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Influence of different doses of Sulphur on Growth of Herb (*Cymbopogon flexuosus)* Lemongrass var. Krishna.

A Ranganadha Reddy[1]*, V Ravi kumar[1], KP Sastry[2], R Bharath Kumar[1], AV Narayana[1], TC Venkateshwarulu[1], and M Priyanka[1]

[1] School of Biotechnology, Vignan University, Vadlamudi, Guntur 522213, Andhra Pradesh, India
[2] Central Institute of Medicinal and Aromatic Plants (CIMAP), Boduppal, Hyderabad 500039

ABSTRACT

Experiment was conducted to study the influence of Sulphur on the growth of herb *Cymbopogon flexuosus)* Lemongrass var. Krishna at CIMAP Research Centre, Hyderabad during October 2010 to May, 2011. In the experiment, five different levels of sulphur (0- 4.0 tons/ha) was applied and tested. In the experiment, it was observed that application of sulphur reduced the pH of the soil. Though the differences noticed in the Electrical Conductivity of the soil due to treatments were significant, a definite pattern was not observed. Application of sulphur reduced the bicarbonate, chloride, calcium and sulphate contents of the soil. Plant height was not influenced by the application of sulphur. Number of leaves /plant increased significantly up to 750 kg/ha sulphur application. No. of tillers/plant and plant weight also showed significant increase up to 750 kg/ ha sulphur application.

Keywords: Lemon grass, Sulphur, pH, Electrical conductivity, Carbonte, Sulplhate.

Corresponding author

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INTRODUCTION

Lemon grass (Cymbopogon flexuous) is a perennial herb widely cultivated in the tropics and subtropics. The reported adaptation zone for lemon grass is: temperature 18 to 29ºC with an annual precipitation of 0.7 to 4.1 meters and a soil pH of 5.0 to 5.8. Since the plants rarely flower or set seed, propagation is by root or plant division. Cymbopogon flexuous Stapf (Andropogon flexuous Nees ex Steud.), Malabar or Cochin grass, is distributed in the Tinnivelli district and in Travancore. According to Stapf, the oil, which is known in commerce as lemon-grass oil, is obtained from two wholly different plants, the oil coming from the Malabar Coast being produced from Cymbopogon flexuous Stapf, whilst the other species of lemon-grass, designated as Cymbopogon citrates Stapf, yields oil which, though very similar, is not identical with the former[1]. Essential oil isolated from Cymbopogon flexuous (citral-type), is reported to contain citral-b from 14% to 35% and citral-a from 23% to 56%, while geraniol type is reported to contain geraniol from 17% to 88 % [2]. The oil is distilled from leaves and flowering tops of lemongrass. The oil has strong lemon-like odour due to high percentage of citral in the oil. The characteristic smell of oil makes its use in scenting of soaps, detergents, insect repellent preparations. However, the major use of oil is as a source of citral, which goes in perfumery, cosmetics, beverages and is a starting material for manufacture of ionones, which produces vitamin–A. The citral rich oil has germicidal, medicinal and flavouring properties [3]. As a medicinal plant, lemon grass has been considered a carminative and insect repellent. Lemon grass is used in herbal teas, other non-alcoholic beverages, and in confections. Lemon grass is generally recognized as safe for human consumption as plant extract/essential oil [4]. There are many reports that application of gypsum on normal soils has shown improved crop yields which may be possible due to supplementation of soil with sulphur and calcium. Gypsum also act as source of plant nutrients i.e. calcium and sulphur to plants. It has 17% sulphate which is the most absorbable form of sulphur for plants.calcium,which is supplied in gypsum is essential for the biochemical mechanisms by which most plant nutrients are absorbed by roots. Without adequate calcium, uptake mechanisms would not function properly. It was also concluded gypsum supplied at lower rates may increase crop yields on normal soils due to supplementation of plant nutrients [5]. Gypsum (CaSO4 .2HO) is one of the most commonly occurring sulfate minerals in soils. It may be present in trace amounts in soils or dominate the pedon as in gypsiferous soils with a gypsie or petrogypsic horizon [6].Gypsum provide a source of calcium (Ca2+) to replace excessive Na+ from the cation exchange sites [7][8]while others (i.e., sulphuric and phosphoric acid) increase the dissolution of calcite in calcareous saline sodic soils[9][10]. The essential oil is produced by distillation of the grass and for obtaining good quality oil,steam distillation in stainless steel units is preferred, with a steam pressure of 18-32 kg/cm in the boiler. The grass is distilled either fresh or after wilting. On an average the oil recovery is 0.2-0.4% and the oil yield is 100-125 kg/ha/year.The physico-chemical properties of *Cymbopogon flexuosus* red and white types,*C. pendulus* and *C. citratus* are given in the following table[11].

