E-ISSN: 2663-1067
P-ISSN: 2663-1075
https://www.hortijournal.com
IJHFS 2022; 4(2): 223-226
Received: 15-08-2022
Accepted: 19-10-2022

Praveen Choyal
Ph.D Scholar, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Dr. OP Garhwal
Associate Professor, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Dr. MR Choudhary
Professor, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Dr. LN Bairwa
Professor, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Dr. AC Shivran
Professor, Department of Agronomy, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Dr. DK Gothwal
Professor, Department of Plant breeding and Genetics, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Praveen Choyal
Ph.D Scholar, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan, India

Effect of sulphur and micronutrients on growth attributes of garlic (*Allium sativum* L.)

Praveen Choyal, Dr. OP Garhwal, Dr. MR Choudhary, Dr. LN Bairwa, Dr. AC Shivran and Dr. DK Gothwal

DOI: https://doi.org/10.33545/26631067.2022.v4.i2c.143

Abstract
The field experiment was conducted at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during *Rabi* seasons 2019-20 and 2020-21. The result showed that soil application of sulphur 60 kg/ha and foliar application Zinc sulphate @ 0.6% was recorded maximum plant height, number of leaves and chlorophyll content of leaves in both the years as well as in pooled analysis. Although, sulphur application at 40 kg/ha along with foliar application of zinc sulphate at 0.6 % was found at par to it.

Keywords: Garlic, plant height, number of leaves and pooled analysis

1. Introduction
Garlic is an important bulbous plant and used throughout India primarily as a spice or condiment. It is botanically known as *Allium sativum* L.is member of the genus *Allium*, which comprises approximately 750 species belonging to the family Alliaceae. It is one of the most important bulbous vegetable crops and is next to onion (Hamma *et al*., 2013) [4]. It is originated from Central Asia and later spread to Mediterranean region (Simon, 2001 and Kigori *et al*., 2005) [8, 5]. 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 100 g 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 and Maynard, 1988) [6].
Nutrient are the product of the magnitude of impacts crop yield per unit area. Plant requires essential nutrients for normal functioning and growth. A plant's sufficiency range is the range of nutrient amount necessary to meet the plant's nutritional need and maximize growth. Boron, Zinc, Iron and Molybdenum as micronutrients and sulphur as a macronutrient are to be applied and in the experimental crop to study the impact on growth, yield and storage. Boron is one of the most important micronutrients, although it is required in very small quantity and regulates the carbohydrate metabolism and water relation in plant growth (Brady, 1990) [2]. Zinc is also an important micronutrient concerned in metabolic processes, enzymatic system, seed production and rate of maturity in plants. It is essential for synthesis of tryptophan, which is originator of indoleacetic acid. It also plays an important role in starch metabolism in plants (Alloway, 2008) [1]. Iron is indispensable for chlorophyll synthesis. It acts as an oxygen carrier and is a constituent of certain enzymes and proteins. Iron is an essential micronutrient for almost all living organisms because it plays critical role in metabolic processes such as DNA synthesis, respiration and photosynthesis. Molybdenum is also an important micronutrient for plants, which plays a vital role in enzymes activity as nitrogenase, catalase and peroxidase (Marschner, 1995 and Campbell, 1999) [7, 3].
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. Pungency in garlic is attributed to presence of an alkaloid "Di allyl disulphide" in which sulphur is prime component.

Material and Methods

The experiment will be carried out at Horticulture farm, S.K.N. College of Agriculture, Jobner, District Jaipur (Rajasthan) during *Rabi* season 2019-20 and 2020-21. The experiment was laid out in factorial randomized block design consisting 20 treatment combinations with four sulphur levels and five micronutrient levels. Each treatment replicated thrice. The treatments were allotted randomly to different plots using random number tables of Fishers and Yates (1963). Five competitive plants were selected at randomly tagged from each plot to record observation on various characters *viz*, plant height, number of leaves etc.

Results

The effect of different treatments on growth of garlic were analyzed statistically to test their significance whenever necessary, the data recorded for important characters have also been presented graphically for elucidation of the important trends. The results obtained have been presented in succeeding pages and table 1 to 3 under following heads.

1 Plant height (cm)

Sulphur: The data presented in the Table 1, showed that different sulphur levels significantly increased the plant height (cm) at 60 and 90 DAS. The maximum plant height was obtained with the treatment S_3- sulphur @ 40 kg/ha (38.97, 36.98 and 37.98 cm at 60 DAS and 59.35, 57.46 and 58.41 cm at 90 DAS) in both the years as well as under pooled analysis, which was statistically at par with the treatment S_2 (Sulphur @ 60 kg/ha) in 2019-20, 2020-21 and pooled analysis.

