



P-ISSN: 2349-8528

E-ISSN: 2321-4902

IJCS 2020; 8(1): 2396-2400

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Received: 25-11-2019

Accepted: 27-12-2019

Kiran Yadav

Ph.D. Scholar, Department of
Soil Science & Agricultural
Chemistry, College of
Agriculture, JAU, Junagadh,
Gujarat, India

SR Naga

Professor & Head (Retd.),
Department of Soil Science &
Agricultural Chemistry,
SKNAU, Jobner, Rajasthan,
India

Sheetal Yadav

Ph.D. Scholar, Department of
Soil Science & Agricultural
Chemistry, SKRAU, Bikaner,
Rajasthan, India

Impact of phosphorus and sulphur on nutrient content and uptake by clusterbean

Kiran Yadav, SR Naga and Sheetal Yadav

DOI: <https://doi.org/10.22271/chemi.2020.v8.i1aj.8627>

Abstract

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur during *khariif*, 2017. The experiment consisted 16 treatment combinations comprising of four levels each of phosphorus (0, 20, 40 and 60kg P₂O₅ ha⁻¹) and sulphur (0, 20, 40 and 60kg S ha⁻¹) was laid out in randomized block design and replicated thrice. Clusterbean variety RGC-1038 was used as a test crop. The results indicated that the application of phosphorus @40kg ha⁻¹ registered significantly maximum increase in content and uptake of nitrogen, phosphorus, potassium and sulphur in seed as well as in straw over control and P₂₀. The treatment P₄₀ and P₆₀ were remained statistically at par. The increasing levels of sulphur upto 40kg ha⁻¹ significantly increased the nitrogen, phosphorus, potassium and sulphur content and uptake by seed and straw of clusterbean as compared to control and S₂₀.

Keywords: Clusterbean, phosphorus, sulphur, uptake, content

Introduction

Cluster bean, called as guar is a drought-tolerant annual legume belongs to the family Leguminosae and sub-family Papilionaceae. Root nodules contain nitrogen fixing bacteria and crop residue when ploughed under, improves the yield of succeeding crops. Cluster bean is a good soil restorative crop which can fix about 40 per cent N in the soil. The primary importance of guar is considered to be the commercial value of its seed gum (galactomannan gum) which is used in sizing textiles and paper as a sticker and in pill formation. Phosphorus stimulates early root development, growth, blooming and aids in seed formation when applied to legumes. It also improves the crop quality and resistance to disease. This is alarming because phosphorus is the backbone of balanced fertilizer use and it occupies a key place in intensive agriculture. The supply of phosphorus to legumes is more important than that of nitrogen because, latter is being fixed by symbiosis with rhizobium bacteria. Thus, it helps in taking more atmospheric N. In general S requirement is slightly less than P. It is essential for synthesis of vitamins (biotin and thiamine), S containing amino acids (cystine, cysteine and methionine) and promotes nodulation in legumes. It helps in chlorophyll formation and encourages vegetative plant growth.

Material and Methods

The experiment was conducted at Agronomy farm, S.K.N College of Agriculture Jobner, Jaipur (Rajasthan). The Agronomy farm is situated at 75° 28' East longitude and 26° 08' North latitude and 427m above mean sea level. This region falls under Agro-climatic zone-III A (Semi-Arid Eastern Plains) of Rajasthan. The experimental soil was loamy sand in texture with high infiltration rate and saturated hydraulic conductivity. The experiment consisted 16 treatment combinations comprising of four levels each of phosphorus (0, 20, 40 and 60kg P₂O₅ ha⁻¹) and sulphur (0, 20, 40 and 60kg S ha⁻¹) was laid out in randomized block design and replicated thrice. Clusterbean variety RGC-1038 was used as a test crop.

Nutrient content and uptake**Nutrient content**

The plant samples at harvest of the clusterbean crop from each plot were collected separately and dried in oven at constant temperature of 70 °C, until they obtained constant weight. The dried samples were powdered in a grinder having stainless steel blades to avoid contamination of micronutrients.