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Physico-chemical properties of lemongrass oils

Property	*C. flexuosus*		*C. pendulus*	*C. citratus*
	Red grass	White grass		
Specific gravity at 30° C	0.881	0.931	0.915	0.898
Refractive index at 30° C	1.482	1.498	1.489	1.491
Optical rotation at 30° C	-3 to 1	-	-0.36	-0.62
Total aldehydes	80-89%	76.4%	75-80%	74.96%
Solubility in 70% alcohol	2.8 vol	Insoluble	-	-

Sulphur (S) is the 13th most abundant element in the earth's crust with an average concentration of 0.06% and one of the 16 essential plant nutrients which is very important for the growth and development of plants. It is now recognized as the fourth major nutrient in addition to nitrogen, phosphorus, and potassium. Deficiency of S is more acute in coarse textured soils and is widespread throughout India including West Bengal. At present S deficiency in the soils of various Indian states varies from 5–83%with an overall mean of 41% [12].Sulphur occurs mainly as organic, inorganic and the form of ester sulphates in soils. Sulphatases play an important role in the processes whereby organic soil Sulphur is mineralized and made available for plant growth. plants can assimilate up to 30% of S from the atmosphere in the form of SO2; however, the rest must be absorbed by roots from the soil [13]. The hydrous oxides of aluminium and to a lesser extent iron show marked tendencies to sulphate retention in soils. They also concluded that the adsorption of sulphate in soils of alkaline reaction (pH 4 6.5) and supplied with phosphate, nitrogen, molybdate has been found to be decreased [14].

MATERIALS AND METHODS

The present study was undertaken to study the influence of different levels and a method of application of sulphur on the growth of herb *Cymbopogon flexuosus* variety 'Krishna' during October, 2010 to May 2011. As per the standardization of protocol and the available literature sources the sequence of experiments were carried out at the research farm of Central Institute of Medicinal and Aromatic Plants, Research Centre, Boduppal, Uppal, Hyderabad. The experimental site is located at the altitude of 542 m above mean sea level with a geographical bearing of 780 8' longitudes and 17032' latitude, Semi -arid tropical climate zone of Hyderabad has an average rainfall of 800 mm per year. The soil of the experimental field was a red sandy loam (alficusto chrept) with pH 7.8 (1.25 soils to solution ratio), EC - 0.42 ds/m, organic C -0.3%, total N -0.03%, available P- 10 ug /g soil and exchangeable K-128 ug/g soil. Experiments were conducted during the period from October, 2010 to May 2011. In the first experiment gypsum was applied at five different levels to study its influence in reducing soil salinity [1].

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Treatment table

Experiment I: Different doses of Sulphur were applied in the following composition on herb i.e., lemongrass variety Krishna as shown in Table-1 and Table-2 Shows the replication of treatments with Gypsum Sulphur.

Table 1: Different levels of Sulphur applications

S.No	Treatment	Sulphur tons/ha	Sulphur Kg/plot
1.	T0	0	0
2.	T1	0.5	0.966
3.	T2	0.75	1.449
4.	T3	1.00	1.932
5.	T4	1.25	2.415

Note: The treatment composition of Sulphur was taken as 0, 0.5, 0.75, 1.00, 1.25 tons/ha.

Table 2: Shows the replication of treatments with Sulphur correspondingly the information has been provided in parenthesis.

SR1T1(0.966Kg)	SR3T1(0.966Kg)
SR1T2(1.449Kg)	SR3T2(1.449Kg)
SR1T3(1.932Kg)	SR3T3(1.932Kg)
SR1T4(2.415Kg)	SR3T4(2.415Kg)
SR2T1(0.966Kg)	SR4T1(0.966Kg)
SR2T2(1.449Kg)	SR4T2(1.449Kg)
SR2T3(1.932Kg)	SR4T3(1.932Kg)
SR2T4(2.415Kg)	SR4T4(2.415Kg)

(S: Sulphur, T: treatment, R: replication)

Plantation: Fully grown slips of size 4-6" were planted in field at 60x60 cm spacing in 3x4 m plots as per the lay out plan.

Treatment imposition: The crop was planted on 10.10.2010.Sulphur was applied 10 days after planting.

Maintenance: The crop was kept weed free and regularly irrigated.

Observations recorded

Soil chemical properties: Observations on the soil pH, E.C, carbonates/bicarbonates, chlorides, calcium and magnesium, sulphates were taken at interval. The soil samples were collected at regular intervals of time i.e., (15, 30, 45, 60, 75, 90, 105, 120 days) as shown in Table-3. The average values were taken for each treatment with different replicates. Titrations were performed with the different procedures like carbonates and bicarbonates, chlorides, calcium and magnesium and sulphates. The details are presented here.

ISSN: 0975-8585

Table 3: Table showing the different stages of soil samples was collected at regular intervals of time i.e., (15, 30, 45, 60, 75, 90, 105, 120 days).

S.No	Regular intervals	Code
1	15	Stage I
2	30	Stage II
3	45	Stage III
4	60	Stage IV
5	75	Stage V
6	90	Stage VI
7	105	Stage VII
8	120	Stage VIII

Procedures for pH, Electrical Conductivity, Carbonates and Bicarbonates, Chlorides, Calcium,Magnesium and Sulphates are presented here:

Estimation of pH and E.C. in soil samples

Introduction: Procedure for estimation of the pH and E.C of the given soil samples is presented here:

pH: The pH meter is switched on and allowed to warm for about 10minutes. Set 0 correction and checked the meter with buffer solutions (7.0 and 4.0 pH) and set the buffer correction. Then the electrode tip was immersed in the soil suspension and the reading shown by the meter was noted down. This gives the pH of the soil.

