be grown under wide range of soil types. It is grown usually as rain fed crop but can also be grown as pre-monsoon and late monsoon crop. In 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 which produce 423 thousand tonnes of green gram from 894 thousand hectares area with an average yield 473 kg/ha (2014-15).

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, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. It serves as “energy currency” within plants and helps in root development and grain formation. Mungbean also responds well to sulphur (S) 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. Wide spread S deficiency have been observed on larger areas due to use of high analysis S free fertilizers like urea and DAP in high yielding varieties and intensive cropping, and is more conspicuous in light textured soils.

Keeping in view the above facts, the present study was planned to investigate the “Effect

of Phosphorus and Sulphur on growth and yield of Mungbean (*Vigna radiate* L.) in sandy soils of hyper arid western plains of Rajasthan”

## Materials and Methods

The experiment was conducted at the Agronomy farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2006. The experimental site is located at 28.01<sup>0</sup>N latitude and 73.22<sup>0</sup>E longitude at an altitude of 234.7m above mean sea level and falls under Agro-ecological region No. 2 (M9E1) under Arid ecosystem (Hot Arid Eco-region), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity and hot and arid climate. The soils of experimental field was loamy sand in texture having pH -8.38, EC -0.22 dS m<sup>-1</sup>, available N – 89.25 kg ha<sup>-1</sup>, available P<sub>2</sub>O<sub>5</sub> – 19.50 kg ha<sup>-1</sup>, available K<sub>2</sub>O – 190.35 kg ha<sup>-1</sup> and available S- 7.30 mg kg<sup>-1</sup>, available iron- 2.90 mg kg<sup>-1</sup> 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). The Net plot size was 5.0m x 3.0 m. The seed of SML-668 of Mungbean was used as the test crop. The seeds @ 16 kg ha<sup>-1</sup> were sown by “pora” method on July, 13, 2016. The treatment details are follows:

### (A) Phosphorus levels

P<sub>0</sub> = Control, P<sub>15</sub> = 15 Kg ha<sup>-1</sup>, P<sub>30</sub> = 30 Kg ha<sup>-1</sup> and P<sub>45</sub> = 45 Kg ha<sup>-1</sup>

### (B) Sulphur levels

S<sub>0</sub> = Control, S<sub>20</sub> = 20 Kg ha<sup>-1</sup>, S<sub>40</sub> = 40 Kg ha<sup>-1</sup>

The phosphorus was applied as per treatments through DAP containing 46 % P<sub>2</sub>O<sub>5</sub>. The

entire quantity of DAP was drilled in furrow 30 cm apart at the depth of 10 cm by kera method. Nitrogen containing in DAP was adjusted with urea. Sulphur was applied through elemental sulphur as per treatments. The whole quantity of sulphur was applied 25 days before sowing. Due to dry spell during crop period (28.08.2016 to 12.10. 2016) no precipitation was received. Therefore, two life saving irrigation one each at 40 DAS and 60 DAS were given.

Chlorophyll content was worked out at 35 DAS. Hiscox and Israelstem (1979) demonstrated that the absorption spectrum (600-680nm) for chlorophyll extracted in DMSO was virtually identical to that for extracted in 90 per cent acetone. Accordingly chlorophyll was extracted in DMSO and transmittance was recorded with spectrophotometer at 645 and 663 nm. Arnon's equation (1949) was used to work out chlorophyll content as here under:

$$\text{Chlorophyll "a" (mg g}^{-1} \text{ fresh weight of leaves)} = \frac{(12.7 \times A_{663}) - (2.69 \times A_{645})}{1000} \times \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

$$\text{Chlorophyll "b" (mg g}^{-1} \text{ fresh weight of leaves)} = \frac{(22.9 \times A_{645}) - (4.6 \times A_{663})}{1000} \times \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

Total chlorophyll content was worked out by adding chlorophyll "a" and chlorophyll "b" as under:

The numbers of total nodules/plant were counted at 40 DAS. Five plants were selected randomly in sample rows of each plot and uprooted carefully. The soil mass embodying

$$\text{Total Chlorophyll (mg g}^{-1} \text{ fresh weight of leaves)} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

The pods of five plants randomly selected from each plot were counted at harvest and averaged. Number of seeds per pod was recorded by counting the seeds of the five randomly collected pods from each plot and the average value was estimated.

the roots of the plants was washed off with water and effective root nodules were counted to record average number of nodules/plant. Effective nodules were pinkish in colour whereas, rest of the nodules was black in colour.

Samples were drawn randomly from produce of each plot and one thousand grains were counted from each sample and weighed to record test weight. After threshing and winnowing of the seeds from each net plot was weighed in kg per plot and converted in kg ha<sup>-1</sup> for seed yield. After complete drying the straw bundles were weighed and yield was recorded plot wise and then converted in kg ha<sup>-1</sup> and expressed as straw yield kg ha<sup>-1</sup>.

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 after development of colours with Nessler's

reagent (Snell and Snell, 1939). Nitrogen was calculated and expressed as percentage.

Phosphorus was estimated by digesting plant samples with tri-acid mixture and was determined by Vanadomolybdo phosphoric yellow colour method (Jackson, 1973) and was expressed as percentage.

Potassium content in samples was determined in tri-acid digested materials by using Flame photometer (Jackson, 1973).

Sulphur was determined by turbidimetric method (Tabatabai and Bremner, 1970). The developed turbidity was measured by colorimeter and S content was expressed in percentage on dry weight basis.

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

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\% \text{ nutrient content in seed or straw}}{100}$$

Protein content was estimated by using following expression.

$$\text{Protein content (\%)} = \text{N content in seed (\%)} \times 6.25$$

To find out the most profitable treatment, economics of different treatments were worked out in terms of net returns (Rs ha<sup>-1</sup>) on the basis of the prevailing market rates so that the most remunerative treatment could be recommended. Benefit-cost ratio for each treatment was calculated to ascertain economic viability of the treatment using the following formula:

$$\text{B:C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

## Results and Discussion

### Effect of phosphorus

Significant increase was observed with respect to chlorophyll content at 40 DAS and number of total and effective root nodules per plant up to the application of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Table 1). This increase in growth parameters may be attributed to better nutritional environment for plant growth and development not only due to increased availability of phosphorus in soil but of other nutrients too, which are considered vitally important for growth and development. The overall improvement in crop growth under the influence of phosphorus application could be ascribed to better root development and proliferation and increased nitrogen fixation in the soil improving thereby the nitrogen status in the soil. The increase in photosynthetic activity in plant led to overall development in terms of growth. Thus, phosphorus fertilization yield (kg ha<sup>-1</sup>) the photosynthesis and other metabolic processes in the plant which ultimately enhanced growth in terms of total and effective root nodules per plant and chlorophyll content. Similar results have also been reported by Singh *et al.*, (2011).

Every increase in level of phosphorus up to 45 kg/ha increased the test weight but not reach at level of significance (Table 2). Whereas every increase in level of phosphorus up to 30 kg/ha significantly increased the number of pods per plant, number of seeds per pods, seed and straw yield (Table 1) over control and 15 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> which was statistically at par with 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Since, an adequate supply of phosphorus during early stage of growth is considered important in promoting vegetative growth and branching by influencing cell division and elongation in meristematic cells thereby increasing the sink in terms of

flowering and seed setting. These findings corroborate the results of Choudhary *et al.*, (2014), Tiwari *et al.*, (2015).