Corresponding Author:**Kiran Yadav**

Ph.D. Scholar, Department of
Soil Science & Agricultural
Chemistry, College of
Agriculture, JAU, Junagadh,
Gujarat, India

After drying and grinding these samples were analysed for N, P, K and S content. The results were expressed as percent N, P, K and S on dry weight basis.

Nutrient uptake

The uptake of N, P and K in seed and straw were estimated by using the following formula

$$\text{Nutrient uptake (Kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Nitrogen content

Nitrogen content in seed and straw

The effect of treatments (P, S) on nitrogen content in seed and straw is depicted in the table-1.

Effect of phosphorus: The data showed that application of phosphorus significantly increased the N content in seed and straw of clusterbean. Data revealed that improvement in N content was progressive and significant due to phosphorus application up to 40kg P₂O₅ ha⁻¹ over control and 20kg P₂O₅ ha⁻¹ by 18.76 and 8.12 percent in seed and 16.19 and 6.45 percent in straw, respectively. However, level P₄₀ and P₆₀ remained statistically at par.

Effect of sulphur: Data further showed that application of sulphur upto 40kg S ha⁻¹ significantly increased the N content in seed and straw of clusterbean over control and 20kg S ha⁻¹ which was higher by 21.94 and 8.96 percent in seed and 21.73 and 9.09 percent in straw, respectively. However, level S₄₀ and S₆₀ remained statistically at par with each other.

Nitrogen uptake by seed and straw

The effect of treatments (P, S) on nitrogen uptake by seed and straw is depicted in the table-1.

Effect of phosphorus: Data presented in table-1 indicated that N uptake by seed and straw of clusterbean increased significantly up to 40kg P₂O₅ ha⁻¹ being statistically at par with 60kg P₂O₅ ha⁻¹. Themagnitude of increase in N uptake with the application of 40kg P₂O₅ ha⁻¹ was recorded as 60.00 and 19.80 percent by seed and 39.62 and 14.48 percent by straw over control and 20kg P₂O₅ ha⁻¹, respectively.

Effect of sulphur: Data presented in same table further indicated that the effect of application of sulphur on N uptake was found significantly up to 40kg S ha⁻¹, which was non significantly differed with 60kg S ha⁻¹. Application of 40kg S ha⁻¹ significantly increased the N uptake over control and 20kg S ha⁻¹ by 79.48 and 19.38 percent by seed and 70.41 and 16.73 percent by straw, respectively.

Phosphorus content

Phosphorus content in seed and straw

The influence of treatments on the Phosphorus content in seed and straw is depicted in table-2.

Effect of phosphorus: The data given in table-2 indicated that increasing levels of phosphorus up to 40kg P₂O₅ ha⁻¹ significantly increased the P content in seed and straw of clusterbean. Application of 40kg P₂O₅ ha⁻¹ recorded significantly higher P content over control and 20kg P₂O₅ ha⁻¹ by 25.44 and 12.63 percent in seed and 21.42 and 8.67 percent

in straw, respectively. The level P₄₀ and P₆₀ were differed non significantly.

Effect of sulphur: Data further showed that application of 40kg S ha⁻¹ significantly enhanced the P content over control and 20kg S ha⁻¹ by 20.76 and 9.84 percent in seed and 18.40 and 8.18 percent in straw, respectively. The level S₄₀ and S₆₀ were differed non significantly.

Phosphorus uptake by seed and straw

The influence of treatments on the Phosphorus uptake by seed and straw is depicted in table-2.

Effect of phosphorus: Data indicated that the P uptake by clusterbean increased significantly up to 40kg P₂O₅ ha⁻¹. Themagnitude of increase in P uptake due to application of 40kg P₂O₅ ha⁻¹ over control and 20kg P₂O₅ ha⁻¹ was higher by 69.28 and 24.73 percent by seed and 46.10 and 16.88 percent by straw, respectively.

