



## Effect of Different Levels of Sulphur on Growth and Yield of Onion (*Allium cepa* L.) Under Drip Irrigation

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### Authors' contributions

This work was carried out in collaboration between all Authors. Author MMH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KSO and MMY managed the analysis of the study, manuscript writing and literature references. All authors read and approved the final manuscript.

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### ABSTRACT

A Field experiment was conducted to study the effect of different levels of sulphur on growth and yield of onion under drip irrigation on years (2013-2014) at RHREC, College of Horticulture, Bangalore. The experiment was conducted with a Randomized block design with four replications. The treatments comprised of 7 combinations (0, 15, 30, 45, 60, 75 and 90 kg S/ha) in which sulphur was supplied through gypsum. The results indicated significantly higher bulb yield (61.96t ha<sup>-1</sup>) and yield components like average bulb weight, bulb yield per plot and marketable bulb yield was obtained due to application of recommended dosage of fertilizer plus 45 kg S ha<sup>-1</sup>. The growth components viz., plant height, number of leaves, collar thickness and neck thickness showed significant with the application of result in the recommended dosage of fertilizer plus 45 kg S ha<sup>-1</sup>. Compared to other levels of sulphur.

Keywords: Growth; onion; sulphur fertilizer; yield.

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## 1. INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae and has chromosome number  $2n=2x=16$  is one of the important commercial vegetable cum spice crops of India and is widely cultivated throughout the world. Onion is a versatile vegetable crop owing to its utility. It is a cool season, long day and highly cross-pollinated crop. Bulb is the economic part used for consumption.

India is the second-largest producer of onion in the world, but its productivity is much lower (16.41 t/ha) and top ranking countries mostly grow long day onions which enjoy congenial climate and as a result the bulking of onion is very high.

In India, onion is grown in an area of 7.56 lakh hectare with total production of 121.67 lakh tons Anonymous [1]. Maharashtra, Karnataka, Gujrat, Bihar, Madhya Pardesh, Rajasthan, Andhra Pradesh and Tamil Nadu are the main onion growing states. The country's 22 per cent area and 22 per cent production come from Maharashtra alone. In India, 90 percent export of onion is from Maharashtra, out of total production, 60 percent is from *Rabi*, 20 percent *Kharif* and 20 percent from late *Kharif* crop. The productivity in late *Kharif* and *Rabi* is around 25 tons per hectare, whereas in *Kharif* season it is 8 – 10 tons per hectare. Cloudy weather and constant drizzling of rain during *Kharif* season favors disease, bulb rotting leading to low productivity.

The productivity and quality of crops can be enhanced by proper nutrient management. Among the secondary nutrients, sulphur plays a vital role in plant growth and improves the yield of important vegetable crops. Sulphur requirement of crops is almost similar to that of phosphorus. Sulphur is a constituent of secondary compounds viz., alline, cycloalline and thio propanol which not only influence the taste, pungency and medicinal properties of onion besides inducing resistance against pests and diseases.

In this experiment, studies were initiated to find the effect of different levels of sulphur on growth and yield of onion and recommended dosage of fertilizer plus 45 kg S ha<sup>-1</sup> on yield and growth of onion.

