

### **Effect of Sulphur and Micronutrients on the Yield and Quality of Garlic (*Allium sativum* L.)**

#### **ABSTRACT**

The field experiment was conducted at the Horticulture Farm, Sri Karan Narendra College of Agriculture, Jobner, Jaipur (Rajasthan) to find out the effect of sulphur and micronutrients on yield and quality of garlic during *Rabi* seasons 2019-20 and 2020-21. The experiment was carried out in factorial randomized block design with three replications and twenty treatment combinations with four levels of sulphur (S<sub>0</sub>-control, S<sub>1</sub>-sulphur 20 kg/ha, S<sub>2</sub>-sulphur 40 kg/ha and S<sub>3</sub>-sulphur 60 kg/ha) and five levels of micronutrients (M<sub>0</sub>-Control, M<sub>1</sub>-zinc sulphate @ 0.6%, M<sub>2</sub>-ferrous sulphate @ 0.2%, M<sub>3</sub>-borax @ 0.5 and M<sub>4</sub>-Ammonium molybdate @ 0.5%). The sulphur was applied as soil application just before sowing and micronutrients (Zn, B, Fe and Mo) as foliar spray at 40 days after sowing. Recommended dose of inorganic fertilizers applied uniformly in whole experimental area. The results of the study have clearly indicated that among sulphur levels, application of sulphur 60 kg/ha significantly improved yield and quality parameters *viz.*, average weight of clove, average weight of bulb, bulb yield per plot, per hectare, nitrogen content, phosphorus content, potassium content and sulphur content in bulb enhanced significantly by application of sulphur 60 kg/ha (S<sub>3</sub>) in both the years as well as in pooled analysis. Although, sulphur application at 40 kg/ha along with foliar application of zinc at 0.6 % was found at par to it. Similarly, among micronutrients foliar application of zinc sulphate @ 0.6% significantly influenced all the yield and quality parameters *viz.*, average weight of clove, average weight of bulb, bulb yield/plot, bulb yield/hectare, nitrogen content, phosphorus content, potassium content and sulphur content in bulb of garlic in both the years as well as in pooled analysis.

**Keywords:** *Garlic, Sulphur, Micronutrients, garlic yield, garlic quality.*

#### **1. INTRODUCTION**

Garlic is an important vegetable crop in bulbous group used throughout India primarily as a spice or condiment. Botanically it is *Allium sativum* belonging to the family Alliaceae. It is originated from Central Asia and later spread to Mediterranean region Simon, W. [1] and

Kigori, J.M. [2]. The bulb of garlic is compound in nature, consisting of numerous bulblets, so called as cloves. These cloves are different in size and whole cloves is surrounded by layers of white scale leaves. Allicin is the main biologically active component of freshly crushed garlic cloves, which is produced by the degradation of alliin, from results of alliinase activity Bocchini, P. *et al.* [3] and Rahman, M.M. *et al.* [4]. Garlic having several medicinal properties including anti-inflammatory activity, antiplatelet aggregation and inhibits cholesterol synthesis. Moreover, it has long been known to have antibacterial, antifungal, anticancer, antioxidant and antiviral activities Lawrence, R. and Lawrence [5].

Besides, garlic also possesses insecticidal properties. The juice of garlic along with chilli and ginger has effective for controlling the soil nematodes. Beneficial use of garlic extract has also been found against many fungi and bacteria Panday, U.B. [6]. Garlic oil or its juice is recommended to many diseases like (inhale in cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and eyes redness) Pruthi, J.S. [7]. Garlic contains volatile oil known as diallel-disulphide which is the major flavouring component in garlic. Garlic has higher nutritive value as compared to other bulbous crops. It is a rich source of sugar, protein, fat, potassium, calcium, sulphur, phosphorus, fiber and iodine. Per hundred gram of edible portion of garlic contains 59 % moisture, 6.4 g protein, 1469 k cal energy, 0.5 g fats, 33.1 g carbohydrates, 1.5 g fiber, 181 mg Ca, 153 mg P, 1.7 mg Fe, 17 mg Na, 401 mg K, 0.08 mg riboflavin, 0.25 mg thiamine, 0.06 mg nicotinamide and 10.8 mg ascorbic acid Lorenz, O.A. and D.N. Maynard [8].