Electrical Conductivity: After recording the soil pH, the soil suspension was allowed in the beaker to settle for some time. Checked with conductivity meter the saturated calcium sulphate solution having E.C 2 milli *mhos*/cm at 250c before proceeding with the sample. Sucked the supernatant liquid with the conductivity cell first and then immersed the electrode bulb completely without air bubbles and measured the conductivity by adjusting the knob until getting maximum dark in the magic indicate and expressed the conductivity in milli mhos/cm at 250C to the nearest decimal point.

Carbonates and Bicarbonates: The estimation of carbonates and bicarbonates in the soil sample is based on simple acidimetric titration using different indicators which work in alkaline pH range (above 8.2) and in acidic pH (below 6.0)

Calcium and Magnesium: The usual method for the determination of calcium and magnesium in the soil is by versenate (EDTA) titration (Chang and Bray 1951) [15].

Determination of Chlorides: Chloride ion is universally present in small amounts in almost all natural waters and its content goes up appreciably with salinity. This estimation may be carried out when the electrical conductivity is greater than 1mmhos/cm at 25oC (Mohr's titration) [16].

Estimation of Sulphates: While traces of sulphates occur universally its content can be appreciable in most saline water showing higher values of EC. Sulphates in solution are quantitatively precipitated and estimated gravimetrically as BaSO4.The sulphate content in many irrigation waters may be quite low and therefore a large volume of the sample has to be first concentrated to about 100ml and the estimation itself is also time consuming. Turbidimetric and colorimetric methods of determination of sulphate have been described earlier. The procedure given here is based on EDTA titration as described by (Jackson 1973) [17].

Observations on herb

Observations were taken at different intervals starting from 10 days after Sulphur application. In each treatment two plants were removed at random from the plants and washed under tap water. Fresh and dry weights of individual components were taken separately. Later observations were recorded. Details about the observations recorded are presented here in Table-4.

Table 4: Table showing the different stages of fresh plant samples was collected at regular intervals of time i.e., (30, 60, 90, 120, 150, 180 days).

S.No	Regular intervals	Code
1	30	Stage I
2	60	Stage II
3	90	Stage III
4	120	Stage IV
5	150	Stage V
6	180	Stage VI

Details about the methods followed in observations;

Height of plant (cm): The height of the regular plants was measured from the base of the plant and expressed as average in cms (approx. 200 leaves/clump).

Number of leaves/plant: The leaves were separated from the stem. The number of fresh and entire leaves were recorded and expressed as average (approx. 350 leaves/clump).

Number of tillers/plant: The number of tiller per clump were counted and expressed as average.

Fresh weight of plant (g): Two plants from each treatment were selected randomly. The fresh weight of the plant of each plant was taken by using electronic balance and it is expressed as average.

Leaf area (Sq.cm)/leaf: The area of the leaf was measured by using Systronics Leaf area meter and it is expressed as average.

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Dry weight of leaves /plant (g): The leaves from two plants were dried in oven at 100 0C till constant weight and the dry weight was recorded.

RESULTS AND DISCUSSION

Experimental studies with application of Sulphur – observations and results

Soil properties: The results pertaining to the initial soil properties are presented in Table-5. The pH of the soil studied over a period of 120 days indicated that application of sulphur reduced the pH of the soil with increase in time. And it was observed that a significant pattern was not observed (Table-6). Sulphur application resulted in a Progressive increase in E.C at all stages and in all the treatments indicating the diminishing influence of sulphur over a period of time (Table-7). The Bicarbonate content of the soil water was also influenced by the treatments. Application of sulphur reduced the bicarbonate content of the soil. It was drastically increased in the third and fourth stages (Table-8). Application of sulphur was resulted in increased chloride content up to three stages and again there is a reduction in the chloride content of the soil. The availability of chloride is influenced very little by soil acidity, aeration these factors affect the growth of plant roots (Table-9). It was observed that Ca and Mg was increased drastically in third, fourth and fifth stages and again there is a significant reduction in the Ca and Mg. Ca tends to loosen soil and Mg tightens it, in a heavy clay soil and improves the water retention (Table-10). It was observed that sulphate contents were drastically increased in the third and fourth stages. Acid sulphate soils show the destructive effect on plants and resulted in reduction of productivity through metal contamination of soils (Table-11).

Table 5: The results pertaining to the initial soil properties are presented here.

