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Effect of Sources and Levels of Sulphur on Quality, Nutrient Content and Uptake of Summer Cowpea (*Vigna unguiculata* L. Walp.) under South Gujarat Condition in India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2021 to study the effect of sources and levels of sulphur on summer cowpea (*vigna unguiculata* L. walp.) under south Gujarat condition. The results revealed that application of sulphur with gypsum source showed significantly higher seed yield (1392 kg ha^{-1}), stover yield (2502 kg ha^{-1}), crude protein yield (295.18 kg ha^{-1}), nutrients content and uptake (N, P, K and S) by seed and stover and maximum net realization of Rs. 56100.38 ha^{-1} with BCR of 1.74. The application of 30 kg S ha^{-1} gave significantly higher crude protein yield (302.03 kg ha^{-1}), seed yield (1393 kg ha^{-1}), stover yield (2508 kg ha^{-1}), nutrients content and uptake by seed and stover and maximum net realization of Rs. 55861.08 ha^{-1} with maximum BCR 1.71.

Keywords: Cowpea; sources of sulphur; levels of sulphur; row spacing; quality; nutrient content and uptake.

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1. INTRODUCTION

Pulses are one of the important food crops globally due to higher protein content. Pulses in India have long been considered as the poor man's only source of protein. India is the largest producer as well as consumer of pulses (also referred to as grain legumes, peas and beans) in the world. In India, pulses are grown nearly on 28.34 M ha with an annual production of 23.15 MT and average productivity of 817 kg ha^{-1} [1]. Cowpea is a member of the Leguminosae family. Due to its tolerance for sandy soil and low rainfall, it is an important crop in the semiarid regions and marginal area of the tropics and subtropics. In Gujarat, cowpea is cultivated in 0.52 M ha with an annual production of 0.35 MT and average productivity of 665 kg ha^{-1} [1]. The importance of sulphur for plant growth has been recognized for long to improve quality production of crop. However its wide spread deficiency in soil and consequently losses on crop productivity have been reported during the last three decades due to the continuous use of S free fertilizer and intensive cultivation with high yielding varieties. Sulphur helps in plant growth and metabolism especially by improving the activities of photolytic enzymes and is a constituent of important amino acids namely cystine, cysteine and methionine. It promotes nodulation in legumes which enhances biological nitrogen fixation. Therefore, it is necessary to study the "Effect of sources and levels of sulphur on summer cowpea (*Vigna unguiculata* L. Walp) under south Gujarat condition''.

2. MATERIALS AND METHODS

A field experiment was conducted during summer season of year 2021 at the Soil and Water Management, NARP Phase – II (NARP Farm), Cotton Research Sub Station, N.A.U., Achhalia (South Gujarat Agro Climatic Zone - II). The soil of the experimental field was clayey in texture having medium to poor drainage, soil pH 7.23, EC 0.265 dS m^{-1} and organic carbon content 0.44 per cent with medium in available nitrogen (282.2 kg ha^{-1}), medium in available phosphorus (36.01 kg ha^{-1}), high in available potassium (318.9 kg ha^{-1}) and low in available sulphur (10.94 mg kg^{-1}) and slightly alkaline in reaction. The experiment was laid out in RBD (factorial concept) design with 12 treatment combinations consisting of two factors i.e., sources of sulphur (S_1- Gypsum, S_2- SSP and S_3- Bentonite sulphur) and levels of sulphur (L_1- 10 kg ha^{-1}, L_2- 20 kg ha^{-1} and L_3- 30 kg ha^{-1}). The entire dose of fertilizer was 20-40-00 N: P_2O_5: K_2O kg ha^{-1}.

The data on seed and stover yield was recorded from the net plot and converted on a hectare basis. The nitrogen content in cowpea seed was estimated by micro alkaline permanganate oxidation method as described by Subbiah and Asija [2]. The crude protein content of the seed was computed by multiplying the nitrogen percentage with 6.25 for each treatment. Chemical studies about nitrogen, phosphorus, potassium and sulphur content and their uptake by seed and stover and available nitrogen, phosphorus, potassium and sulphur status in the soil after harvest of the crop were determined as per different methods *viz.,* Modified alkaline permanganate oxidation method (for N), Spectro photometric (for P and S) and Flame photometric method (for K). The data were analyzed statistically by adopting the standard procedures described by Panse and Sukhatme [3]. The purpose of the analysis of variance was to determine the significant effect of treatments on green gram. Uptake of nutrients by seed and plant was calculated by using following formula:

$$Nutrient\ uptake = (kg\ ha - 1)\ \frac{Nutrient\ content\ (\%)\ x\ seed\ /\ stover\ yield\ (kg\ ha-1)}{100}$$

