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Influence of sulphur on growth and yield of garlic (*Allium sativum* L.)

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Abstract
The experiment was conducted at Main Agricultural Research Station, UAS, Dharwad during *rabi* season of 2014-15 to study the effect of sulphur on productivity of garlic. Plant height (43.71 cm), no. of leaves per plant (7.25), bulb diameter (36.27 mm), no. of cloves/ bulb (21.75), 10 cloves weight (10.23 gm) and avg. bulb weight (11.75 gm) increased significantly with the application of 60 kg of S/ha (T_5) and marketable yield (5.19 t/ha), total yield (5.79 t/ha) were also recorded numerically higher values and net returns in the same treatment. From this study it is observed that foliar application of 60 kg of S/ha improved crop growth and productivity in garlic.

Keywords: sulphur, *Allium sativum* L, foliar application, growth and productivity

1. Introduction
Garlic (*Allium sativum* L.) is the second most important spice crop next to the onion and belongs to family *Alliaceae*. (Bose and Som, 1990) [6]. It is used for curing human diseases (Augustis, 1997, Durak, 2004 and Pitman, 2008) [7, 16]. In garlic the flavour is due to the presence of chemical content *diallyl disulphide*. Sulphur is an essential plant nutrient and its role in balanced fertilization and consequently in crop production is being increasingly appreciated. Sulphur is the fourth major plant nutrient after nitrogen, phosphorus and potassium. It is essential for synthesis of amino acids like cystine, cystiene and methionine a component of vitamin A and activates certain enzyme systems in plants (Havlin *et. al.*, 2004). Continuous removal of sulphur from soil by plant led to widespread to deficiency and affected soil sulphur budget (Aulukh, 2003) all over the world. Sulphur application in garlic enhances the uptake of NPK and Ca by the crop (Hossain, 1997) [10]. Report is available that apart from NPK fertilizer sulphur can play a vital role in increase in yield of garlic (Ahmed *et.al.*, 1998). Plant height, number of leaves per plant, cloves per bulb, diameter and weight of bulb and bulb yield increased with the application of sulphur (Nasrin *et. al*., 2007) [14]. Alam (1995) [2] stated that sulphur played an important role increasing yield by increasing the number of leaves per plant, plant height, number of cloves per bulb and fresh and dry weight of bulb. Therefore, the present investigation was undertaken to study the impact of sulphur application on growth and yield of garlic.

Materials and methods
The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad and is located in the Northern transitional zone of Karnataka and located at 15^0 26 North latitude, 75^0 27 East longitude with an altitude of 678 m above mean sea level. The experiment was conducted under the All India Network Research Project on Onion and Garlic by using garlic DWDG-1 variety during *Rabi* season of 2014-15. Before treatment imposition soil samples and analyzed for chemical properties and composite nutrient status. The soil was low in available nitrogen (224.6 kg/ha), sufficient in available of phosphor (19.3 kg/ha) and medium available of potash (19.3 kg/ha).
The experiment was laid out a randomized block design with six treatments replicated four times. The treatment included 6 levels of sulphur T_1: Control, T_2: 15 kg/ha S, T_3:30 kg/ha S, T_4: 45 kg/ha S, T_5: 60 kg/ha S, T_6: 75 kg/ha S. replicated four times. The cloves were directly sown in the experimental plots at a spacing of 10cm X 15cm on November 2014, after imposition of treatments and recommended NPK was common for all the treatments and the crop was raised as per the recommended package of practices. Five plants were selected randomly from each plot as unit for all observations on growth and yield. Statistical analysis was done using standard procedure given by Panse and Sukhatme (1978) [15]

