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Influence of sources and levels of sulphur on green pod yield of summer cowpea (*Vigna unguiculata* L. Walp) under middle Gujarat conditions

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Abstract
A field experiment was conducted at Bidi Tobacco Research Station, Anand Agricultural University, Anand, during summer 2013–2014 to investigate the "Effect of sources and levels of sulphur on green pod yield of summer cowpea (*Vigna unguiculata* L. Walp) under middle Gujarat conditions." Vegetable cowpea plant height measured at 60 DAS and at final picking, number of branches per plant, leaf area index at 30 and 60 DAS, number of green pods per plant, length of pod, number of seeds per pod, total yield of green pods, yield of dry stover and dry weight of root nodules per plant were significantly influenced by sulfur application. Production potential and profit from cowpea variety Anand Vegetable Cowpea-1 could be secured by applying sulphur @ 20-30 kg S/ ha through Gypsum or Bentonite during summer season under middle Gujarat conditions.

Keywords: Yield, sources, sulphur and cowpea

Introduction
Cowpea, also known as black-eyed pea or southern pea, is an annual plant in pea family (*Fabaceae*) farmed for its edible legumes. The plants are assumed to be native to West Africa and are commonly cultivated in tropical and subtropical climates around the world. Cowpeas are widely produced as a hay crop, as well as a green manure or cover crop, in addition to being a protein-rich food crop**,** forage, fodder, green manuring and vegetable**.** Cowpea is recognized for its drought tolerance; its wide and droopy leaves store soil and soil moisture due to its shading effect. Cowpea seed is a nutritious component of human diet as well as a low-cost cattle feed. Green and dried seeds are both acceptable for canning and boiling. It is a minor pulse cultivated primarily in arid and semi-arid parts of Punjab, Haryana, Delhi, and West UP, as well as a significant area in Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra, and Gujarat. Cowpea seeds have 0.1% fat, 24.1% protein and 54.5% carbohydrate. Additionally, it is a good source of calcium, iron and phosphorus (Anon., 2007) [1]. Being a component of amino acids cysteine, cystine and methionine, sulfur plays a crucial part in production of proteins, oils, coenzymes, and enzymes as well as synthesis of chlorophyll. Despite the fact that crops absorb almost as much sulfur as phosphorus, there is diversity among many crop species. Sulphur is now correctly referred to as 4th essential plant nutrient after nitrogen, phosphorus and potassium. Sulphur is a developing plant nutrient that is essential for pulse crops. It is absorbed by plants in the form of sulphates from the soil. Sulphur plays an important role in total pulse production by boosting protein content, nodule development and plant biomass through the synthesis of sulphur- containing amino acids. Use of S-free fertilizers, sparing use of organic matter, intense farming with high yielding cultivars and increased irrigation infrastructure are the main causes of sulphur deficit in soils and crops (Tandon, 1991) [6]. Sulphur content in soils of Gujarat is about 37% below average. Therefore, it's necessary to study the "Effect of sources and levels of sulphur on green pod yield of summer cowpea (*Vigna unguiculata* L. Walp) under middle Gujarat conditions".

Objectives
- To study the impact of source and level of sulphur on growth yield attributing characters, green pod yield and economics of cowpea

Material and Method

During summer season of 2013–2014, a field experiment was carried out in plot No. 7–A at Bidi Tobacco Research Station, Anand Agricultural University, Anand (Gujarat) to investigate the effect of sulphur sources and levels on green pod yield of summer cowpea (*Vigna unguiculata* L.) under middle Gujarat condition. The soil in experimental field had a loamy sand texture, low levels of accessible nitrogen (190.10 kg/ ha) and organic carbon (0.39%), medium levels of phosphorus (45.70 kg/ ha) and potash (280 kg/ ha) and low levels of sulphur (9.50 mg/ kg). Cowpea variety AVC-1 was grown to investigate the effects of treatments, which included three sulphur sources, S1- Gypsum, S2- Bentonite, and S3- Elemental Sulphuras well as three doses of Sulphur, L1- 10 kg S/ ha, L2- 20 kg S/ ha, and L3- 30 kg S/ ha. Nitrogen and phosphorus were supplied using urea and DAP, respectively. Each plot received a basic application of these fertilizers in opened furrows. Soil was treated with elemental sulfur two weeks prior to seeding. Bentonite and gypsum were added to the soil as part of treatment. Green pods from border row plants were harvested first and all of the green pods from each net plot were then gathered, weighed and recorded. Total green pod yield, which was then converted into kg/ha, was calculated by adding green pod yield data from four pickings. Cowpea was sown on March 21, 2013, with a seed rate of 25 kg/ha.