Treatment	pH	EC	Carbonates and Bicarbonates	Chlorides	Calcium and Magnesium	Sulphates
T0	7.20	0.20	0.90	12.80	13.62	14.04
T1	7.43	0.22	1.10	13.50	15.45	15.06
T2	7.00	0.36	1.20	14.62	14.39	13.69
T3	7.12	0.20	1.32	14.90	14.57	15.10
T4	7.50	0.25	1.40	15.40	18.12	19.60
F'- Test	NS	*	NS	*	*	*
C.D.(P=0.05)	0.89	0.03	0.17	1.92	1.82	1.84
C.V.%	7.56	9.39	8.90	8.30	7.36	7.31

The pH of irrigation water should be in the range of 6.0 to 7.0 is most desirable. Water becomes more acidic as pH value below 7.0, if it is above 7.0 there is an alkalinity in the soil. In the above table, it was observed that the pH range is above 7.0. So the soil was alkaline. If the salinity is more than 1.0 mS/cm, it will effectively damage the plants. Monitoring of salinity helps manage the effects of soluble salts on plant growth. EC is an indicator of water quality, soil salinity and fertilizer concentration. Carbonates were not present in the soil water where as the presence of bicarbonates was observed. Chlorides are universally present in almost all waters and chloride salts will accumulate in saline soil. When Cl- concentrations are high, it can

be toxic to plants. The crop yields are not significantly affected by the soil Ca/Mg ratio as long as both nutrients are present in adequate amounts. Presence of sulphates in the soils can have a destructive effect on plant and reduction in agricultural productivity through metal contamination of soils.

pH of the soil: The results pertaining to the soil pH as influenced by different treatments during the experimental period is presented in Table-6. The pH of the soil studied over a period of 120 days indicated that application of sulphur reduced the pH of the soil with increase in time. And it was observed that a significant pattern was not observed.

Table 6: Influence of different levels of Sulphur on the soil pH at different stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	8.10	8.10	8.10	7.80	8.10	8.09	7.97	7.64
T1	7.48	7.98	7.73	6.65	7.90	7.62	6.99	7.33
T2	7.13	8.03	7.23	7.25	7.95	5.60	6.33	7.30
T3	8.10	7.98	7.48	7.33	7.77	6.07	6.52	7.06
T4	7.55	7.43	6.75	7.13	7.70	7.81	6.72	7.59
F'- Test	NS	NS	*	*	NS	*	*	NS
C.D.(P=0.05)	1.00	1.02	0.94	0.93	0.99	0.71	0.80	0.89
C.V.%	7.99	7.96	7.75	7.91	7.75	6.15	7.09	7.44

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting
NS: Non significant * Significant at P=0.05

Electrical Conductivity of the soil: The results pertaining to the soil EC as influenced by different treatments during the experimental period is presented in **Table-7 and Figure-1.** The E.C of the soil shown a Progressive increase at all stages and in all the treatments indicating the diminishing influence of sulphur over a period of time.

Table 7: Influence of different levels of Sulphur on the soil EC at different stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	0.20	0.25	0.36	0.36	0.38	0.57	0.62	0.57
T1	0.25	0.25	0.39	0.99	0.83	0.65	1.17	0.70
T2	0.50	0.25	0.48	0.55	0.58	0.91	1.08	0.80
T3	0.17	0.26	0.43	0.56	0.67	0.82	1.19	0.82
T4	0.25	0.41	0.54	0.72	0.62	0.69	1.26	0.85
F'- Test	*	*	*	*	*	*	*	*
C.D.(P=0.05)	0.05	0.03	0.06	0.08	0.09	0.12	0.19	0.11
C.V.%	11.86	7.04	8.21	7.67	8.90	9.98	9.17	8.96

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting.
NS: Non significant * Significant at P=0.05

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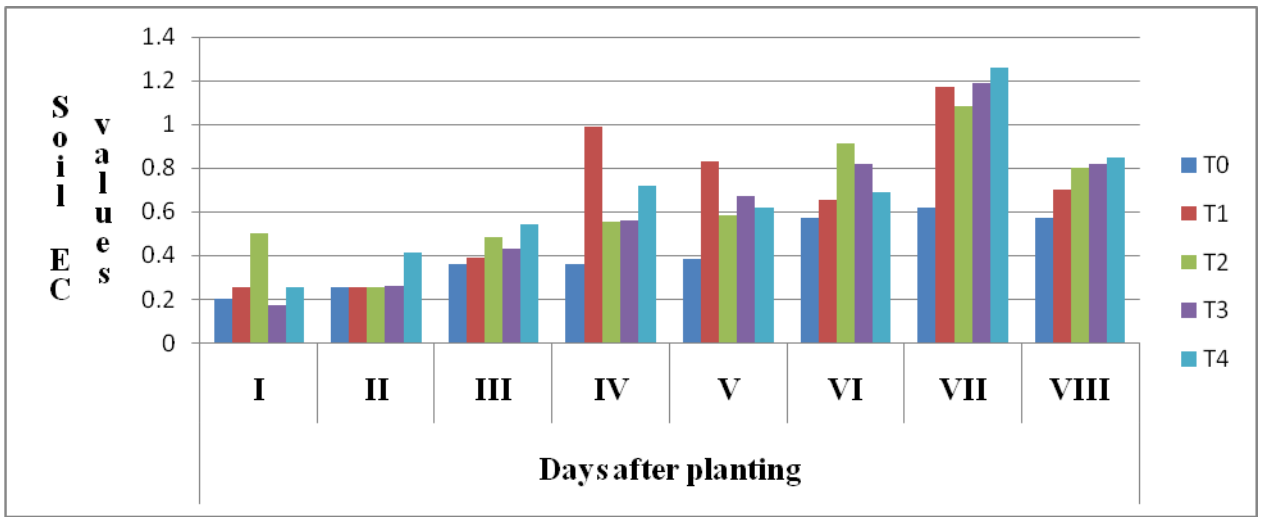

Figure 1: Influence of different levels of Sulphur on the soil EC at different days after planting.

