The Pharma Innovation Journal 2022; 11(8): 1523-1526

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(8): 1523-1526

www.thepharmajournal.com
Received: 14-05-2022
Accepted: 18-06-2022

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Effect of different level of Sulphur on physiological characters of cotton (*Gossypium hirsutum* L.)

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Abstract
A Field experiment was conducted at Main Cotton Research Station Athwa farm, Navsari Agricultural University, Seurat (Gujarat) during *kharif* (June – December) 2020-21 entitled "Effect of different level of Sulphur on Physiological characters of cotton". The treatment comprised of different level of Sulphur i. e. S0 Control (No gypsum and No elemental Sulphur), S1 (20 kg S/ha gypsum), S2 (40 kg S/ha gypsum) S3 (60 kg S/ha gypsum), S4 (20 kg S/ha elemental Sulphur), S5 (40 kg S/ha elemental Sulphur) and S6 (60 kg S/ha elemental Sulphur) were conducted in randomized block design (RBD) with three replications, variety GN. Cot. Hy. 18 was taken as a promising hybrid. The result revealed that application of different treatments was significantly improved Physiological parameters *viz*., plant height, No. of boll per plant, seed cotton yield, seed oil content, available nutrient (N, P2O5, K2O and S) and plant nutrients (P, K and S) uptake were found significantly higher with application of 60 kg S/ha as soil application at the time of sowing while, boll weight, No. of Sympodial per branch, available K2O and plant nutrient (N) were non-significantly by various Sulphur levels. Seed cotton yield were found higher in soil application of 40 kg S/ha before sowing while physiological attributes were found higher with 60 kg S/ha in both the Sulphur source.

Keywords: Gypsum, elemental sulphur, growth attributes, yield and yield attributes, seed quality

Introduction
Cotton is the most important fiber crop not only of India but of entire world. It provides the basic raw material (cotton fiber) for the cotton textile industry. It includes approximately 50 species distributed worldwide. Among these 50, two diploid (*Gossypium arboretum* and *Gossypium herbaceum*) and two tetraploid (*Gossypium hirsutum* and *Gossypium barbadense*) species are under *cultivation* in tropical and sub-tropical environmental conditions. Four species are under commercial cultivation *Gossypium herbaceum* L. (2n=26), *Gossypium arboretum* L. (2n=26), *Gossypium hirsutum* L. (2n=52) and *Gossypium barbadense* L. (2n=52). All these four species are cultivated only in India on the commercial scale (Prajapat *et al*., 2018) [17].

The introduction of new high yielding variety, change the concept of nutrient requirement of cotton. Application of potassium to cotton crop boost up seed cotton yield by 25% and 1% oil content. Similarly, Sulphur also improved yield and quality parameters of seed cotton (Mamatha *et al*., 2009) [9]. Sulphur (S) is an important factor influencing cotton yield, the plant growth and development. (Najafian and Zahedifar, 2015) [12]. Soil available S is generally low in the Cotton growing regions due to the hot and humid climate and high likelihood of Sulphate leaching. High soil pH, light textured soils low level of organic matter besides development of plough pan further aggravates the availability of Sulphur to growing crops (Hue *et al*., 1984) [6]. In general, oil crops require about the same amount of Sulphur (S) as or more than, phosphorus (P) for high yield and product quality. In intensive crop rotations including oil crops, Sulphur uptake can be very high, especially when the crop residue is removed from the field along with the product. (Tiwari *et al*., 1997) [19].

Material and Methods
Location and chemical Properties of soil: A field experiment was conducted at the Main Cotton Research Station Athwa farm, Navsari Agricultural University, Surat (Gujarat) during *kharif* season 2020-21. The soil of the experimental field was fairly levelled and uniform. The soils of South Gujarat are locally known as "Deep black cotton soil", and showed low, medium and high rating for available nitrogen (262.16 kg ha-1), phosphorus (27.15 kg ha- 1), potassium (430.31 kg ha-1) and Sulphur (6.78 mg kg-1), respectively.

The soil was found slightly alkaline (pH 7.61) with normal electric conductivity (0. 29 ds m-1).

Climate and weather condition

Weather prevailed during the course of investigation was quite congenial for the satisfactory growth and development of cotton crop. Moreover, there was no serious incidence of disease and pests. The maximum temperature ranged between 24.17℃ to 41.00℃, while minimum temperature ranged between 13.06 to 32.1℃ relative humidity maximum 99.0 and minimum 52.0, Sunshine hours per day ranged between 1.01 to 6.5 during the period of experiment which was found favourable for normal growth of cotton. The crop has got optimum duration of sunlight and humidity during the growth period.