3. RESULTS AND DISCUSSION

3.1 Effect of Sources of Sulphur

3.1.1 Yield

The result pertaining to yield (Table 1) showed significant response for seed yield and stover yield of cowpea were influenced due to different sources of sulphur. Significantly higher seed yield (1392 kg ha^{-1}) was recorded with gypsum source (S_1), which was at par with SSP source (S_2) and stover yield (2502 kg ha^{-1}) was observed with gypsum source (S_1), which was at par with SSP source (S_2). Increase in seed yield and stover yield because of growth parameters and yield attributes might be due to the presence of readily available SO_4 - sulphur in gypsum as compared to other sources. This also might be due to its ability to mobilize more sulphur for the crop plant. Another reason might be due to application of gypsum attributed to the fact that addition of gypsum brought about remarkable improvement in the physico-chemical properties of soil. The increased mineralization of native as well as applied nutrients brought about a considerable increase in both macro (N, P and S) and micronutrient particularly of Fe in the soil. This also might be due to the gypsum application influenced the productivity of the crop by improving the both, the basic infrastructural frame (bearing capacity) and the leaf area (the photosynthate production efficiency). These results are in conformity with findings of those reported by Yadav et al. [4] in blackgram, the gypsum recorded significantly higher grain (10.82 q/ha) and straw (24.91 q/ha) yield over elemental sulphur.

3.1.2 Quality parameters

The data of Table 1 indicated that protein content was not differed significantly due to different sources of sulphur. Numerically higher crude protein content (21.17 %) was recorded with gypsum source (S_1) and the lowest crude protein content (20.79 %) was recorded with bentonite sulphur (S_3). However, crude protein yield was significantly influenced due to different sources of sulphur. The gypsum source (S_1) recorded significantly higher crude protein yield over other sources of sulphur, which was at par with SSP source (S_2). The increase in protein content with S application could be due to the fact that N is an integral part of protein and the protein of cowpea contains relatively large quantities of the S containing amino acids like methio nine and cystine. This may be attributed to higher grain yield as well as increased protein content in grain of cowpea. The protein yield was higher in cowpea grown with gypsum than that of SSP and Bentonite sulphur. Similar research result was reported by Singh et al. [5] in greengram, they revealed that protein content (20.62 %) and protein yield (224.7 kg/ha) of greengram was found significantly higher in gypsum over rest of the treatment.

3.1.3 Nutrient content and uptake

An appraisal of data given in Table 2 revealed that no significant difference was observed in nitrogen, phosphorus, potassium and sulphur content in seed and stover due to different sources of sulphur. However, significantly higher nitrogen, phosphorus, potassium and sulphur uptake by seed and stover was recorded with gypsum source (S_1), which was at par with SSP source (S_2). This might be due to application of gypsum attributed to the fact that addition of gypsum brought about remarkable improvement in the physico-chemical properties of soil. The increased mineralization of native as well as applied nutrients brought about a considerable increase in macro nutrients (N, P and S). These results are in agreement with Gokhale et al. [6] they reported that higher S uptake by seed and straw was observed due to gypsum (5.87 and 5.29 kg/ha, respectively) and SSP (5.80 and 5.21 kg/ha, respectively) which was at par with each other and was found significantly superior to elemental sulphur (5.27 and 4.68 kg/ha, respectively).

3.1.4 Available nutrient in soil after harvest

The data shown in Table 2 indicated that the effect of different sources of sulphur on available nitrogen, phosphorus, potassium and sulphur in soil after harvest of the crop was found non-significant.

3.1.5 Economics

It is obvious from the data reported in Table 1 that the maximum net realization (INR57398 ha^{-1}) and BCR (1.853) was obtained by gypsum source (S_1) and the minimum net income (INR46270 ha^{-1}) and BCR (1.405) was secured under bentonite sulphur (S_3). This might be due to the higher yields produced by gypsum source (S_1) of cowpea. The results are close conformity to these obtained by Rampin et al. [7] reported that application @ 800 kg/ha gypsum gave significantly higher grain yield of soybean and provided US$ 14.56 profit with 44 % economic returns to pay half investment (US$ 33.32).

3.2 Effect of Levels of Sulphur

3.2.1 Yield

The result pertaining to yield (Table 1) showed that seed and stover yield of cowpea were influenced significantly due to different levels of sulphur. Significantly higher seed yield (1393 kg ha^{-1}) and stover yield (2508 kg ha^{-1}) found under 30 kg S ha^{-1} (L_3) over other levels of sulphur. This might be due to fact that application of suitable dose in crop increases the sulphur amount and available sulphur to plant which helps in increasing seed and stover yield. Similar finding was recorded by Kumawat et al. [8] stated that the use of 30 kg S ha^{-1} on summer greengram undoubtedly enhanced seed yield and stover yield than the 40 and 20 kg S ha^{-1}.