Carbonates and Bicarbonates: The result pertaining to the soil carbonates and bicarbonates as influenced by different treatments during the experimental period is presented in Table-8. The Bicarbonate content of the soil water was also influenced by the treatments.Application of sulphur reduced the bicarbonate content of the soil. It was drastically increased in the third and fourth stages.

Table 8: Influence of different levels of Sulphur on the Carbonates and Bicarbonates (m.eq/lt) at different stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	0.80	0.60	2.40	2.60	0.40	1.20	1.00	0.40
T1	1.40	0.55	2.15	2.00	0.70	0.65	1.15	0.45
T2	1.00	0.40	2.20	2.20	0.55	0.90	1.20	0.55
T3	1.10	0.50	2.20	2.00	0.60	0.90	0.95	0.45
T4	1.05	0.55	2.10	1.95	0.60	0.75	1.00	0.40
F'- Test	NS	*	*	*	*	*	*	*
C.D.(P=0.05)	0.14	0.06	0.28	0.26	0.08	0.12	0.13	0.07
C.V.%	8.20	6.85	7.76	7.44	8.43	8.28	7.79	8.94

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting.
NS: Non significant * Significant at P=0.05

Chlorides: The result pertaining to the soil chlorides as influenced by different treatments during the experimental period is presented in Table-9. Application of Sulphur resulted in increased chloride content up to three stages and again there is a reduction in the chloride content of the soil. The availability of chloride is influenced very little by soil acidity, aeration these factors affect the growth of plant roots

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Table 9: Influence of different levels of Sulphur on the Chlorides (m.eq/lt) at different Stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	14.80	18.00	26.80	24.00	15.20	16.00	15.20	10.00
T1	13.90	17.50	24.00	23.30	13.10	14.00	16.60	13.70
T2	14.90	19.10	26.10	23.00	12.00	15.80	16.20	14.10
T3	14.60	18.10	25.50	23.00	12.00	15.00	15.40	14.50
T4	15.40	17.20	26.50	22.30	11.80	15.20	13.50	15.10
F'- Test	NS	NS	NS	NS	*	*	*	*
C.D.(P=0.05)	1.87	2.38	3.26	2.92	1.49	1.95	2.03	1.92
C.V.%	7.80	8.13	7.77	7.76	7.13	7.87	8.11	8.74

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting.
NS: Non significant * Significant at P=0.05

Calcium and Magnesium: The result pertaining to the soil calcium and magnesium as influenced by different treatments during the experimental period is presented in Table-10. It was observed that Ca and Mg was increased drastically in third, fourth and fifth stages and again there is a significant reduction in the Ca and Mg. Ca tends to loosen soil and Mg tightens it, in a heavy clay soil and improves the water retention.

Table 10: Influence of different levels of Sulphur on the Calcium and Magnesium (m.eq/lt) at different stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	14.40	13.60	26.60	29.80	26.00	30.20	14.80	6.40
T1	15.45	14.90	27.60	32.85	28.50	23.15	15.80	6.45
T2	20.10	15.15	30.45	32.15	33.70	29.55	17.80	7.40
T3	14.40	15.20	31.05	29.15	30.40	25.75	20.50	8.70
T4	14.45	17.35	32.80	30.05	31.60	28.25	15.40	7.70
F'- Test	*	*	*	NS	*	*	*	*
C.D.(P=0.05)	2.23	1.94	4.01	3.84	4.15	3.45	2.69	1.12
C.V.%	8.69	7.83	8.30	7.66	8.49	7.74	9.79	9.38

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting.
NS: Non significant * Significant at P=0.05

Sulphates: The result pertaining to the soil sulphates as influenced by different treatments during the experimental period is presented in Table-11. It was observed that sulphate contents were drastically increased in the third and fourth stages. Acid sulphate soils show the destructive effect on plants and resulted in reduction of productivity through metal contamination of soils

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Table 11: Influence of different levels of Sulphur on the Sulphates (m.eq/lt) at different stages.

Treatment	Days after planting							
	I	II	III	IV	V	VI	VII	VIII
T0	14.04	13.20	25.80	29.29	25.24	29.43	14.38	6.00
T1	15.06	14.51	26.99	32.13	27.81	22.55	15.30	6.07
T2	19.64	13.52	29.88	31.62	33.07	28.93	17.23	6.97
T3	13.93	14.78	30.48	28.67	29.72	25.12	19.96	8.24
T4	14.10	16.86	32.23	29.49	30.92	27.63	14.82	7.28
F'- Test	*	*	*	NS	*	*	*	*
C.D.(P=0.05)	2.17	1.83	3.95	3.78	4.07	3.37	2.62	1.06
C.V.%	8.68	7.72	8.34	7.67	8.52	7.75	9.83	9.43

Note: Stage I, II, III, IV, V, VI, VII, VIII refers to 15, 30, 45, 60, 75, 90, 105, 120 days after planting.
NS: Non significant * Significant at P=0.05

Morphological characters: The crop was harvested at 75 days and 180 days after planting as shown in Table-12. It was observed that plant height was not influenced by the application of sulphur (Table-13 and Figure-2). Number of leaves /plant increased significantly up to 750 kg/ha sulphur application. Beyond that a slight decrease in the number of leaves/plants was noticed (table-38). No. of tillers/plant, plant weight also showed significant increase up to 750 kg/ ha sulphur application. Beyond application of 750 Kg/ha no significant improvement was noticed in case of leaf area and leaf dry weight (Table-14 and Figure-3, Table-15, Table-16 and Figure-4, Table-17, Table-18).