Deficiency of micronutrients during the last three decades has become a major constraint to production and productivity of vegetables in general and garlic in particular. Thus, there is an urgent need for correction of individual nutrient deficiency and for arresting its further spread. The lower productivity of Indian garlic is primarily due to cultivation of low yield potential varieties, susceptibility to both biotic and abiotic factors. Therefore, imbalanced nutrition is treated as one of the major abiotic factors which adversely affects growth and yield of garlic.

The foliar application of micronutrients reduces the cost of owing to the lesser requirement of nutrients and better absorption through the foliage. It has been observed that application of micronutrients are important in enhancing the translocation of carbohydrates from the site of synthesis to the storage organ. Among the macronutrients, sulphur is one of a major plant nutrient essential for building up sulphur containing amino acids namely cystine,

cysteine & methionine and is involved in synthesis of protein and sulphur containing vitamins like biotin, thiamine and some coenzymes.

Keeping these points in view, foliar application of boron, zinc, iron and molybdenum as micronutrients and basal doses of sulphur as a macronutrient were used in the experimental crop to study the impact on growth, yield and storage of garlic.

## **2. MATERIALS AND METHODS**

### **2.1 LOCATION OF EXPERIMENTAL SITE**

The experiment was conducted at Horticulture farm, Sri Karan Narendra College of Agriculture, Jobner, District-Jaipur, State-Rajasthan, Country-India during *Rabi* season 2019-20 and 2020-21. Geographically, Jobner is situated 45 km in West of Jaipur at 26°5' North latitude, 75°20' East longitude and at an altitude of 427 meters above mean sea level. This region falls under Agro-Climatic Zone-III A (Semi- Arid Eastern Plain Zone) of Rajasthan.

### **2.2 CLIMATE AND WEATHER**

Jobner region belong to semi-arid region characterized by extremes of temperature both in summer and winter, rainfall is low and relative humidity is moderate. The annual average rainfall varies between 250 to 500 mm, most of which is received in rainy season fall during July to early September, sporadic showers also received in winters. The maximum temperature ranges from 30 to 46°C during month of May and June, while in December and January, it falls down below -1°C and evaporation ranges from 1.2-6.9 mm per day.

### **2.3 SOIL CHARACTERISTICS OF EXPERIMENTAL FIELD**

To know the fertility status and other physical constraints of soil, samples were taken and analyzed in the department of Soil Science and Agricultural Chemistry, Sri Karan Narendra College of Agriculture, Jobner to evaluate physico-chemical characteristics of the soil before experimentation. Before applications of manures and fertilizers the soil samples (0-15 cm depth) were taken from different locations of the experimental field. The sample was prepared by mixing the soil and then analysed for physical and chemical properties of soil. The experimental site was sand loamy in texture, slightly alkaline in reaction, poor in organic carbon with low available N, P & S and medium in K content. The underground water used for irrigation is partially saline in nature.

### **2.4 Quality of irrigation water**

The sample irrigation water was taken from tube well of horticulture farm, Sri Karan Narendra College of Agriculture, Jobner and analysed in the department of soil science of S.K.N. College of Agriculture, Jobner. The irrigation water falls under class C<sub>3</sub>S<sub>1</sub> to USDA Hand Book No. 60. The pH and EC were found to be 7.75 and 7.68 and 1.01 and 1.02 ds/m in the year 2019-20 and 2020-21 respectively. The water of Jobner location is little but saline in nature.