Effect of sulphur: Data presented in same table further indicated that the S uptake by clusterbean was significantly enhanced up to the level of 40kg S ha⁻¹, which was non significantly differed with 60kg S ha⁻¹. The application of 40kg S ha⁻¹ increased the S uptake by 77.52 and 20.61 percent by seed and 66.16 and 16.04 percent by straw over control and 20kg S ha⁻¹, respectively.

Potassium content

Potassium content in seed and straw

The impact of application of various levels of P and S on the potassium content in seed and straw is presented in table-3.

Effect of phosphorus: The data given in table-3 showed that increasing levels of phosphorus upto 40kg P₂O₅ ha⁻¹ significantly increased the K content in seed and straw of clusterbean. Application of 40kg P₂O₅ ha⁻¹ resulted in significantly higher K content over control and 20kg P₂O₅ ha⁻¹ by 18.44 and 8.08 percent in seed and 24.57 and 7.77 percent in straw, respectively. However, the level P₄₀ and P₆₀ were remained statistically at par with each other.

Effect of sulphur: Data further showed that the application of 40kg S ha⁻¹ significantly increased the K content in seed and straw of clusterbean over control and 20kg S ha⁻¹ by 19.09 and 9.26 percent in seed and 34.52 and 14.72 percent in straw, respectively. However, the level S₄₀ and S₆₀ were found statistically at par.

Potassium uptake by seed and straw

The impact of application of various levels of P and S on the potassium uptake by seed and straw is presented in table-3.

Effect of phosphorus: Data indicated that the K uptake by seed and straw increased significantly with increasing levels of phosphorus up to 40kg P₂O₅ ha⁻¹, which was statistically at par with 60kg P₂O₅ ha⁻¹. Themagnitude of percent increase in K uptake due to application of 40kg P₂O₅ ha⁻¹ over control and 20kg P₂O₅ ha⁻¹ was 59.62 and 19.76 percent by seed and 49.68 and 15.90 percent by straw, respectively.

Effect of sulphur: Data presented in same table further indicated that the application of sulphur up to 40kg S ha⁻¹ significantly increased the K uptake by seed and straw of clusterbean. Application of 40kg S ha⁻¹ significantly increased

the K uptake in seed by 75.43 and 19.76 percent over control and 20kg S ha⁻¹, respectively. Similarly, the corresponding increase in K uptake by straw was 88.79 and 23.09 percent, respectively. The level S₄₀ was remained statistically at par with the level S₆₀.

Sulphur content

Sulphur content in seed and straw

The effect of P and S applied at various levels on sulphur content in seed and straw is presented in table-4.

Effect of phosphorus: It is evident from the data that increasing levels of phosphorus up to 40kg P₂O₅ ha⁻¹ significantly increased the S content in seed and straw of clusterbean, which was found at par with 60kg P₂O₅ ha⁻¹. The maximum S content in seed and straw was observed under 40kg P₂O₅ ha⁻¹ and registered 30.70 and 11.19 percent higher sulphur content in seed over control and 20kg P₂O₅ ha⁻¹, respectively. The corresponding increase in straw was 21.48 and 5.75 percent, respectively.

Effect of sulphur: Data further showed that sulphur content in seed and straw tended to increase significantly with increasing levels of sulphur. Significantly higher sulphur content in seed and straw was recorded with application of sulphur up to 40kg S ha⁻¹ over control and 20kg S ha⁻¹ but being at par with 60kg S ha⁻¹. The significantly highest S content was recorded under 40kg S ha⁻¹ and it was higher by 28.44 and 13.74 percent in seed and 21.13 and 12.87 percent in straw, respectively.

Sulphur uptake by seed and straw

The effect of P and S applied at various levels on sulphur uptake by seed and straw is presented in table-4.