Treatment

The details of treatment consisted of level of Sulphur *viz.,* S0 - Control (No gypsum and No elemental Sulphur) S1 - 20 kg S/ha gypsum S2 - 40 kg S/ha gypsum S3 - 60 kg S/ha gypsum S4 - 20 kg S/ha elemental Sulphur S5 - 40 kg S/ha elemental Sulphur S6 - 60 kg S/haelemental Sulphur to cotton in *kharif* (June-December 2020-21) season. The treatments are evaluated in randomized block design with three replications.

Genotype and seed treatment

The cotton cv. GN. Cot.Hy.18 was sown with spacing of 120 × 45 cm in the second week of June and harvested in thread and fourth week of December during the year 2020-21. RDF (Recommended dose) @ 240:0:0 kg ha-1 NPK of nitrogen was applied in 5 equal splits at 30, 60, 75, 90 and 105 DAS before sowing and mixed well in soil and sulphur applied by different source gypsum and element sulphur as per treatment at before sowing. The seeds treated with Imidacloprid @ 3g kg-1 seed were sown manually in the previously opened furrows of each plot using seed rate of 2.5 kg ha-1. The plant sample were collected from each plot at 45 days after sowing and analysed using standard procedures.

Statistically analysis was done using standard methodology of randomize block design as per the method using OPSTAT (O.P. Sheoran Programmer, Computer Section, CCS HAU, Hisar) web-based statistic software. The critical difference (CD) among the variances was calculated at $p \leq 0.05$.

Table 1: Physiological Observation Recorded

Sr. No.	Particulars	DAS	Sample
A)	**Growth Attributes**		
1	Plant height(cm)	At Harvest	5 random plants/net plot
2	No. of sympodial branches per plant	At Harvest	5 random plants/net plot
B)	**Yield and yield attributes**		
3	No. of boll per plant	At Harvest	5 random plants/net plot
4	Boll weight(g)	At Harvest	5 random plants/net plot
5	Seed cotton yield(kg/ha)	At Harvest	Net plot
C)	**Seed Quality**		
6	Seed Oil content (%)	At Harvest	5 random plants/net plot
D)	**Soil Analysis**		
7	Available nutrients [N, P2O5, K2O (kg/ha) and S (mg/kg)]	Before sowing, After sowing,	0-22.5 cm Depth
E)	**Plant Analysis**		
8	Nutrients (N, P2O5, K2O and S) %	At Harvest	5 random plants/net plot

Result and Discussion

The data presented in Table 2 Indicate that the application of different level of Sulphur application by gypsum and elemental Sulphur revealed that significantly highest plant height 152.89 cm and 33.53 Number of Boll per plant were found in treatment S6 (60 kg S/ha elemental sulphur). This was in conformity with the findings of Rathinavel *et al.* (2004) [16]. Parmar *et al.* (2010) [14] revealed that number of bolls per plant were significantly influenced by sulphur application. The low S treatment significantly reduced the total number of harvestable bolls per plant in both years (Gormus, 2014) [5]. Maximum value of Number of sympodial branches per plant (18.88), Boll weight (4.01 g) and highest Seed cotton yield (2294.72 kg/ha) was found in the treatment of S5 (40 kg S/ha elemental sulphur). The Number of sympodial branches per plant was significantly influenced by the application of sulphur (Gobi and Vaiyapuri, 2012) [4]. Similar results were also documented by Chhabra *et al.* (2004) [1]. Gormus (2014) [5] studied that boll weight increased by application of Sulphur could be attributed to the favourable effect of Sulphur on carbohydrate metabolism and accelerated mobility of photosynthates from source to sink. Similar results were found by Parlawar *et al.* (2018) [13]. Mirzashahi *et al.* (2010) [10] proved that the highest seed yield was obtained with the application of Sulphur. It was in accordance with Jackson (2000) [7] and Mamatha, *et al.*, 2009 [9].

The oil content (%) of different level of Sulphur application showed in Table 2. The significantly higher (18.90%) oil content was found in treatment S3 (60 kg S/ha Gypsum). Sarkar *et al.* (2002) revealed that Sulphur had remarkable influence on oil content because Sulphur is required for the synthesis of fatty acid which are essential components of oil. These results are similar to several observations on cereals and other oil seeds (Singh *et al.*, 1970; Randall, 1988; Munshi *et al.*, 1990; Eppendorfer and Eggum, 1992) [18, 15, 11, 2].

Table 2: Plant height (cm), No of Sympodial branches per plant, Number of bolls per plant, boll weight, seed cotton yield and Seed oil content (%) as influenced by different Sulphur treatments.

