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EFFECT OF SOURCES AND LEVELS OF SULPHUR ON GROWTH, YIELD AND ECONOMICS OF SUMMER COWPEA (*Vigna unguiculata* L. Walp.) UNDER SOUTH GUJARAT CONDITION

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ABSTRACT

A field experiment was conducted at Soil and Water Management, Cotton Research Sub Station, Navsari Agricultural University, Achhalia during summer season of the year 2021 to study the effect of sources and levels of sulphur on cowpea (*Vigna unguiculata* L. walp.) under south Gujarat condition. The results revealed that application of 30 kg S ha^{-1} significantly increased the growth (plant height, number of branches plant^{-1}) and yield attributes (number of pods plant $^{-1}$, number of seeds pod^{-1}, length of pod, 100 seed weight), seed yield (1393 kg ha^{-1}) and stover yield (2508 kg ha^{-1}) and harvest index (35.83 %) as well as highest net realization (₹ 56,466 ha^{-1}) and BCR (1.62). Application of sulphur with gypsum source recorded significantly higher growth and yield attributes, seed yield (1392 kg ha^{-1}) and straw yield (2502 kg ha^{-1}) as well as highest net realization (₹ 57,398 ha^{-1}) and BCR (1.85).

(Key words: Cowpea, sulphur, yield, yield attributes, economics)

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 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} (Anonymous. 2021). 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} (Anonymous, 2021).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.

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- Bentonitesulphur) 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 five plants from each plot was randomly selected and tagged for measuring the plant height (cm) and number of branches plant^{-1} at 30, 45, 60 days after sowing and at harvest. Total number of pods plant^{-1} were recorded and averaged to get the number of seeds pod^{-1}. The length of pods were recorded using a measuring tape,

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weighed using an electronic weighing machine and then averaged to get mean 100 seed weight. The data on seed and stover yield was recorded from the net plot and converted on a hectare basis. The gross realization, cost of production, net realization and B:C ratio were calculated. Collected data were analyzed as per the method suggested by Panse and Sukhatme (1973). The harvest index was computed by using following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

RESULTS AND DISCUSSION

Effect of sources of sulphur

The data given in Table 1 indicated that application of gypsum (S_1) recorded significantly higher plant height i.e. 34.76, 53.37 and 63.17 cm at 45, 60 DAS and at harvest, respectively.However, it was at par with the application of sulphur with single super phosphate (S_2). Significantly higher number of branches plant^{-1} i.e. 6.00, 7.00 and 7.06 was recorded with the application of sulphur with gypsum (S_1) at 45, 60 DAS and at harvest, respectively when compared with other sources of sulphur. However, it was at par with the application of sulphur with single super phosphate (S_2).This might be due to application of gypsum. It play important role in energy transformation, activation of enzyme and also in carbohydrate metabolism which helps in improvement in growth of crop.Similar results were reported by Bainade *et al.* (2019). They recorded significantly higher plant height at 30, 60 and 90 DAS and branches plant^{-1} at 45, 60, 90 DAS and at harvest by the application of RDF + 25 kg S ha^{-1} through bensulf over application of RDF 60 : 30: 00 NPK kg ha^{-1}, RDF + 15 kg S ha^{-1} through gypsum, RDF + 20 kg S ha^{-1} through gypsum, RDF + 15 kg S ha^{-1} through bensulf and no fertilizer treatments, however it was at par with RDF + 25 kg S ha^{-1} through gypsum and RDF + 20 kg S ha^{-1} through bensulf in linseed.

The data given in Table 1 indicated that application of gypsum (S_1) recorded significantly higher number of pods plant^{-1} at harvest (23.88) with the application of sulphur with gypsum (S_1) as compared to other sources of sulphur. However, it was at par with the application of sulphur with single super phosphate (S_2).The number of seeds pod^{-1}, length of pod and 100 seed weight of cowpea were not significantly influenced due to different sources of sulphur. Higher number of pods plant^{-1} might be due to application of gypsum may be attributed to the fact that addition 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. The other reason might be due to readily soluble sulphate sulphur source which could supply sufficient sulphate ions in the rooting medium which in turn changed the amino acid composition. Similar results were found by Khan *et al*. (2017). They reported that application of gypsum recorded higher yield attributes and yield as compared to elemental Sulphur and SSP. Bainade *et al.* (2018) also reported that significantly higher capsules plant^{-1} at harvest was recorded by the application of RDF + 25 kg S ha^{-1} through bensulf over application of RDF 60 : 30: 00 NPK kg ha^{-1}, RDF + 15 kg S ha^{-1} through gypsum, RDF + 20 kg S ha^{-1} through gypsum, RDF + 15 kg S ha^{-1} through bensulf and no fertilizer treatments, however it was at par with RDF + 25 kg S ha^{-1} through gypsum and RDF + 20 kg S ha^{-1} through bensulf.