## 2. MATERIALS AND METHODS

A field experiment was carried out in sandy loam soil at RHREC, College of Horticulture, Bangalore during *Kharif* season of 2013-14. Seven levels of sulphur fertilizer 0, 15, 30, 45, 60, 75, 90 kg S ha<sup>-1</sup>, were used as treatment variable. The trail comprised seven treatments: T<sub>1</sub> – RDF (control), T<sub>2</sub> – RDF + 15 kg S ha<sup>-1</sup>, T<sub>3</sub> – RDF + 30 kg S ha<sup>-1</sup>, T<sub>4</sub> – RDF + 45 kg S ha<sup>-1</sup>, T<sub>5</sub> – RDF + 60 kg S ha<sup>-1</sup>, T<sub>6</sub> – RDF + 75 kg S ha<sup>-1</sup> and T<sub>7</sub> – RDF + 90 kg S ha<sup>-1</sup>. The experiment was laid out in randomize complete block design with four replications. The unit plot size 3 × 2 m. Fertilizers at the rate of 125 kg N from Urea, 75 kg P<sub>2</sub>O<sub>5</sub> from triple super phosphate (TSP) and 125 kg K<sub>2</sub>O from muriate of potash (MOP) were used as a blanket dose. Sulphur fertilizer was used in the form of gypsum (calcium sulphate) as per treatments. Besides, farm yard manure (FYM) was applied at the rate of 25 t ha<sup>-1</sup>. Full dose of TSP, MOP, Gypsum, FYM and 50% of Urea were applied at final land preparation. Healthy and disease free 40 days old seedlings of onion (Cv. Arka kalyan) were transplanted during the third week of August at a spacing of 15 × 10 cm. The remaining 50% of urea were applied 30 days after transplanting (DAT) followed by irrigation. The plots were fixed with drip pipes system and irrigated 1-2 days interval depending on climatic condition.

The crop was harvested on first week of January 2014 when the plant attained to maturity and showing drying up of most of the leaves and bending over. Harvesting was done with help of a Godli. Care was taken to avoid any kind of bulb injury during lifting.

### 2.1 Statistical Analysis

Data of plant height, number of leaves, collar thickness, neck thickness, polar diameter of bulb, equatorial diameter of bulb, number of rings per bulb, average bulb weight, bulb dry weight, bulb yield, total bulb yield and marketable bulb yield were subjected to statistical analysis (ANOVA) using SAS statistical package [2]. The DMTR test was used for mean separations of the studied parameters.

## 3. RESULTS AND DISCUSSION

The data pertaining to plant height as influenced due to different levels of sulphur showed a significant variation at 30, 60 and 90 days after

transplanting during *Kharif* (Table 1 and Fig. 1). Plant height gradually increased with increase in levels of sulphur up to 45 kg S ha<sup>-1</sup> beyond which it decreased. The tallest plant (19.35, 22.45 and 23.38 cm) was recorded in T<sub>4</sub> – 45 kg S ha<sup>-1</sup>, which was statistically significant on par to that recorded in T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (17.75, 21.67 and 22.73). The shortest plants (14.70, 18.84 and 19.28 cm) were found in T<sub>1</sub> – RDF (control). Increased plant height with different levels of sulphur was also reported by Jaggi [3] and Channagoudra [4].

The data pertaining to numbers of leaves per plant as influenced by different levels of sulphur at 30, 60 and 90 DAT differed significantly during *Kharif* 2013 (Table 1). At 30 DAT, T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded a significantly maximum number of leaves per plant (8.38) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (7.50) followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (7.20), whereas T<sub>1</sub> – control recorded the minimum (5.75) number of leaves. At 60 DAT, T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded a significantly higher number of leaves (9.90) which was on par with T<sub>3</sub> – 30 kg ha<sup>-1</sup> S (9.30) followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (8.75) and T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (8.63), while T<sub>1</sub> – control recorded lowest number of leaves (8.10). At 90 DAT, T<sub>4</sub> – 45 kg S ha<sup>-1</sup> produced significantly highest number of leaves (10.88) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (9.43) and T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (9.30), followed by T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (9.15), whereas T<sub>1</sub> – control produced lowest number of leaves (8.88).

With respect to collar thickness at harvest differed significantly as influenced due to the different levels of sulphur. The T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded the highest bulb collar thickness (1.47 cm) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (1.41 cm), followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (1.36 cm). The lowest collar thickness was observed in T<sub>1</sub> – control (1.21 cm) (Table 1).

The data pertaining to neck thickness after curing differed significantly as influenced by different levels of sulphur. T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded the maximum neck thickness (0.73 cm) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (0.70 cm) and T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (0.67 cm) followed by T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (0.58 cm), while the T<sub>1</sub> – control recorded the minimum neck thickness (0.53 cm) (Table 1).

These results may be due to the application of sulphur helps in the availability of other nutrients resulting in better growth and increased uptake of all the nutrients at higher levels of sulphur. Similar results have also been reported by Dabhi et al. [5], Jaggi [3] and Nasreen et al. [6].