Effect of phosphorus: Data indicated that S uptake by clusterbean seed and straw increased significantly up to the level of 40kg P₂O₅ ha⁻¹, being at par with 60kg P₂O₅ ha⁻¹. The significant increase in S uptake by seed due to application of 40kg P₂O₅ ha⁻¹ was 76.04 and 23.35 percent and by straw 45.92 and 13.87 percent over control and 20kg P₂O₅ ha⁻¹, respectively.

Effect of sulphur: Data presented in same table further indicated that the effect of application of sulphur on S uptake was observed resulting in significant increase in seed and straw up to 40kg S ha⁻¹, which was differed with 60kg S ha⁻¹. The magnitude of significant increase in S uptake upto 40kg S ha⁻¹ being 87.91 and 23.91 percent by seed and 70.24 and 21.17 percent by straw over control and 20kg S ha⁻¹, respectively.

Discussion

Effect of phosphorus

Application of phosphorus @40kg ha⁻¹ registered significantly maximum increase in content and uptake of N, P, K and S in seed as well as in straw over control and 20kg P₂O₅ ha⁻¹ (Table1-4). Application of phosphorus increased total biomass (seed and straw) and nutrient (N, P, K and S) content in clusterbean by providing balanced nutritional environment to the plant and higher photosynthetic efficiency. Uptake of nutrients is the function of their concentration in plant, seed and

straw yields, the higher concentration of these nutrients coupled with significantly higher seed and straw yield improved the uptake of N, P, K and S. Higher seed and straw yield with higher dose of phosphorus contributed more removal of N and P by the crop (Yadav *et al.*, 2014) [13]. Similar results were observed by Kumari and Ushakumari (2002) [5], Singh *et al.*, (2009) [10], Wagadre *et al.*, (2010) [12], Awomi *et al.*, (2012) [1] and mohammad *et al.*, (2017) in mungbean.

Effect of sulphur

The nutrient content and uptake by seed and straw were significantly influenced with the application of sulphur (Table 4.7 to 4.10). The significantly maximum N, P, K and S content and uptake by seed and straw were recorded with the application of sulphur @40kg ha⁻¹ as compared to control. This increase in nitrogen content might be due to favourable effect on availability of nitrogen at the higher level of sulphur.

The sulphur fertilization helps in improving the uptake of N, P, K and S in the plant due to synergistic effect with these elements. Moreover, it is one of the essential nutrient for plant growth accumulating 0.2 to 0.5% in plant tissue on dry matter basis. It is also a key ingredient in the formation of chlorophyll and required to synthesis of sulphur containing amino acids such as cystine, cysteine and methionine and building block of protein which might have resulted in turn enhanced growth and development of plant and ultimately resulted into higher uptake of N, P, K and S (Shah *et al.*, 2013). The higher uptake of N, P, K and S may also be due to the accelerated harvest index at higher levels of S application elaborated the better assimilate portioning towards developing seeds which might have turned into higher yields and ultimately in higher content and uptake of N, P, K and S by the crop. Karche *et al.*, (2012) [4] have also reported significant improvement in concentration and uptake of N, P, K and S in plant with sulphur application @40kg ha⁻¹. Similar findings have also been reported by Kaprekar *et al.*, (2003) [3], Sharma and Singh (2004) [9], Nagar and meena (2004) [8], Chandra Deo and Khandelwal (2009) [2] in chickpea and Kuniya *et al.*, (2018) [6].