## **2.5 Treatments and design**

A field experiment was laid out during *Rabi* season of 2019-20 and 2020-21 in factorial randomized block design with twenty treatment combinations viz., (S<sub>0</sub>-control, S<sub>1</sub>-sulphur 20 kg/ha, S<sub>2</sub>-sulphur 40 kg/ha and S<sub>3</sub>-sulphur 60 kg/ha, M<sub>0</sub>-Control, M<sub>1</sub>-zinc sulphate @ 0.6%, M<sub>2</sub>-ferrous sulphate @ 0.2%, M<sub>3</sub>-borax @ 0.5 and M<sub>4</sub>-Ammonium molybdate @ 0.5%) and three replications. The sulphur was applied as a basal dose before sowing and micronutrients (Zn, B, Fe and Mo) as foliar spray. Recommended dose of inorganic fertilizers applied uniformly in whole experimental area.

## **2.6 Crop Management**

The experimental land was prepared by ploughing and double harrowing to bring it to the fine tilth. Farm yard manure was applied at the rate of 25 t/ha before final harrowing and incorporated into the soil one week before sowing. The plots of required size were prepared. Bunds, irrigation channels and roads were laid out as per the plan. The seeds of cv. G -282 procured from National Horticultural Research & Development Foundation in Karnal, (Haryana). The garlic cloves was treated with Carbendazim @ 2 g/kg seed to control seed borne diseases. The seeds were sown on 16<sup>th</sup> October, 2019 and 22<sup>th</sup> October, 2020 manually with a seed rate of 500 kg /ha in row at 15 cm apart.

## **2.7 STATISTICAL ANALYSIS**

The field experimental data recorded for growth, yield, quality and storage parameters were subjected to statistical analysis in accordance with the 'Analysis of variance' technique suggested by Fisher. The critical difference was calculated wherever the difference was found significant. Assuming homogeneity in the experimental data of two years, pooled analysis was done. The analysis of variance of different components for all parameters discussed is given in the annexures at the end.

# **3. RESULTS AND DISCUSSION**

## **3.1 Effect of Sulphur on yield parameters**

The perusal of data in the table (1, 2 and 3) reveals that all the sulphur levels (20, 40 and 60 kg ha<sup>-1</sup>) significantly increased the average weight of clove, average weight of bulb, bulb yield/plot and bulb yield/hectare as compared to control during both the years and in pooled mean. The maximum average weight of clove (1.50, 1.47 and 1.48g), average weight of bulb (26.82, 25.00 and 25.91g), bulb yield/plot (3.22, 3.00 and 3.11 kg/plot) and bulb yield/hectare (178.77, 166.64 and 172.71 q/ha) was recorded with 60 kg S ha<sup>-1</sup> that was at par with 40 kg S ha<sup>-1</sup>. Where as the minimum average weight of clove (1.30, 1.28 and 1.29 g), average weight of bulb (20.82, 19.93 and 20.37 g), bulb yield per plot (2.50, 2.39 and 2.44 kg/plot) and per hectare (138.77, 132.88 and 135.83 q/ha) was recorded with control.

The yield attributing characters namely average weight of clove, average weight of bulb and bulb yield/plot and bulb yield/hectare increased significantly with the application of sulphur (S<sub>3</sub>) sulphur @ 60 kg/ha over control. Pooled mean basis, the maximum values of yield and yield attributes *i.e.*, average weight of clove (1.48 g), average weight of bulb (25.91 g), bulb yield per plot (3.11 kg/plot) and bulb yield per hectare (172.71 q/ha) were recorded with application of 60 kg S/ha (S<sub>3</sub>) which at par with 40 kg S/ha (S<sub>2</sub>) and minimum under control (S<sub>0</sub>). Further, sulphur is essential element for constituent of certain amino acids, proteins, enzymes also essential constituent of chlorophyll formation, promotes nodulation in legumes. Thus, it might have resulted in increased the yield attributes. Increase in yield of garlic due to application of sulphur. low initial available sulphur content in experimental soil and better development and thickening of xylem and collenchyma fibers because of maximum rate of synthesis of protein and enhanced the photosynthetic activity of plant with increases in chlorophyll synthesis due to fertilization with sulphur which in turn resulted in more yield attributes and yield of plant. These results are agreement with findings of Srinidhi, N. [9]. Channagoudra, R.F. and Janawade, A.D. [10], Jaggi, R.C. [11], Verma, D. and Singh, H. [12], Singh, S.K. et al. [13] and Raghavendra, B.H. et al. [14].