Treatment	Plant height (cm)	No of sympodial branches per plant	No of Boll per plant	Boll weight (g)	Seed cotton yield (kg/ha)	Seed oil content (%)
S0	140.00	16.88	25.60	3.23	2110.00	17.45
S1	143.33	17.33	28.93	3.38	2189.23	18.28
S2	147.22	18.11	30.60	3.70	2272.32	18.76
S3	152.11	17.55	32.00	3.37	2198.69	18.90
S4	142.78	18.77	27.06	3.27	2140.79	18.48
S5	148.78	18.88	27.93	4.01	2294.72	18.74
S6	152.89	18.11	33.53	3.61	2164.11	18.84
S.Em ±	3.79	0.76	1.46	0.089	29.79	0.13
CD at p≤0.05	11.68	NS	NS	0.23	92.82	0.43
CV%	4.51	7.36	8.63	3.75	2.35	1.30

Data furnished in Table 3 indicated that nitrogen content of cotton leaf was non- significantly differed due to application of various level of sulphur, the higher N content were observed 2.48% and 2.42% in the treatment S1 (20 kg S/ha gypsum). Jaylalitha and Narayanan (1995) [8], gave treatments with and without Sulphur application along with complete nutrient. They found the application of complete nutrient with Sulphur gave non-significantly higher nitrogen content in leaf lamina and stem petiole in cotton.

Phosphorus content of cotton leaf showed significantly higher values under the different treatment of Sulphur. The highest Phosphorus content 0.25% were reported under treatment S3 (60 kg S/ha Gypsum), Higher potash content (0.99%) under treatment S6 (60 kg S/ha elemental Sulphur) and Sulphur content (0.15%) was reported under treatment S3 (60 kg S/ha Gypsum) and S6 (60 kg S/ha elemental Sulphur). Application of S through Gypsum recorded significantly higher value of N, P, K (Parlawar *et al*., 2018) [13]. Same result was found Jaylalitha and Narayanan (1995) [8]. The total Sulphur in cotton seed was recorded higher under applications of Sulphur @ 40 kg/ha as compared to remaining treatments. (Parmar *et al*., 2010) [14]. Gormus in (2014) [5], revealed that Sulphur concentrations of cotton leaf applied with Sulphur fertilizer at the high rate had increased nearly two times compared to the control treatment

Available Nutrient content in soil as influenced by different Sulphur treatments after harvesting data furnished in Table 3 indicated that the non-significantly result was found in available nutrient content in soil such as N, P2O5, K2O but maximum content found in treatment S6 (60 kg S/ha elemental Sulphur) that is (258.57 Kg ha-1) nitrogen, (21.11 Kg ha-1) Phosphorus and Potash (396.53 Kg ha-1). The application of different levels of Sulphur was found non-significant in available K2O (Yadav *et al*, 2019) [20]. The similar record was found by Parmar *et al*., (2010) [14]. The significantly highest Sulphur content was found in the treatment inS6 (60 kg S/ha elemental sulphur) 20.59 Kg ha-1 in soil. These results are in accordance with the findings of (Parmar *et al*., 2010) [14]. Application of Sulphur significantly increased the available sulphur in soil at harvest which was maximum over preceding levels. Ergle, (1953) [3]. Same results regarding effect of low nitrogen and Sulphur supply on their accumulation in the cotton plant was found.

Table 3: Available Nutrient content in leaf and soil as influenced by different Sulphur treatments after harvesting.

Treatment	Nutrient content (%) in plant leaf				Nutrient content in soil after harvesting			
	N	P	K	S	N (kg/ha)	P2O5 (kg/ha)	K2O (kg/ha)	S (mg/kg)
S0	2.35	0.20	0.70	0.10	217.93	19.10	338.66	9.52
S1	2.48	0.22	0.88	0.12	225.02	18.43	383.52	17.13
S2	2.42	0.23	0.91	0.13	245.56	19.77	386.22	18.17
S3	2.40	0.25	0.94	0.15	251.92	20.10	393.32	19.80
S4	2.37	0.23	0.92	0.12	230.97	19.10	365.13	16.44
S5	2.17	0.23	0.97	0.13	242.23	18.76	394.54	17.73
S6	2.13	0.24	0.99	0.15	258.57	21.11	396.53	20.59
S.Em ±	0.09	0.006	0.025	0.002	8.39	1.49	14.76	0.33
CD at p≤0.05	NS	0.017	0.077	0.007	NS	NS	NS	1.01
CV%	6.79	4.13	4.71	2.97	6.08	13.27	6.73	3.32

Conclusion

Concluded that physiological parameter *viz*. plant height, No. of boll per plant, boll weight, seed oil content, available nutrient (N, P2O5, K2O & S) and plant nutrients (N, P, K and S), Seed cotton yield were significantly higher in 60 kg S/ha by elemental Sulphur treatment as compare to other treatment. No. of sympodial per branch were not significantly deviated by various Sulphur levels.

Acknowledgement

Authors are thankful to Department of Soil Science and Agricultural Chemistry, (Biochemistry), NMCA, Navsari Agricultural University, Navsari to provide lab facility and MCRS, NAU, Seurat for provide support and land facility during the M.Sc. research work.

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