Table 1: Effect of phosphorus and sulphur on N content and uptake by seed and straw of clusterbean

Treatments	N concentration (%)		N uptake (kg/ha)	
	Seed	Straw	Seed	Straw
Phosphorus (P₂O₅)				
P ₀	3.25	1.42	27.30	31.65
P ₂₀	3.57	1.55	36.46	38.60
P ₄₀	3.86	1.65	43.68	44.19
P ₆₀	3.90	1.67	45.23	45.90
SEm±	0.05	0.02	1.09	0.80
CD (P=0.05%)	0.15	0.06	3.15	2.30
Sulphur				
S ₀	3.19	1.38	24.81	27.18
S ₂₀	3.57	1.54	37.30	39.68
S ₄₀	3.89	1.68	44.53	46.32
S ₆₀	3.93	1.69	46.02	47.15
SEm±	0.05	0.02	1.09	0.80
CD (P=0.05%)	0.15	0.06	3.15	2.30

Table 2: Effect of phosphorus and sulphur on P content and uptake by seed and straw of clusterbean

Treatments	P concentration (%)		P uptake (kg/ha)	
	Seed	Straw	Seed	Straw
Phosphorus (P₂O₅)				
P ₀	0.334	0.196	2.80	4.36
P ₂₀	0.372	0.219	3.80	5.45
P ₄₀	0.419	0.238	4.74	6.37
P ₆₀	0.421	0.246	4.88	6.75
SEm _±	0.007	0.006	0.07	0.15
CD (P=0.05%)	0.021	0.016	0.21	0.43
Sulphur				
S ₀	0.342	0.201	2.67	3.96
S ₂₀	0.376	0.220	3.93	5.67
S ₄₀	0.413	0.238	4.74	6.58
S ₆₀	0.415	0.240	4.87	6.72
SEm _±	0.007	0.006	0.07	0.15
CD (P=0.05%)	0.021	0.016	0.21	0.43

Table 3: Effect of phosphorus and sulphur on K content and uptake by seed and straw of clusterbean

Treatments	K concentration (%)		K uptake (kg/ha)	
	Seed	Straw	Seed	Straw
Phosphorus (P₂O₅)				
P ₀	0.824	1.758	6.91	39.39
P ₂₀	0.903	2.032	9.21	50.87
P ₄₀	0.976	2.190	11.03	58.96
P ₆₀	0.992	2.240	11.49	61.90
SEm _±	0.024	0.054	0.26	1.43
CD (P=0.05%)	0.069	0.155	0.75	4.12
Sulphur				
S ₀	0.822	1.680	6.39	33.12
S ₂₀	0.896	1.970	9.36	50.80
S ₄₀	0.979	2.260	11.21	62.53
S ₆₀	0.998	2.310	11.69	64.68
SEm _±	0.024	0.054	0.26	1.43
CD (P=0.05%)	0.069	0.155	0.75	4.12

Table 4: Effect of phosphorus and sulphur on S content and uptake by seed and straw of clusterbean

Treatments	S concentration (%)		S uptake (kg/ha)	
	Seed	Straw	Seed	Straw
Phosphorus (P₂O₅)				
P ₀	0.114	0.121	0.96	2.70
P ₂₀	0.134	0.139	1.37	3.46
P ₄₀	0.149	0.147	1.69	3.94
P ₆₀	0.153	0.148	1.78	4.07
SEm _±	0.003	0.004	0.04	0.09
CD (P=0.05%)	0.009	0.010	0.11	0.27
Sulphur				
S ₀	0.116	0.123	0.91	2.42
S ₂₀	0.131	0.132	1.38	3.40
S ₄₀	0.149	0.149	1.71	4.12
S ₆₀	0.154	0.151	1.81	4.22
SEm _±	0.003	0.004	0.04	0.09
CD (P=0.05%)	0.009	0.010	0.11	0.27

Conclusion

Application of phosphorus @40kg ha⁻¹ registered significantly maximum increase in content and uptake of nitrogen, phosphorus, potassium and sulphur in seed as well as in straw over control and P₂₀. The treatment P₄₀ and P₆₀ were remained statistically at par.

Application of 40kg S ha⁻¹ registered significantly maximum increase in content and uptake of N, P, K and S in seed as well as in straw of clusterbean over lower levels of sulphur. The treatment S₄₀ and S₆₀ remained statistically at par with each other.

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