### **3.2 Effect of Sulphur on quality parameters**

Data (Table 2) indicated that the nitrogen content was significantly increased by the application of increasing levels of sulphur fertilization during both the years as well as pooled mean. The maximum nitrogen content (0.821, 0.850 and 0.836 per cent), phosphorus content (0.302, 0.339 and 0.321 per cent) and potassium content (0.522, 0.542 and 0.532 per cent) was recorded under treatment S<sub>3</sub> (Sulphur @ 60 kg/ha) and minimum nitrogen content (0.942, 1.020 and 0.981 %), phosphorus content (0.260, 0.292 and 0.276 per cent) and potassium content (0.439, 0.461 and 0.450 per cent) under control during 2019-20, 2020-2021 and in

pooled mean. The treatment S<sub>3</sub> where Sulphur @ 60 kg/ha was applied observed as significantly superior over control but remained statistically at par with treatment S<sub>2</sub> (Sulphur @ 40 kg/ha).

The soil application of sulphur significant increases in chlorophyll content of leaves, which might have enhanced the rate of photosynthesis which further increased growth and provided more site for translocation of photosynthesis which might have resulted in increased accumulation of carbohydrate and metabolic activity, thus increases the total soluble solids content in garlic bulb. These results are in accordance with the findings of Quareshi, A. and Lawande, K.E. [15], Channagoudra, R.F. and Janawade, A.D. [16], Pradhan, K. [17], Patidar, M. [18], Chattoo, M.A. [19], Singh, C.V. [20] and Singh, S.K. [21].

### **3.3 Effect of Micronutrients on yield parameters**

Data (Table 3) also showed that significant improvement in average weight of clove (1.45, 1.44 and 1.44 g), average weight of bulb (25.70, 24.84 and 25.75 g), bulb yield per plot (3.08, 2.92 and 3.00 kg/plot) and bulb yield per hectare (171.34, 162.14 and 166.74 q/ha) of garlic was recorded with foliar application of micronutrients wherein zinc sulphate @ 0.6% produced significantly maximum average weight of clove, average weight of bulb, bulb yield per plot and bulb yield per hectare compared to control (M<sub>0</sub>). While, micronutrient treatments viz., zinc sulphate @ 0.6%, ferrous sulphate @ 0.2%, borax @ 0.5% and ammonium molybdate @ 0.5% remaining at par with each other also proved significantly superior to control.

The average weight of clove, average weight of bulb, bulb yield per plot and bulb yield per hectare increased significantly with foliar application of micronutrients (zinc sulphate @ 0.6%) over control. Pooled mean basis, the maximum values of yield and yield attributes *i.e.*, average weight of clove (1.44 g), average weight of bulb (25.01 g), bulb yield per plot (3.00 kg/plot) and yield per hectare (166.74 q/ha) was recorded with the foliar application of zinc sulphate @ 0.6% (M<sub>1</sub>) and minimum under control. These results are in conformity with the findings of Sharangi, A.B. *et al.* [22] in garlic, Srivastava, R. *et al.* [23] in garlic, Rohidas, S.B. *et al.* [24] in garlic, and Abedin, M.J. *et al.* [25] in onion.

Increased yield and yield characteristics through foliar use of micronutrient (Zn) may contribute to the formation of other growth hormone in the plant as it is associated with plant-water interactions and is involved in auxins metabolism such as tryptophan synthetase, tryptamine, metabolism, influencing enzyme activity dehydrogenase Pyridine nucleotide,

glucose-6 phosphate and triose phosphate and tryptophane compounds, a combination of proteins and are required for the production of growth hormones such as IAA and GA. Similar findings were recorded by Patnaik, M.C. *et al.* [26] in tomato, Kumar, M. *et al.* [27] in okra, Vekaria, L.C. *et al.* [28] in garlic and Khatemenla *et al.* [29] in onion.