### 3.1 Yield Parameters

The data pertaining to polar diameter of bulb produced as influenced by different levels of sulphur differed significantly during *Kharif*. The results revealed that, the highest polar diameter of bulb was recorded in treatment T<sub>4</sub> – 45 kg S ha<sup>-1</sup> (7.23 cm) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (6.90 cm) and T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (6.88 cm), followed by T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (6.85 cm), whereas the T<sub>1</sub> – control recorded the lowest (5.55 cm) polar diameter of bulb (Table 2).

The data pertaining to the equatorial diameter of bulb produced as influenced due to different levels of sulphur differed significantly during *Kharif*. The results revealed that, the highest equatorial diameter of bulb was recorded in treatment T<sub>4</sub> – 45 kg S ha<sup>-1</sup> (6.28 cm) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (5.90 cm) and T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (5.83 cm), followed by T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (5.68 cm), whereas T<sub>1</sub> – control recorded the least (4.95 cm) equatorial diameter of bulb (Table 2).

Significant differences were observed for number of rings per bulb among the different levels of sulphur evaluated. Among the different levels of sulphur the maximum number of rings per bulb was recorded in case of T<sub>4</sub> – 45 kg S ha<sup>-1</sup> (7.92) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (6.88) and T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (6.82), followed by T<sub>6</sub> – 75 kg S ha<sup>-1</sup> (6.79), while T<sub>1</sub> – control recorded the minimum number of rings per bulb (6.00) (Table 2).

The increase in yield was mainly because of a positive association between yield and yield attributing characters like bulb polar diameter, bulb equatorial diameter, number of rings per bulb and bulb weight differed significantly. Previous studies also reported significant variation with respect to bulb polar diameter, bulb equatorial diameter, number of rings per bulb and bulb weight due to the application of different levels of sulphur. Nandi et al. [7,8,5,9,3,10,6,11,12] and [13] are reported similar trends.

The data pertaining on bulb weight produced as influenced by different levels of sulphur differed significantly during *Kharif*. The T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded the maximum average bulb weight (88.88 g) which was on par with T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (85.65 g) and T<sub>7</sub> – 75 kg S ha<sup>-1</sup> (84.75 g), followed by T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (82.66 g). While T<sub>1</sub> – control registered the minimum bulb weight (74.64 g) (Table 3).

### 3.2 Average Bulb Dry Weight (g)

The dry matter accumulation in bulb was significantly influenced by different levels of sulphur. Application of sulphur at the rate of 45 kg S ha<sup>-1</sup> recorded maximum dry matter accumulation in bulb (14.35 g bulb<sup>-1</sup>) which was on par with T<sub>3</sub>– 30 kg S ha<sup>-1</sup> (13.39 g bulb<sup>-1</sup>), followed by T<sub>5</sub>– 60 kg S ha<sup>-1</sup> (13.02 g bulb<sup>-1</sup>). Whereas T<sub>1</sub> – control recorded the minimum dry matter accumulation in bulb (9.91 g) per bulb.

The data pertaining bulb yield per plot produced as influenced by different levels of sulphur differed significantly during *Kharif*. The bulb yield per plot was found to be highest in treatment T<sub>4</sub> – 45 kg S ha<sup>-1</sup> (37.18 kg plot<sup>-1</sup>) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (35.83 kg plot<sup>-1</sup>), followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (35.15 kg plot<sup>-1</sup>), whereas the T<sub>1</sub> – control recorded the lowest (29.40 kg plot<sup>-1</sup>).

The results revealed that, there was a significant difference among the different levels of sulphur with respect to total bulb yield per hectare during *Kharif*. Among the different levels of sulphur T<sub>4</sub> – 45 kg S ha<sup>-1</sup> recorded the maximum estimated total bulb yield per hectare (61.96 t ha<sup>-1</sup>) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (59.71 t ha<sup>-1</sup>), followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (58.58 t ha<sup>-1</sup>), while

the T<sub>1</sub> – control registered the minimum total bulb yield (49.00 t ha<sup>-1</sup>).