Results and Discussion

Different sulphur treatments significantly influenced growth in garlic. Plant height in control was 37.62 cm and increased due to application of graded levels of sulphur and the highest value was recorded in T_5 with 60 kg S ha^{-1} sulphur (43.71 cm) and was significantly superior to all the treatments except T_6. Similarly, T_4 (40 kg S ha^{-1}) is significantly superior to T_2 and control but at par with T_3. Similarly significantly highest number of leaves (7.25) was recorded in T_5 with 60 kg S ha^{-1} and T_4 bring on par with T_3 differed significantly to T_2 and control. Bulb diameter in garlic differed significantly due to sulphur levels. It was 33.06 mm in control and increased to 36.27 in T_5 with 60 kg S ha^{-1} and was significantly superior to all the treatments except T_6. Similarly, 10 cloves weight and average bulb weight were also highest under T_6 (10.23 g and 12.70 g respectively) and the control recorded the lowest values. In general, there was successive improvement is growth and yield attributing characters in garlic is due to greaded levels of application of sulphur increased both marketable bulb yield and total bulb yield and the highest values were recorded in the treatment receiving sulphur at 60 kg S ha^{-1} (5.19 t/ha and 5.79 t/ha respectively). However, there was statistical purity among the treatments and similar studies were done by Farooqui *et al.* (2009) [8] and the results coincided with the present study *i.e.,* plant height, number of leaves, bulb diameter, number of cloves per bulb, bulb weight and bulb yield were higher in plots treated with 60 kg S ha^{-1}. Hove *et al*, (2014) also made similar observations. The improvement in growth characters with the application of sulphur might be due to its role in the synthesis of chlorophyll (Naigaich *et.al*, 1999). Sulphur is an essential plant nutrient, its role in balanced fertilization and consequently in crop production is being realized in recent times. It performs many physiological functions like synthesis of sulphur containing amino acids. Overall increase in growth attributes of crop may be due to higher availability of sulphur in the rhizosphere system of the plants which might have resulted in increased uptake of nutrients and were used in photosynthesis. Randle (1992) [17], Randle and Bussard (1993) [18], Sadarea *et al*. (1997) [19], Alam *et al*. (1999) [3], Jaggi and Dixit (1999) [12] and Jaggi (2005) also found similar results.

The data on economics of garlic as influenced by graded levels of sulphur application (Table.2) revealed that application of 60 kg S ha^{-1} to garlic resulted in the highest gross (Rs. 463200.00) and net (Rs. 366796.00) returns. This was mainly caused due to higher marketable yield recorded in this treatment. The lowest values were recorded in control with no sulphur application. In Chile, Ruiz (1986) reported improvement in economics in garlic due to graded levels of sulphur application.

Table 1: Effect of different levels of sulphur on growth and yield of garlic.

Treatment	Plant height (cm)	No. leaves per plant	Bulb diameter (mm)	No. cloves/bulb	10 Cloves weight (g)	Avg. bulb weight (g)	MBY (t/ha)	TBY (t/ha)
T_1 (0 kg/ha)	37.62	4.50	33.06	15.50	6.79	9.18	4.38	4.85
T_2 (15 kg/ha)	39.36	4.50	33.59	16.75	7.70	9.42	4.43	4.84
T_3 (30 kg/ha)	40.43	5.50	34.22	18.25	9.05	11.34	4.58	5.12
T_4 (45 kg/ha)	40.37	5.00	33.16	17.75	8.67	10.21	4.68	5.23
T_5 (60kg/ha)	43.71	7.25	36.27	21.75	10.23	12.70	5.19	5.79
T_6 (75 kg/ha)	41.76	6.00	35.54	19.00	9.07	11.75	4.79	5.40
SEM±	0.66	0.36	0.45	0.61	0.19	0.13	0.34	0.38
CD (0.05)	1.98	1.09	1.35	1.85	0.58	0.37	1.05	1.16

MBY: Marketable Bulb Yield TBY: Total Bulb Yield

Table 2: Effect of different levels of sulphur on economics in garlic.

Treatment	Cost of cultivation (Rs/ha)	Yield (t/ha)	Gross income (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1 (0 kg/ha)	83204.5	4.85	3,88,000	3,04,796	3.66
T_2 (15 kg/ha)	86504.5	4.84	3,87,200	3,00,696	3.48
T_3 (30 kg/ha)	89804.5	5.12	4,09,600	3,19,796	3.56
T_4 (45 kg/ha)	93104.5	5.23	4,18,400	3,25,296	3.49
T_5 (60kg/ha)	96404.5	5.79	4,63,200	3,66,796	3.80
T_6 (75 kg/ha)	99704.5	5.40	4,32,000	3,32,296	3.33

Conclusion

It could be inferred from the results of the above studies that garlic responds to sulphur. Application of 60 kg S ha^{-1} found advantageous for achieving higher productivity and net returns.

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