Yield of a crop is the cumulative effect of yield attributing characters like pods/plant, seeds/pod and test weight. Thus, the seed yield of mungbean also increased significantly due to sulphur fertilization (Table 2). Significant and positive correlation between seed yield and yield attributes also supports higher seed yield obtained in the present investigation (Table 2). The increase in straw yield due to sulphur application might be due to the cumulative effect of increased plant height, dry matter production and number of branches/plant i.e. increased growth parameters. Yadav (2004) and Kumawat *et al.*, (2006) in mungbean also provided support to the findings of the present investigation.

Application of increasing levels of phosphorus up to 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> gave significantly higher net return (₹44965 ha<sup>-1</sup>) and BC ratio (3.17) over control and 15 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Table 2). This might be due to increase in seed yield in diminishing manner under the increasing levels of phosphorus. This increase in the net return due to application of increasing levels of phosphorus also has been reported by Singh *et al.*, (2010).

A significant increase in N, K and S content in seed and straw was recorded due to application of phosphorus up to 30 kg/ha (Table 3). Whereas Phosphorus content in seed and straw was significantly improved due to application of 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>.

As stated earlier that application of phosphorus might have improved the nutritional environment in rhizosphere as well as in the plant system leading to increased uptake and translocation of nutrients especially of N, P, K and S in reproductive

structures which led to higher concentration and uptake. The protein content increased significantly with increasing level of phosphorus up to 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Table 3). Better root development and increased Rhizobium multiplication resulted in better utilization of soil and atmospheric nitrogen with the increasing levels of phosphorus and there by nitrogen content of seed increased. The reason behind the improvement of protein content might be that it is a function of nitrogen content, phosphorus being an energy source also plays an important role in protein synthesis. Similarly, fertilization with phosphorus enhanced the protein content in seed, which may be due to more protein synthesis in the presence of phosphorus and the formation of some stable phosphoprotein compound. These results are in close conformity with the findings of Jain *et al.*, (2007).

### **Effect of sulphur**

Significant increase was observed due to the application of sulphur up to 20 kg/ha with respect to number of total and effective nodules/plant at 40 DAS and leaf chlorophyll content at 35 Das (Table 1). It is obvious, because of the fact that application of sulphur has been reported to improve not only the availability of sulphur itself but of other nutrients too, which are considered important for the growth and development of plant. The improvement in overall vegetative growth of the crop with the application of sulphur in present investigation is in cognizance with the findings of Prajapat *et al.*, (2011), Kumawat *et al.*, (2014).

Successive increase in level of sulphur upto 20 kg/ha tended to increase significantly in pods/plant, number of seeds per pod, seed and straw yields. The highest value of all the attributes were recorded at 40 kg S/ha (Table 1 and 2).

**Table.1** Effect of phosphorus and sulphur on growth and yield attributes of mungbean

Treatment	Total chlorophyll content (mg g <sup>-1</sup> )	Total nodules	Effective nodules	Number of pods per plant	Number of seeds per pod	Test weight (g)
A. Phosphorus (kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> )						
P <sub>0</sub>	2.74	29.16	23.16	16.32	7.86	35.14
P <sub>15</sub>	3.10	33.64	26.14	19.39	8.95	36.26
P <sub>30</sub>	3.43	36.95	28.82	22.03	9.97	37.28
P <sub>45</sub>	3.68	37.18	29.11	22.63	10.18	37.48
SEm <sub>±</sub>	0.11	1.05	0.87	0.70	0.31	1.28
CD (p= 0.05)	0.32	3.08	2.54	2.07	0.92	NS
B. Sulphur (kg S ha <sup>-1</sup> )						
S <sub>0</sub>	2.59	31.93	24.55	17.83	8.55	35.84
S <sub>20</sub>	3.52	34.87	27.26	20.39	9.51	36.81
S <sub>40</sub>	3.60	35.90	28.61	22.06	9.66	36.96
SEm <sub>±</sub>	0.10	0.91	0.75	0.61	0.27	1.11
CD (p= 0.05)	0.28	2.67	2.20	1.79	0.80	NS