Table 1. Effect of sources and levels of sulphur on quality parameter, yield and economics on cowpea

Treatment	Crude protein content (%)	Crude protein yield (kg ha^{-1})	Yield (kg ha^{-1})		Gross realization (INR ha^{-1})	Cost of cultivation INR ha^{-1})	Net realization (INR ha^{-1})	B: C ratio
			Seed	Stover				
Sources of Sulphur (S)								
S_1: Gypsum	21.17	295.18	1392	2502	88371	30973	57398	1.853
S_2: SSP	20.84	267.16	1279	2463	82432	30789	51643	1.677
S_3: Bentonite Sulphur	20.79	259.85	1247	2248	79193	32923	46270	1.405
S Em. ±	0.30	8.55	39	70	--	--	--	--
C D at 5 %	-	24.97	115	203	--	--	--	--
Levels of Sulphur (L)								
L_1: 10 kg S ha^{-1}	20.44	251.65	1231	2256	78489	31131	47358	1.521
L_2: 20 kg S ha^{-1}	20.70	268.51	1294	2449	83048	31562	51486	1.631
L_3: 30 kg S ha^{-1}	21.65	302.03	1393	2508	88459	31993	56466	1.62
S Em. ±	0.30	8.55	39	70	--	--	--	--
C D at 5 %	0.88	24.97	115	203	--	--	--	--
Interaction								
S X L								
S Em. ±	0.52	14.82	68.41	120.54	-	-	-	-
C D at 5 %	-	-	-	-	-	-	-	-
CV %	5.01	10.81	10.48	10.03	-	-		-

Table 2. Nutrient content, uptake and available nutrient status of soil in summer cowpea as influenced by sources and levels of sulphur

Treatments	Nutrient content (%)								Nutrient uptake (kg ha^{-1})								Available nutrients (kg ha^{-1})			
	Seed				Stover				Seed				Stover							
	N	P	K	S	N	P	K	S	N	P	K	S	N	P	K	S	N	P_2O_5	K_2O	S (mg/kg)
Sources of Sulphur (S)																				
S_1: Gypsum	3.39	0.482	0.805	0.258	0.77	0.243	0.527	0.206	47.23	6.72	11.22	3.60	19.24	6.06	13.17	5.14	276.22	40.95	303.57	11.87
S_2: SSP	3.33	0.474	0.788	0.253	0.76	0.238	0.508	0.200	42.74	6.07	10.09	3.26	18.74	5.86	12.52	4.96	267.67	40.76	296.93	11.53
S_3: Bentonite sulphur	3.33	0.468	0.767	0.251	0.73	0.234	0.504	0.196	41.58	5.85	9.60	3.15	16.41	5.28	11.37	4.40	260.80	39.31	296.58	11.23
S Em. ±	0.05	0.008	0.012	0.004	0.01	0.004	0.008	0.003	1.37	0.24	0.40	0.11	0.64	0.18	0.41	0.14	4.62	0.60	4.52	0.19
C D at 5 %	-	-	-	-	-	-	-	-	3.99	0.69	1.17	0.32	1.86	0.52	1.19	0.42	-	-	-	-
Levels of sulphur (L)																				
L_1: 10 kg S ha^{-1}	3.27	0.457	0.763	0.214	0.74	0.229	0.496	0.191	40.26	5.64	9.39	2.63	16.64	5.18	11.19	4.31	260.03	39.48	292.40	10.62
L_2: 20 kg S ha^{-1}	3.31	0.469	0.778	0.262	0.74	0.234	0.508	0.201	42.96	6.08	10.10	3.39	18.09	5.73	12.47	4.92	265.01	39.55	295.74	11.74
L_3: 30 kg S ha^{-1}	3.46	0.498	0.818	0.287	0.78	0.251	0.535	0.210	48.32	6.92	11.41	4.00	19.67	6.29	13.40	5.27	279.65	41.98	308.93	12.27
S Em. ±	0.05	0.008	0.012	0.004	0.01	0.004	0.008	0.003	1.37	0.24	0.40	0.11	0.64	0.18	0.41	0.14	4.62	0.60	4.52	0.19
C D at 5 %	0.14	0.024	0.036	0.013	0.03	0.011	0.023	0.009	3.99	0.69	1.17	0.32	1.86	0.52	1.19	0.42	13.49	1.74	13.18	0.54
C V %	5.01	5.914	5.403	5.865	5.84	5.531	5.272	5.463	10.81	13.19	13.48	11.52	12.16	10.73	11.43	10.27	5.97	5.13	5.23	5.58
S Em. ±	0.05	0.008	0.012	0.004	0.01	0.004	0.008	0.003	1.37	0.24	0.40	0.11	0.64	0.18	0.41	0.14	4.62	0.60	4.52	0.19
C D at 5 %	0.14	0.024	0.036	0.013	0.03	0.011	0.023	0.009	3.99	0.69	1.17	0.32	1.86	0.52	1.19	0.42	13.49	1.74	13.18	0.54
C V %	5.01	5.914	5.403	5.865	5.84	5.531	5.272	5.463	10.81	13.19	13.48	11.52	12.16	10.73	11.43	10.27	5.97	5.13	5.23	5.58
Interaction																				
V x S																				
S Em. ±	0.08	0.014	0.021	0.007	0.02	0.007	0.014	0.005	2.37	0.41	0.69	0.19	1.10	0.31	0.71	0.25	8.01	1.03	7.82	0.32
C D at 5 %	-	-		-	-	-		-	-	-	-		-	-		-	-	-		-