Result and Discussion

Impact of sources of sulphur

Results summarized in Table 1 revealed that different sulphur sources had no discernible effect on plant population measured at 25 DAS and at harvest, as well as various growth parameters including plant height measured at 30, 60 DAS and harvest, number of branches per plant and leaf area index at 30 and 60 DAS (Girish and Reddy 2005) [3]. Similarly, data presented in Table 3 indicated that different sources of sulphur failed to exert their significant influence on different yield and yield attributing characters viz., number of green pods per plant, length of pod, number of seeds per pods, total output of green pods and yield of dry stover as well as dry weight of root nodules per plant. Eventhough, an application of Gypsum as a source of sulphur produced significantly longer green pods as compared to Bentonite application (Bandopadhyay and Samui, 2000) [2].

Effects of levels of sulphur

The results (Table-1) reveled that plant population measured at 25 DAS and at time of final picking, as well as plant height measured at 30 DAS, were not changed significantly due to impact of varying sulfur levels. Although an application of different levels of sulphur to vegetable cowpea dramatically altered plant height measured at 60 DAS and final plucking. With an increase in sulphur levels, plant height measured at 60 DAS and at final picking were increased wherein, upper level of sulphur (L3- 30 kg S/ha) registered considerably higher plant as compared to lower level of sulphur (L1- 10 kg S ha) (Kumar and Singh 2005) [4]. Similar trend was also observed in other growth parameters viz., number of branches per plant and leaf area index measured at 30 and 60 DAS. Information provide4d in Table 3 proved that varying amounts of sulphur had a substantial impact on many yield metrics, including number of green pods per plant, length of pod, number of seeds per pod, total yield of green pods, yield of dry stover and dry weight of root nodules per plant. Additionally, according to the results regarding various yield-attributing parameters, an application sulfur @ 30 kg S/ha established their superiority over both the lower levels of sulphur (10 and 20 kg S/ha) by recording significantly the highest values for number of green pods per plant, length of pod, and number of seeds per pod. With regard to green pod yield, significantly higher total green pod yield was produced with an application of 30 kg S/ha but it was comparable with optimum level of sulphur (20 kg S/ha). However, upper level of sulphur (30 kg S/ha) established its superiority over both the lower levels of sulphur (10 and 20 kg S/ha) by recording the highest values of dry strover yield and dry weight of root nodules per plant.

Effect of control v/s rest

Data illustrated in Table-1 indicated that control v/s rest failed to signify their influence on plant population recorded at 25 DAS and at final picking as well as various growth parameters viz., plant height recorded at 60 DAS and final picking, number of branches per plant and leaf area index at 30 DAS. While, with regard to plant height recorded at 30 DAS and leaf area index recorded at 60 DAS, rest treatment reported their superiority over control by providing significantly higher values of these growth parameters. Likewise, significantly the highest values of different yield and yield attributing characters (Table-3) viz., number of green pods per plant, length of pod, number of seeds per pod, total green pod yield, dry stover yield and dry weight of root nodules per were registered under the treatment of rest.

Interaction effect

All possible interactions between different sources and levels of sulphur could not establish their significant influence on plant population, growth parameters (plant height, number of branches per plant and leaf area index) as well as all yield and yield attributing characters (Table 1 and 3). Even yet, interaction between various sources and sulphur levels had a considerable impact on plant height (Table 2) and leaf area index per plant (Table 4) observed at 30 DAS. However, significantly taller plants and higher leaf area index recorded at 3 DAS were observed with an application of 30 kg S/ha through Gypsum.

Table 1: Effect of different sulphur sources and levels on summer cowpea growth parameters