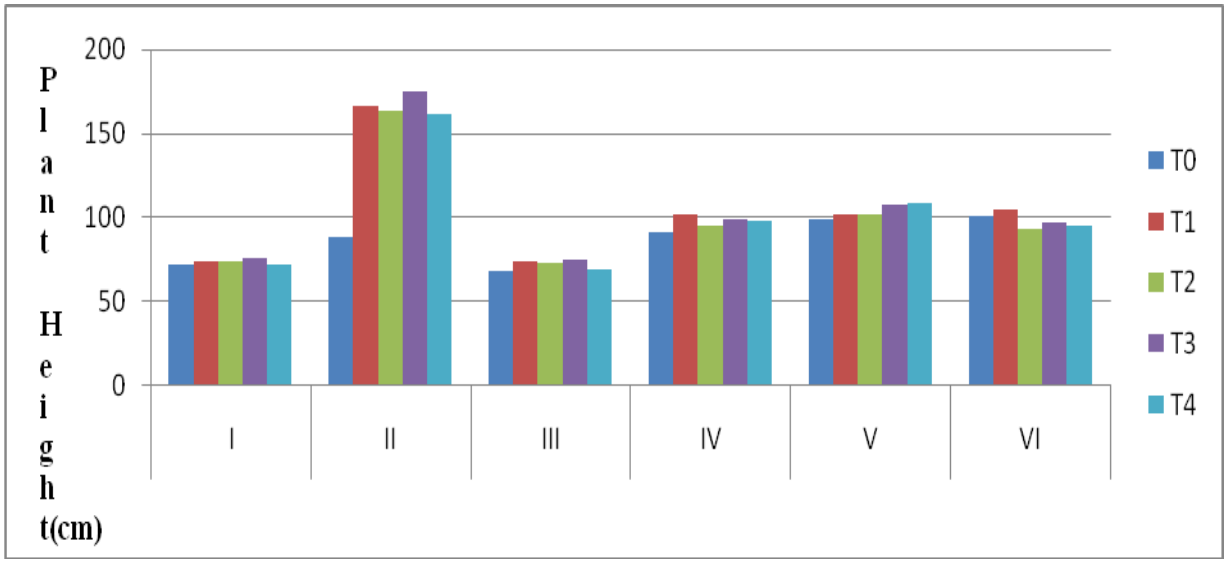

Figure 2: Influence of different levels of Sulphur on the plant height (cm) at different days after planting.

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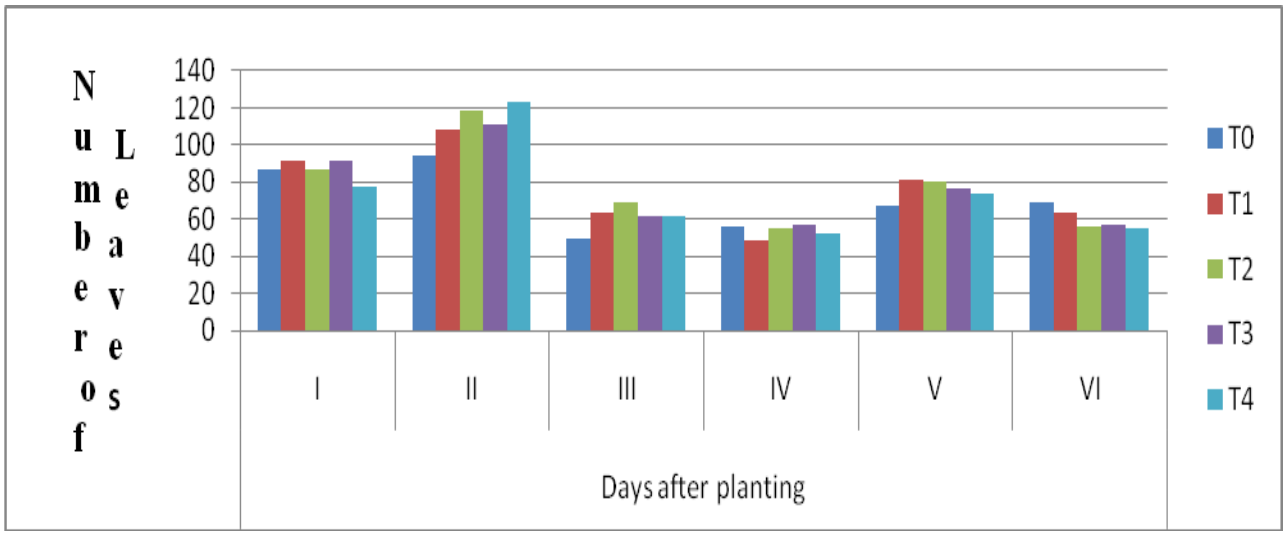

Figure 3: Influence of different levels of Sulphur on the number of leaves at different days after planting.