### **3.4 Effect of Micronutrients on quality parameters**

The data regarding the application of micronutrients on nitrogen content, phosphorus and potassium content presented in the table 2. The perusal of data revealed that the nitrogen was significantly increased by application of micronutrients during both the years as well as pooled mean. The nitrogen content (0.922, 0.986 and 0.954 per cent), phosphorus content (0.295, 0.335 and 0.315 per cent) and potassium content (0.505, 0.531 and 0.518 per cent) was recorded maximum under treatment M<sub>1</sub> (zinc sulphate @ 0.6%) whereas, the minimum nitrogen content (0.825, 0.865 and 0.845 per cent), phosphorus content (0.267, 0.293 and 0.280 per cent) and potassium content (0.453, 0.470 and 0.462 per cent) was recorded under the treatment M<sub>0</sub> (control). The treatment M<sub>1</sub> was observed as significantly superior over control and remained statistically at par with treatment M<sub>2</sub> (ferrous sulphate @ 0.2%), M<sub>3</sub> (borax @ 0.5%), M<sub>4</sub> (ammonium molybdate @ 0.5%) during both the years and in pooled mean. It may be due to the availability of sufficient nutrients in the food environment which ultimately increases nutrient absorption, photosynthetic quality and ultimately greater plant growth by improving bulb quality. Zinc plays an important role in the metal activator of various enzymes and trace elements in various plant functions such as increasing chlorophyll levels, antioxidant enzymes and important components of many proteins and improving mineral status (TSS, ascorbic acid, protein and sugar) and increase crop yield and quality. Similar results were also recorded by Chhipa, B.G. [30], Srivastava, R. *et al.* [31], El-Tohamy *et al.* [32], Alam, M.N. *et al.* [33], Abd El-Samad *et al.* [34], Gurmani, A.R. *et al.* [35], Singh, H.M *et al.* [36], Pramanik, K. *et al.* [37] and Sethupathi, S. [38].

## **4. CONCLUSION**

Based on the results of two years experiments, it may be concluded that soil application of sulphur at 60 kg/ha combined with foliar spray of Zinc sulphate at 0.6% proved the most superior treatment combination in garlic fetching the significantly higher yield. Although, sulphur application at 40 kg/ha along with foliar application of zinc at 0.6 % was found at par to it.

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**Table 1 Effect of sulphur and micronutrient on average weight of clove and average weight of bulb**

Treatments	Average weight of clove			Average weight of bulb		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
<b>Sulphur levels</b>						
S <sub>0</sub>	1.29	1.27	1.28	21.17	19.78	20.48
S <sub>1</sub>	1.40	1.36	1.38	24.31	22.46	23.38
S <sub>2</sub>	1.47	1.45	1.46	26.22	24.51	25.36
S <sub>3</sub>	1.49	1.46	1.47	26.65	24.84	25.75
<b>SEm ±</b>	0.03	0.03	0.02	0.46	0.46	0.32
<b>CD (P = 0.05)</b>	0.07	0.08	0.05	1.32	1.31	0.91
<b>Micronutrients</b>						
M <sub>0</sub>	1.33	1.29	1.31	21.81	20.04	20.93
M <sub>1</sub>	1.45	1.44	1.44	25.70	24.32	25.01
M <sub>2</sub>	1.43	1.40	1.42	25.19	23.34	24.27
M <sub>3</sub>	1.45	1.42	1.43	25.58	23.97	24.77
M <sub>4</sub>	1.41	1.38	1.39	24.66	22.81	23.73
<b>SEm ±</b>	0.03	0.03	0.02	0.52	0.51	0.36
<b>CD (P = 0.05)</b>	0.08	0.09	0.06	1.48	1.46	1.02

**SEm: Standard error of the mean**

**Table 2 Effect of sulphur and micronutrient on average weight of bulb per plot and yield of bulb per hectare of garlic**