The result pertaining to yield (Table 1) showed significant response of different sources of sulphur for seed yield and stover yield of cowpea. Significantly higher seed yield (1392 kg ha^{-1}) and stover yield (2502 kg ha^{-1}) was recorded by the application of sulphur with gypsum source (S_1), which was at par with SSP source (S_2). Increase in seed yield and stover yield 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 and remarkable improvement in the physico-chemical properties of soil for the crop plant. 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 might be due to the application of gypsum 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 the findings of those reported by Singh *et al.* (2017).They reported that the application of 40 kg S ha^{-1} as gypsum recorded significantly higher grain (10.90 q ha^{-1}) and straw (28.78 q ha^{-1}) yield over elemental sulphur in green gram. Bainade *et al.* (2018) also reported that RDF + 25 kg S ha^{-1} through bensulf found significantly higher grain yield and straw yield over application of RDF 60 : 30: 00 NPK kg ha^{-1}, RDF + 15 kg S ha^{-1} through gypsum, RDF + 20 kg S ha^{-1} through gypsum, RDF + 15 kg S ha^{-1} through bensulf and no fertilizer treatment and were at par with RDF + 25 kg S ha^{-1} through gypsum and RDF + 20 kg S ha^{-1} through bensulf.

It is obvious from the data reported in Table 1 that the maximum net realization (₹ 57398 ha^{-1}) and BCR (1.85) was obtained by gypsum source (S_1) and the minimum net income (₹ 46270 ha^{-1}) and BCR (1.41) was secured under bentonitesulphur (S_3). This might be due to the higher yields produced by gypsum source (S_1) of cowpea. The results are close conformity with those obtained by Rampin *et al*. (2015). They reported that the application @ 800 kg ha^{-1} gypsum gave significantly higher grain yield of soybean and provided profit of 14.56 US$ with 44 per cent economic returns to pay half investment (US$ 33.32).Bainade *et al.* (2018) also reported the highest NMR (₹ 34434 ha^{-1}) and BCR (3.30) by the application of RDF + 25 kg S ha^{-1} through bensulf followed by the application of RDF + 25 kg S ha^{-1} through gypsum and RDF + 20 kg S ha^{-1} through bensulf.

Effect of levels of sulphur

The data given in Table 1 indicated that application of 30 kg S ha^{-1} (L_3) recorded significantly the highest plant

Table 1. Effect of sources and levels of sulphur on growth and yield parameters on summer cowpea

Treatments	Plant height (cm)				Number of branches plant^{-1}				Number of pods plant^{-1}	Number of seeds pod^{-1}	Length of pod (cm)	100 Seed weight (g)
	30 DAS	45DAS	60DAS	At harvest	30 DAS	45DAS	60 DAS	At harvest				
Sources of sulphur (S)												
S_1: Gypsum	23.94	34.76	53.57	63.17	4.56	6.00	7.00	7.06	23.88	12.67	13.56	11.67
S_2: SSP	23.90	33.59	52.74	61.98	4.53	5.80	6.77	6.87	23.23	12.39	13.15	11.58
S_3: Bentonitesulphur	23.73	32.04	49.04	57.52	4.25	5.54	6.49	6.53	21.67	11.85	13.12	11.49
SEm±	0.53	0.74	1.30	1.42	0.09	0.12	0.14	0.14	0.61	0.37	0.37	0.10
C D at 5 %	-	2.16	3.80	4.16	-	0.35	0.40	0.41	1.79	-	-	-
Levels of sulphur (L)												
L_1: 10 kg S ha^{-1}	22.91	30.19	47.86	56.83	4.25	5.43	6.44	6.54	21.88	11.58	12.75	11.52
L_2: 20 kg S ha^{-1}	24.13	33.31	51.84	60.65	4.42	5.80	6.77	6.78	22.64	12.51	13.27	11.57
S_3: 30 kg S ha^{-1}	24.52	36.90	55.65	64.89	4.67	6.10	7.05	7.14	24.26	12.83	13.81	11.66
SEm±	0.53	0.74	1.30	1.42	0.09	0.12	0.14	0.14	0.61	0.37	0.37	0.10
C D at 5 %	-	2.16	3.80	4.16	0.27	0.35	0.40	0.41	1.79	-	-	-
Interaction												
SEm±	0.91	1.28	2.26	2.47	0.16	0.21	0.24	0.24	1.06	0.64	0.64	0.18
C D at 5 %	-	-	-	-	-	-	-	-	-	-	-	-
CV %	7.66	7.66	8.72	8.12	7.20	7.16	7.07	7.14	9.26	10.45	9.58	3.05