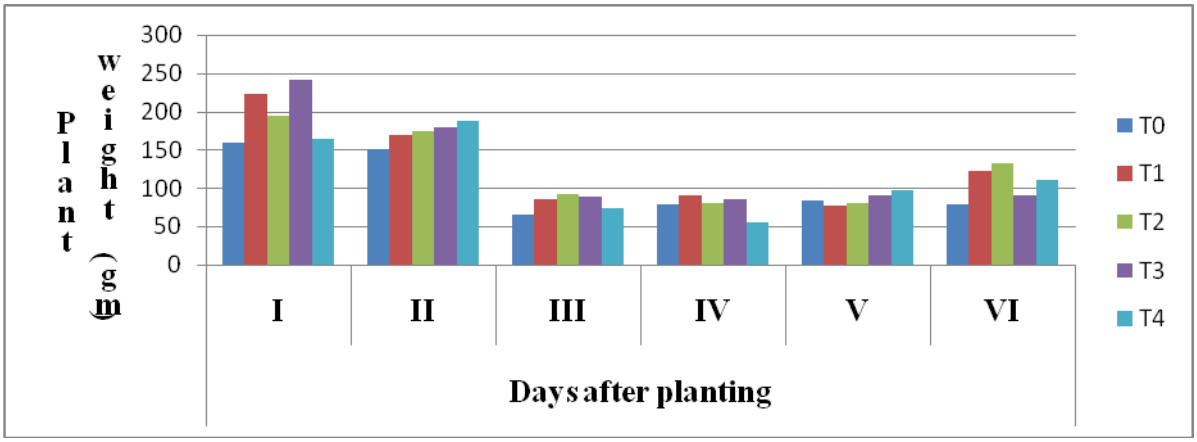

Figure 4: Influence of different levels of Sulphur on the leaf weight (gm) at different days after planting.

Table 12: Crop was harvested at 75 and 180 days after planting.

Treatment	Crop harvest	
	I	II
T_0	13.50	9.50
T_1	20.12	16.97
T_2	19.00	14.65
T_3	22.00	14.07
T_4	19.00	14.65

Note: Stage I & II refers to crop was harvested at 75 and 180 days after planting.

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Table 13: Influence of different levels of Sulphur on the plant height (cm) at different Stages.

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	72.50	88.50	68.50	91.50	99.50	101.00
T1	73.75	166.37	73.75	101.50	102.25	104.62
T2	74.00	163.75	72.75	95.25	101.50	93.25
T3	75.75	174.75	75.37	99.37	108.00	97.00
T4	72.12	161.75	69.37	98.25	109.12	95.37
F'- Test	NS	*	NS	NS	NS	NS
C.D.(P=0.05)	9.67	23.86	9.67	12.58	13.60	12.09
C.V.%	8.07	9.70	8.25	7.95	8.03	7.56

Note: Days after planting 30, 60, 90, 120, 150, 180 NS: Non significant * Significant at P=0.05
Crop harvested at 75 and 180 days after planting

Table 14: Influence of different levels of Sulphur on the number of leaves at different stages.

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	87.00	94.00	49.50	56.00	67.00	69.00
T1	91.75	108.62	63.25	48.25	81.62	63.37
T2	87.00	118.75	68.87	55.12	80.12	55.75
T3	91.37	110.62	61.87	56.62	76.37	56.50
T4	77.25	123.50	62.00	51.87	73.62	55.12
F'- Test	*	*	*	*	*	*
C.D.(P=0.05)	11.69	14.75	8.53	7.29	10.11	6.99
C.V.%	8.27	8.15	8.57	8.36	8.20	7.16

Note: Stage I, II, III, IV, V, VI, refers to 30, 60, 90, 120, 150, 180 days after planting NS: Non significant
* Significant at P=0.05 Crop harvested at 75 and 180 days after planting

Table 15: Influence of different levels of Sulphur on the number of tillers at different stages

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	26.00	19.00	16.50	21.00	22.50	26.00
T1	30.75	29.87	15.12	18.37	19.12	33.00
T2	28.37	39.87	18.75	19.12	18.87	23.75
T3	30.50	37.12	18.00	18.87	23.00	27.50
T4	22.87	32.25	18.25	17.87	21.87	32.87
F'- Test	*	*	*	*	*	*
C.D.(P=0.05)	3.97	5.42	2.39	2.41	2.81	3.31
C.V.%	8.81	10.53	8.47	7.76	8.18	7.10

Note: Stage I, II, III, IV, V, VI, refers to 30, 60, 90, 120, 150, 180 days after planting NS: Non significant
* Significant at P=0.05 Crop harvested at 75 and 180 days after planting

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Table 16: Influence of different levels of Sulphur on the Leaf weight (gm) at different stages.