**Table.2** Effect of phosphorus and sulphur on yield and economics of mungbean

Treatment	Seed yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Net returns (₹ ha <sup>-1</sup> )	B:C ratio
A. Phosphorus (kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> )				
P <sub>0</sub>	501	1392	13965	1.72
P <sub>15</sub>	814	2238	33495	2.68
P <sub>30</sub>	1003	2767	44965	3.17
P <sub>45</sub>	1033	2818	46086	3.14
SEm±	25	72	1601	0.08
CD (p= 0.05)	72	212	4696	0.22
B. Sulphur (kg S ha <sup>-1</sup> )				
S <sub>0</sub>	525	1445	17751	2.06
S <sub>20</sub>	972	2690	43379	3.16
S <sub>40</sub>	1015	2777	42753	2.82
SEm±	21	63	1387	0.07
CD (p= 0.05)	63	184	4067	0.19

**Table.3** Effect of phosphorus and sulphur on nutrient content and protein content of mungbean

Treatment	N content (%)		P content (%)		K content (%)		S content (%)		Protein content (%)
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	
A. Phosphorus (kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> )									
P <sub>0</sub>	2.96	0.71	0.522	0.170	0.406	1.088	0.311	0.086	18.51
P <sub>15</sub>	3.30	0.86	0.582	0.182	0.449	1.295	0.332	0.096	20.61
P <sub>30</sub>	3.84	1.00	0.633	0.198	0.487	1.454	0.354	0.110	24.02
P <sub>45</sub>	4.05	1.03	0.663	0.207	0.490	1.480	0.355	0.114	25.31
SEm <sub>±</sub>	0.09	0.02	0.009	0.003	0.007	0.034	0.005	0.002	0.54
CD (p= 0.05)	0.26	0.07	0.026	0.008	0.020	0.100	0.016	0.006	1.60
B. Sulphur (kg S ha <sup>-1</sup> )									
S <sub>0</sub>	3.13	0.71	0.555	0.172	0.414	1.109	0.319	0.078	19.57
S <sub>20</sub>	3.67	0.97	0.620	0.194	0.477	1.417	0.340	0.110	22.94
S <sub>40</sub>	3.81	1.01	0.625	0.201	0.484	1.462	0.355	0.117	23.83
SEm <sub>±</sub>	0.08	0.02	0.008	0.002	0.006	0.029	0.005	0.002	0.47
CD (p= 0.05)	0.22	0.06	0.023	0.007	0.017	0.086	0.014	0.005	1.38



The improvement in yield attributes seems to be due to the balanced nutritional environment. Supply of sulphur in adequate amount helps in the development of floral primordia i.e. reproductive parts which results in the development of pods and grains in plant. Thus, the application of sulphur might have increased the yield attributing parameters in mungbean.

Application of increasing levels of sulphur up to 20 kg S ha<sup>-1</sup> gave significantly higher net return (₹43379 ha<sup>-1</sup>) and BC ratio (3.16) (Table 2). This might be due to increase in seed yield in diminishing manner under the increasing levels of Sulphur.

This increase in the net return due to application of increasing levels of sulphur also has been reported by Bhunia *et al.*, (2006), Dutta *et al.*, (2008).

Sulphur fertilization upto 20 kg/ha significantly influenced the N, P and K content (Table 4.7, 4.12, and 4.22) and N, P, K and S uptake by crop (Table 3). 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. These findings are in accordance with the findings of Kumawat *et al.*, (2007) and Bahadur *et al.*, (2009) in mungbean.

In conclusion, application of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 20 kg S ha<sup>-1</sup> significantly increased the total leaf chlorophyll content, total and effective root nodules per plant, number of pods per plant, number of seeds per pod, seed and straw yield and nitrogen, potassium, sulphur content and their uptake by seed and straw and protein content in seed. Whereas, the phosphorus content in seed and straw significantly increased with increasing levels of phosphorus up to 45 kg P<sub>2</sub>O<sub>5</sub>.

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