Table 2. Effect of sources and levels of sulphur on yield attribute and economics on summer cowpea

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Gross realization (₹ ha^{-1})	Cost of production (₹ ha^{-1})	Net realization (₹ ha^{-1})
Sources of sulphur (S)						
S_1: Gypsum	1392	2502	35.83	88371	30973	57398
V_2: SSP	1279	2463	34.20	82432	30789	51643
V_3: Bentonitesulphur	1247	2248	35.67	79193	32923	46270
S Em±	39	70	1.05	-	-	-
C D at 5 %	115	203	-	-	-	-
Levels of sulphur (L)						
L_1: 10 kg S ha^{-1}	1231	2256	35.33	78489	31131	47358
L_2: 20 kg S ha^{-1}	1294	2449	34.63	83048	31562	51486
L_3: 30 kg S ha^{-1}	1393	2508	35.73	88459	31993	56466
S Em±	39	70	1.05	-	-	-
C D at 5 %	115	203	-	-	-	-
Interaction						
S Em±	68.41	120.54	1.82	-	-	-
C D at 5 %	-	-	-	-	-	-
CV %	10.48	10.03	10.34	-	-	-

height i.e.36.90, 55.65 and 64.89 cm at 45, 60 DAS and at harvest, respectively. Significantly higher number of branches plant^{-1}i.e. 4.67, 6.10, 7.05 and 7.14 at 30, 45, 60 DAS and at harvest, respectively were recorded with the application of 30 kg S ha^{-1} (L_3) as compared to other levels of suphur. However, it was at par with the application of 20 kg S ha^{-1} (L_2).This might be due to sulphur application could be ascribed to its important role in improving enzymatic processes including photosynthesis, respiration and nitrogen fixation activity in plant resulting into improvement in plant height and branches.Similar results were recorded by Lyngkhoi *et al*. (2020). They reported maximum plant height of 57.28 cm with 30 kg sulphur ha^{-1} in soybean. Punse *et al.* (2018) also found that application of 30 kg S ha^{-1} to greengram enhanced the plant height and branches plant^{-1}.

The data given in Table 1 indicated that application of 30 kg S ha^{-1} (L_3) recorded significantly higher number of pods plant^{-1} at harvest (24.26). The effect of sulphur application showed a positive impact on number of pods plant^{-1} in soybean as reported by Lyngkhoi *et al*. (2020). The number of seeds pod^{-1} of cowpea was not significantly influenced due to different levels of sulphur. The application of different levels of sulphur in soybean had no significant impact in the number of seeds pod^{-1} in soybean as also reported by Lyngkhoi *et al*. (2020). The data revealed that length of pod of cowpea was not significantly influenced due to different levels of sulphur. The increase in number of pods plant^{-1}might be due to application of 30 kg S ha^{-1}might have increased sulphur amount and available sulphur to plant which helped in increasing number of pods plant^{-1} in the present study. Similar results were recorded by Patel *et al.* (2018). They revealed that the use of 30 kg S ha^{-1}enhanced the number of pods plant^{-1}, grains pod^{-1} and grain yield in *kharif* greengram.

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. The highest seed yield might be due to cumulative favourable effect of the higher number of pods plant^{-1}and number of seeds plant^{-1} due to greater availability of nutrients and plant metabolism which in turn produced higher seed yield. The highest straw yield might be due to the fact that sulphur encourages above ground vegetative growth due to increased synthesis of amino acids and fatty acids and merristimatic activity that enhanced higher dry matter accumulation.Similar finding was recorded by Punse *et al*. (2018). They stated that highest seed yield (1310 kg ha^{-1}) and straw yield (1932 kg ha^{-1}) in green gram was obtained with the application of 30 kg sulphur ha^{-1} which was at par with 20 kg sulphur ha^{-1}. Marbaniang *et al.* (2020) also recorded the highest seed yield (286.11 kg ha^{-1}) and stover yield (396.95 kg ha^{-1}) with the application of 20 kg S ha^{-1} over control in mung bean.

The result presented in Table 1 indicated that the maximum net realization (₹ 56466 ha^{-1}) and BCR (1.77) obtained from 30 kg S ha^{-1}. This might be due to higher yields of cowpea under 30 kg sulphur ha^{-1}. Similar result was reported by Punse *et al.* (2018) in greengram. They revealed that application of sulphur 30 kg ha^{-1}recorded significantly higher net realization (₹ 51674 ha^{-1}) and BCR (3.82) over application of 10 kg sulphur ha^{-1}, but it was at par with the application of 20 kg sulphur ha^{-1}.

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