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	159.50	151.50	65.50	78.50	84.50	79.00
T1	222.12	169.37	85.62	90.25	76.50	122.75
T2	195.25	174.75	91.50	80.25	80.37	132.62
T3	242.12	180.12	89.50	84.87	91.25	89.87
T4	164.37	188.25	73.25	54.75	96.75	111.37
F'- Test	*	*	*	*	*	*
C.D.(P=0.05)	31.49	23.17	12.23	11.20	11.31	14.38
C.V.%	9.83	8.24	9.27	8.85	8.09	8.25

Note: Stage I, II, III, IV, V, VI, refers to 30, 60, 90, 120, 150, 180 days after planting NS: Non significant
* Significant at P=0.05 Crop harvested at 75 and 180 days after planting

Table 17: Influence of different levels of Sulphur on the Leaf area (Sq.cm) at different stages.

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	64.20	42.10	28.70	39.80	48.90	57.90
T1	59.70	40.75	34.05	36.70	44.27	57.95
T2	57.75	44.17	64.10	45.75	48.00	56.52
T3	53.75	46.20	65.45	48.40	47.97	46.02
T4	72.55	47.47	38.95	38.90	47.72	57.32
F'- Test	*	*	*	*	NS	*
C.D.(P=0.05)	6.68	5.88	9.77	6.42	6.13	6.69
C.V.%	6.66	8.19	12.97	9.40	7.95	7.45

Note: Stage I, II, III, IV, V, VI, refers to 30, 60, 90, 120, 150, 180 days after planting NS: Non significant
* Significant at P=0.05 Crop harvested at 75 and 180 days after planting

Table 18: Influence of different levels of Sulphur on the Leaf dry weight (g) at different stages.

Treatment	Days after planting					
	I	II	III	IV	V	VI
T0	45.00	38.00	22.50	23.00	24.00	39.00
T1	54.87	42.25	32.75	20.87	27.50	34.37
T2	54.00	45.62	32.87	19.00	32.00	39.75
T3	48.12	45.00	24.75	23.62	30.37	35.25
T4	40.87	46.87	32.37	25.62	25.37	31.00
F'- Test	*	*	*	*	*	*
C.D.(P=0.05)	7.71	5.79	3.62	2.83	4.17	5.00
C.V.%	9.36	8.24	7.66	7.75	9.20	8.55

Note: Stage I, II, III, IV, V, VI, refers to 30, 60, 90, 120, 150, 180 days after planting NS: Non significant
* Significant at P=0.05 Crop harvested at 75 and 180 days after planting

Plant Height (cms): The results pertaining to the plant height as influenced by different treatments during the experimental period is presented in Table-13 and Figure- 2. The crop was harvested after the second observation. The crop was again harvested after the 6th

observation. An increase in plant height was noticed with sulphur application only upto 500 kg/ha treatment. Thereafter increase in sulphur application did not influence the plant height.

Number of leaves: The results pertaining to the number of leaves as influenced by different treatments during the experimental period is presented in Table-14 and Figure-3. Though there is an increase in plant weight and number of leaves no specific pattern to be observed and the results are in consequential. It also showed the significant increase up to 750 kg/ha of sulphur application.

Number of Tillers: The results pertaining to the number of tillers as influenced by different treatments during the experimental period is presented in Table-15. Number of tillers was significantly higher compared to the control with all levels of sulphur application. It also showed the significant increase up to 750 kg/ha of sulphur application.

Leaf weight (gm): The results pertaining to the leaf weight (gm) as influenced by different treatments during the experimental period is presented in Table-16 and Figure- 4. There is an increase in plant weight but no specific pattern was observed and the results are in consequential. The application of sulphur up to 750 kg/ha had significant effect in increasing the growth character (plant weight) over the control.

Leaf Area (Sq.cm): The results pertaining to the leaf area (Sq.cm) as influenced by different treatments during the experimental period is presented in Table-17. Area of the leaf was calculated by Systronics leaf area meter machine using the 200 sq.cm plate and the values were recorded. No significant improvement was noticed in case of area of the leaf.

Leaf Dry Weight (gm): The results pertaining to the leaf dry weight as influenced by different treatments during the experimental period is presented in Table-18. No significant improvement was noticed in the case of leaf dry weight. The crop was harvested at 75 days and 180 days.

SUMMARY AND CONCLUSIONS

Experiment was conducted to study the influence of Sulphur on the growth of herb (lemongrass). As per the standardization of protocol, the observations and results obtained for the experiment is summarized. Experiment was laid out at the research farm of Central Institute of Medicinal and Aromatic Plants (CIMAP), Research Centre, Boduppal, Uppal, Hyderabad.

The results obtained are summarized here:

- Application of sulphur reduced the pH of the soil.
- Application of sulphur resulted in significant differences in the EC of the soil, but a definite pattern was not observed.
- Application of sulphur reduced the bicarbonate, chloride, calcium and sulphate contents

of the soil. This has resulted in a decrease in the salinity of the soil and improvement in the crop growth.

- Plant height was not influenced by the application of Sulphur. Number of leaves /plant increased significantly up to 750 kg/ha sulphur application. No. of tillers/plant and Plant weight also showed significant increase up to 750 kg/ ha sulphur application.
- No significant improvement was noticed in case of leaf area and leaf dry weight.

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