The results revealed that, there was a significant difference among the different level of sulphur treatment concerning marketable bulb yield per hectare during *Kharif*. The maximum marketable bulb yield was recorded in T<sub>4</sub> – 45 kg S ha<sup>-1</sup> (59.06 t ha<sup>-1</sup>) which was on par with T<sub>3</sub> – 30 kg S ha<sup>-1</sup> (56.46 t ha<sup>-1</sup>), followed by T<sub>5</sub> – 60 kg S ha<sup>-1</sup> (55.28 t ha<sup>-1</sup>), whereas the T<sub>1</sub> – control recorded the lowest (45.27 t ha<sup>-1</sup>).

The highest yield of bulbs could be due to different levels of sulphur which can be attributed to maximum plant height and number of leaves which are important component of growth which resulted in accumulation of maximum photosynthesis in the bulb and also better percentage plant establishment which is directly proportional to number of bulbs produced. Apart from these, it may be related to increased uptake of N, P, K and S by the crop to maximum bulb polar diameter, bulb equatorial diameter, number of rings per bulb and bulb weight which are major yielding contributing components. Similar results were also reported in onion crop by Nasreen et al. [14], Sankaran et al. [15], Mishu et al. [13] and Jaggi [3] who also recorded a significantly higher bulb yield of onion due to application of sulphur.

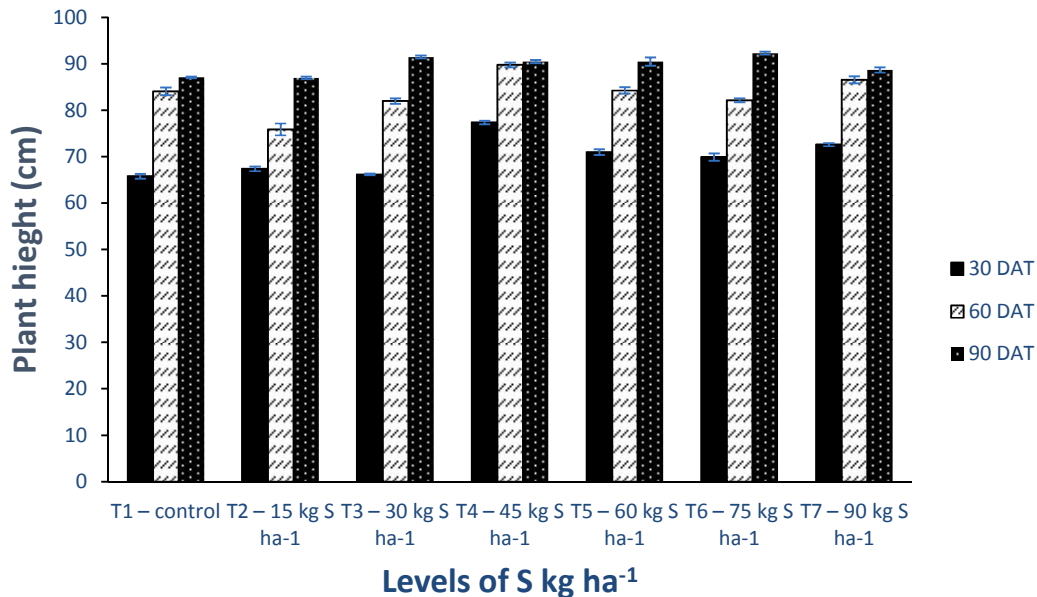


Fig. 1. Effect of different levels of sulphur on plant height (cm) of onion at 30, 60 and 90 DAT under drip

**Table 1. Effect of different levels of sulphur on plant height (cm), number of leaves per plant at different stages of crop growth, collar thickness at harvest and neck thickness after curing under drip irrigation**