Treatments	Plant population/meter row length		Plant height (cm)			No. of branches/plant	Leaf area index (LAI)	
	25 DAS	Final picking	30 DAS	60 DAS	Final picking		30 DAS	60 DAS
Sources of sulphur (S)								
S1: Gypsum	11.65	11.53	24.02	67.85	68.17	12.17	1.97	4.42
S2: Bentonite	11.83	11.64	23.80	64.97	68.08	11.18	1.80	4.13
S3 : ES	11.91	11.36	23.90	65.45	66.48	11.77	1.91	4.17
S. Em. ±	0.27	0.21	0.59	1.72	1.32	0.37	0.07	0.10
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Level of sulphur (L)								
L1 : 10 kg ha^{-1}	11.70	11.61	23.43	62.17	64.72	10.88	1.64	3.92
L2 : 20 kg ha^{-1}	11.54	11.30	23.58	66.52	67.10	11.95	1.92	4.33
L3 : 30 kg ha^{+}	12.15	11.61	24.70	69.58	70.92	12.28	2.12	4.46
S. Em. ±	0.27	0.21	0.59	1.72	1.32	0.37	0.07	0.10
CD (P=0.05)	NS	NS	NS	4.98	3.84	1.07	0.19	0.30
Control v/s Rest								
Control	11.59	11.25	20.65	60.95	63.50	10.88	1.75	3.65
Rest	11.80	11.51	23.91	66.09	67.58	11.71	1.89	4.24
S.Em. ±	0.50	0.38	1.08	3.13	2.41	0.67	0.12	0.19
CD (P=0.05)	NS	NS	2.22	NS	NS	NS	NS	0.39
Interaction (S x L)								
CD (P=0.05)	NS	NS	2.98	NS	NS	NS	0.34	NS
CV %	7.47	6.14	8.82	9.46	7.01	10.80	9.81	8.31

Table 2: Interaction effect of different sulphur sources and levels on plant height (cm) at 30 DAS

Treatments	Levels of sulphur		
Sources of sulphur	**L1 : 10 kg/ ha**	**L2 : 20 kg/ ha**	**L3 : 30 kg/ ha**
S1 : Gypsum	23.25	22.60	26.20
S2 : Bentonite	24.05	25.00	22.35
S3 : ES	23.00	23.15	25.55
S. Em. ±	1.03		
CD (P=0.05)	2.98		
CV %	8.82		

Table 3: Interaction effect of different sulphur sources and levels on plant height (cm) at 30DAS

Treatment	No. of green pods/ plant	No. of seeds/pod	Length of pod (cm)	Yield (kg/ ha)		Dry weight of root nodule (mg/ plant)	Net realization on (₹ ha^{-1})	BC R
				Total green pod	Dry stover			
Sources of sulphur (S)								
S1: Gypsum	73.25	11.73	12.39	6482	6358	87.36	95867	2.59
S2: Bentonite	69.75	11.20	11.49	6068	5958	81.59	86864	2.32
S3: ES	70.33	11.54	12.02	6316	6100	84.88	87952	2.12
S. Em. ±	1.65	0.39	0.25	177.5	157.0	2.65		
CD(P=0.05)	NS	NS	0.71	NS	NS	NS		
Levels of sulphur (L)								
L1 : 10 kg/ ha	68.83	10.59	11.57	5818	5833	80.61	81611	2.17
L2 : 20 kg/ ha	69.83	11.13	11.71	6382	6083	83.11	92058	2.38
L3 : 30 kg/ ha	74.67	12.75	12.63	6667	6500	90.11	97015	2.45
S. Em. ±	1.65	0.39	0.25	177.5	157.0	2.65		
C. D. at 5%	4.79	1.13	0.71	515.1	455.5	7.70		
Control v/s Rest								
Control	64.25	9.50	10.75	5495	5325	74.30	75827	2.06
Rest	71.11	11.49	11.97	6289	6139	84.61		
S.Em. ±	3.01	0.71	0.45	324	287	4.84		
CD (P=0.05)	6.18	1.46	0.92	665.0	588.0	9.94		
Interaction (S x L)								
CD (P=0.05)	NS	NS	NS	NS	NS	NS		
CV %	7.53	12.38	7.51	8.74	8.13	10.49		

Table 4: Interaction effect of different sources and levels of sulphur on leaf area index at 30 DAS

Treatments	Levels of sulphur		
Sources of sulphur	**L1 : 10 kg/ ha**	**L2 : 20 kg/ ha**	**L3 : 30 kg/ ha**
S1 : Gypsum	1.58	1.90	2.42
S2 : Bentonite	1.46	1.77	2.17
S3 : ES	1.89	2.10	1.75
S. Em. ±	0.12		
CD (P=0.05)	0.34		
C V%	9.81		

Conclusion

According to aforementioned study, an application of sulphur at 20–30 kg S/ha resulted in significantly greater total green pod yield values of cowpea as compared to application of 10 kg S/ha. Higher net realization and BCR values were however obtained with an application of 30 kg S/ha.

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