Treatments	Bulb yield (kg/plot)			Bulb yield (q/ha)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
<b>Sulphur levels</b>						
S <sub>0</sub>	2.54	2.37	2.46	141.15	131.86	136.51
S <sub>1</sub>	2.92	2.70	2.81	162.05	149.73	155.89
S <sub>2</sub>	3.15	2.94	3.04	174.79	163.39	169.09
S <sub>3</sub>	3.20	2.98	3.09	177.68	165.62	171.65
<b>SEm ±</b>	0.05	0.05	0.04	3.07	3.22	2.23
<b>CD (P = 0.05)</b>	0.16	0.15	0.11	8.80	9.22	6.27
<b>Micronutrients</b>						
M <sub>0</sub>	2.62	2.41	2.51	145.39	133.63	139.51
M <sub>1</sub>	3.08	2.92	3.00	171.34	162.14	166.74
M <sub>2</sub>	3.02	2.80	2.91	167.94	155.62	161.78
M <sub>3</sub>	3.07	2.88	2.97	170.54	159.78	165.16
M <sub>4</sub>	2.96	2.74	2.85	164.37	152.07	158.22
<b>SEm ±</b>	0.06	0.06	0.04	3.44	3.60	2.49
<b>CD (P = 0.05)</b>	0.18	0.17	0.12	9.84	10.31	7.01

**SEm: Standard error of the mean**

**Table 3 Effect of sulphur and micronutrient on number of cloves per plant of garlic**

Treatments	N content (%)		
	2019-20	2020-21	Pooled
<b>Sulphur levels</b>			
S <sub>0</sub>	0.821	0.850	0.836
S <sub>1</sub>	0.870	0.920	0.895
S <sub>2</sub>	0.912	0.980	0.946
S <sub>3</sub>	0.942	1.020	0.981
<b>SEm ±</b>	0.013	0.018	0.011
<b>CD (P = 0.05)</b>	0.037	0.050	0.031
<b>Micronutrients</b>			
M <sub>0</sub>	0.825	0.865	0.845
M <sub>1</sub>	0.922	0.986	0.954
M <sub>2</sub>	0.895	0.955	0.925
M <sub>3</sub>	0.905	0.970	0.937
M <sub>4</sub>	0.885	0.937	0.911
<b>SEm ±</b>	0.014	0.020	0.012
<b>CD (P = 0.05)</b>	0.041	0.056	0.034

**SEm: Standard error of the mean**

**Table 4 Effect of sulphur and micronutrient on phosphorus and potassium content in garlic bulb**

Treatments	Phosphorus content (%)			Potassium content (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
<b>Sulphur levels</b>						
S <sub>0</sub>	0.260	0.292	0.276	0.439	0.461	0.450
S <sub>1</sub>	0.282	0.312	0.297	0.481	0.502	0.492
S <sub>2</sub>	0.295	0.331	0.313	0.511	0.533	0.522
S <sub>3</sub>	0.302	0.339	0.321	0.522	0.542	0.532
<b>SEm ±</b>	0.004	0.006	0.004	0.007	0.008	0.005
<b>CD (P = 0.05)</b>	0.013	0.018	0.011	0.021	0.023	0.015
<b>Micronutrients</b>						
M <sub>0</sub>	0.267	0.293	0.280	0.453	0.470	0.462
M <sub>1</sub>	0.295	0.335	0.315	0.505	0.531	0.518
M <sub>2</sub>	0.287	0.320	0.303	0.495	0.516	0.506
M <sub>3</sub>	0.292	0.329	0.311	0.503	0.524	0.514
M <sub>4</sub>	0.283	0.316	0.299	0.485	0.506	0.496
<b>SEm ±</b>	0.005	0.007	0.004	0.008	0.009	0.006
<b>CD (P = 0.05)</b>	0.014	0.020	0.012	0.023	0.026	0.017

**SEm: Standard error of the mean**

UNDER PEER REVIEW