Treatments	Plant height (cm)			Number of leaves			Collar thickness (cm)	Neck thickness (cm)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT		
T <sub>1</sub> – RDF (control)	14.70	18.84	19.28	5.75	8.10	8.88	1.21	0.53
T <sub>2</sub> – RDF +15 kg S ha <sup>-1</sup>	16.44	20.13	21.33	7.08	8.50	9.05	1.38	0.62
T <sub>3</sub> – RDF + 30 kg S ha <sup>-1</sup>	17.75	21.67	22.73	7.50	9.30	9.43	1.41	0.70
T <sub>4</sub> – RDF + 45 kg S ha <sup>-1</sup>	19.35	22.45	23.38	8.38	9.90	10.88	1.47	0.73
T <sub>5</sub> – RDF + 60 kg S ha <sup>-1</sup>	17.49	20.79	21.43	7.20	8.75	9.3015	1.36	0.67
T <sub>6</sub> – RDF + 75 kg S ha <sup>-1</sup>	16.55	20.55	21.17	7.13	8.63	9.15	1.25	0.58
T <sub>7</sub> – RDF + 90 kg S ha <sup>-1</sup>	16.00	19.77	20.68	7.05	8.25	9.03	1.24	0.55
S Em±	0.472	0.673	0.778	0.336	0.315	0.343	0.054	0.042
CD at 5%	1.402	2.000	2.281	0.999	0.936	1.020	0.160	0.125
CV (%)	5.59	6.54	7.17	9.40	7.18	7.31	8.11	13.48

DAT: Days After Transplanting, RDF: Recommended Dosage of Fertilizer

**Table 2. Effect of different levels of sulphur on polar diameter of bulb, equatorial diameter of bulb and number of rings per bulb of onion at harvest under drip irrigation**

Treatments	Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Number of rings per bulb
T <sub>1</sub> – RDF (control)	5.55	4.95	6.00
T <sub>2</sub> – RDF +15 kg S ha <sup>-1</sup>	6.70	5.40	6.78
T <sub>3</sub> – RDF + 30 kg S ha <sup>-1</sup>	6.90	5.90	6.88
T <sub>4</sub> – RDF + 45 kg S ha <sup>-1</sup>	7.23	6.28	7.92
T <sub>5</sub> – RDF + 60 kg S ha <sup>-1</sup>	6.88	5.83	6.82
T <sub>6</sub> – RDF + 75 kg S ha <sup>-1</sup>	6.85	5.68	6.79
T <sub>7</sub> – RDF + 90 kg S ha <sup>-1</sup>	6.55	5.25	6.76
S Em±	0.257	0.254	0.250
CD at 5%	0.763	0.755	0.742
CV (%)	7.70	9.06	7.30

RDF: Recommended Dosage of Fertilizer

**Table 3. Effect of different levels of sulphur on yield and yield attributes of onion under drip irrigation**

Treatments	Av. bulb weight (g)	Av. bulb dry weight(g)	Bulb yield (Kg plot <sup>-1</sup> )	Total bulb yield (t ha <sup>-1</sup> )	Marketable bulb yield(t ha <sup>-1</sup> )
T <sub>1</sub> – RDF (control)	74.64	9.91	29.40	49.00	45.27
T <sub>2</sub> – RDF +15 kg S ha <sup>-1</sup>	78.25	11.40	31.66	52.75	49.15
T <sub>3</sub> – RDF + 30 kg S ha <sup>-1</sup>	82.66	13.39	35.83	59.71	56.46
T <sub>4</sub> – RDF + 45 kg S ha <sup>-1</sup>	88.88	14.35	37.18	61.96	59.06
T <sub>5</sub> – RDF + 60 kg S ha <sup>-1</sup>	85.65	13.02	35.15	58.58	55.28
T <sub>6</sub> – RDF + 75 kg S ha <sup>-1</sup>	84.75	12.40	34.33	59.21	55.76
T <sub>7</sub> – RDF + 90 kg S ha <sup>-1</sup>	82.25	12.32	32.72	54.53	51.03
S Em±	2.913	0.499	1.353	1.972	2.055
CD at 5%	8.654	1.483	4.019	5.860	6.104
CV (%)	7.07	8.05	8.02	6.98	7.73

RDF: Recommended Dosage of Fertilizer

#### 4. CONCLUSION

From the discussion, it can be concluded that for getting higher yield from the onion, it is advisable to apply 45 kg Sulphur ha<sup>-1</sup> with the recommended dose of fertilizers as basal application on soil.

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The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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