3.2.2 Quality parameters

The data presented in Table 1 showed that different level of sulphur in cowpea crop was significantly affected on crude protein content and crude protein yield. Significantly higher crude protein content (21.65) and crude protein yield (302.03 kg ha^{-1}) was recorded with 30 kg S ha^{-1} (L_3) over other levels of sulphur. The increase in protein yield was mainly due to higher protein content in cowpea seed and higher seed yield of cowpea due to sulphur application. Similar research result was reported by Singh et al. [9] was found protein yield showed significant improvement up to 30 kg S/ha.

3.2.3 Nutrient content and uptake

An appraisal of data given in Table 2 revealed that different levels of sulphur were significantly influenced on N, P, K and S content and uptake in seed and stover. The result showed that 30 kg S ha^{-1} (L_3) recorded significantly higher N, P, K and S content in seed i.e. 3.464 %, 0.498 %, 0.818 % and 0.287 %, respectively and N, P, K and S content in stover i.e. 0.782 %, 0.251 %, 0.535 % and 0.210 %, respectively as compared to over other levels of sulphur and significantly higher N, P, K and S uptake by seed i.e. 48.32, 6.92, 11.41 and 4.00 kg ha^{-1}, respectively and N, P, K and S uptake by stover i.e. 19.67, 6.29, 13.40 and 5.27 kg ha^{-1}, respectively as compared to over other levels of sulphur This increase in N, P, K and S content and uptake by seed and stover might be due to cumulative effect of increased seed and stover yield. The findings are in accordance with those of Singh and Singh [10] performed an experiment on cowpea and reported that the use of 30 kg S ha^{-1} enhanced the nitrogen, phosphorus, potassium and sulphur content at various growth stage of plant.

3.2.4 Available nutrient in soil after harvest

The data shown in Table 2 indicated that different levels of sulphur were significantly influenced on available N, available P_2O_5, available K_2O and available S in the soil after harvest of cowpea crop. The result showed that 30 kg S ha^{-1} (L_3) recorded significantly higher available N, P, K and S in soil after harvest i.e. 279.65, 41.98, 308.93 kg/ha and 12.27 mg/kg, respectively. Similar research result was reported by Kudi et al. [11] in greengram and they found that the use of 30 kg S/ha significantly increased available N (346.17 kg/ha), P (34.58 kg/ha) and K (226.29 kg/ha).

3.2.5 Economics

The result presented in Table 1 indicated that the maximum net realization (INR56466 ha^{-1}) and BCR (1.765) obtained from 30 kg S ha^{-1}. This might be due to higher yields of cowpea under 30 kg S ha^{-1}. Similar research result was reported by Arunraj et al. [12] in summer greengram, they revealed that application of sulphur 30 kg/ha along with RDF (25:50:25 N, P_2O_5, K_2O) had registered the maximum net return (18,875 INR/ha).

4. CONCLUSION

It is concluded that sulphur's significance for plant growth has long been understood to enhance crop quality production. However, due to the ongoing use of S-free fertiliser and intensive cultivation with high yielding varieties, its widespread deficiency in soil and, as a result, losses on crop productivity, have been reported over the last three decades. Sulphur is an essential component of the amino acids cystine, cysteine, and methionine and aids in photolytic enzyme activity, which is a key factor in plant growth and metabolism.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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