Micronutrients: Data further indicated that application of different micronutrients also significantly enhanced the plant height during experimentation. Application of zinc sulphate @ 0.6% (M_1) significantly affected the plant height over rest of the treatments except borax @ 0.5% (M_3) which was statistically at par to it during experimentation.

2 Number of leaves

Sulphur: The data presented in table 2 revealed that application of different sulphur levels significantly influenced the number of leaves per plant of garlic. The maximum number of leaves (6.37, 5.83 and 6.10 at 60 DAS and 8.06, 7.14 and 7.60 at 90 DAS) were observed in treatment S_2 (Sulphur @ 40 kg/ha) which is significantly superior than rest of the treatments except treatment S_3 (sulphur @ 60 kg/ha) and minimum (5.52, 4.92 and 5.22 at 60 DAS and 7.03, 6.17 and 6.60 at 90 DAS) found under control during both years as well as in pooled mean.

Micronutrients: Similarly, the application of various micronutrients also significantly influenced the number of leaves per plant during both the years as well as pooled analysis. The maximum number of leaves per plant at 60 and 90 DAS was recorded with application of Zinc sulphate @ 0.6% (M_1), which was found significantly higher over control. Application of Zinc sulphate @ 0.6% registered 17.75, 18.20 and 17.87 per cent at 60 DAS and 16.31, 16.94 and 16.44 per cent at 90 DAS number of leaves per plant than control, respectively during both the years and in pooled analysis.

3 Chlorophyll content in leaves (mg/g)

Sulphur: It is evident from data (Table 3) that application of sulhpur levels had significant effect on chlorophyll content in leaves was observed. The maximum chlorophyll content (38.97, 36.98 and 37.98 mg/g) was recorded with application of treatment S_3 (Sulphur @ 60 kg/ha) which was found statistically at par with treatment S_2 (Sulphur @ 40 kg/ha) during both the years as well as in pooled mean, respectively. However, minimum chlorophyll content in leaves (32.86, 30.89 and 31.88 mg/g) noted under control which was 14.30 and 16.41 and 15.31 per cent lesser than treatment S_2 (Sulphur @ 40 kg/ha) during individual year and in pooled analysis, respectively.

Micronutrients: A further reference to data (Table 3) showed that application of micronutrients significantly increased chlorophyll content in leaves of garlic during both the years as well as pooled analysis. The maximum chlorophyll content (38.38, 36.54 and 37.46 mg/g) was registered under treatment M_1 (Zinc sulphate @ 0.6%) which was at par with the treatment M_3 (borax @ 0.5%) whereas minimum (33.00, 31.10 and 32.05 mg/g) in treatment M_0 (control).

Discussion

Effect of sulphur

1 Growth attributes

The result of present study clearly indicate that plant height, number of leaves per plant, and chlorophyll content of leaves increased significantly due to application of S_3-sulphur @ 60 kg/ha. Pooled mean basis, the maximum value of growth parameters *i.e.* plant height both at 60 and 90 DAS (37.98 and 58.41 cm), number of leaves per plant both at 60 and 90 DAS (6.25 and 7.78), and chlorophyll content at 60 DAS (1.24 mg/g in leaves), was recorded with treatment S_3 (Sulphur @ 60 kg/ha) and the minimum value of growth parameters *i.e.* plant height both at 60 and 90 DAS (31.88 and 49.05 cm), number of leaves per plant both at 60 and 90 DAS (5.22 and 6.60), and chlorophyll content at 60 DAS (31.88 mg/g in leaves) were recorded under control, respectively which were at par with S_2 (Sulphur @ 40 kg/ha). Similar results were recorded by Chattoo *et al*. (2018) [14], Choudhary *et al*. (2018) [15] in garlic, Hariyappa (2003) [18], Jaggi (2005) [19], Singh *et al.* (2019) [25] and Raghavendra *et al.* (2020) [22] in onion, respectively.

Effect of micronutrients

1 Growth attributes

The results of present investigation showed that foliar application of micronutrients significantly increased the plant height, number of leaves per plant, and chlorophyll content of leaves as compared to control (water spray). Pooled mean basis, the maximum value of growth parameters *i.e.* plant height both at 60 and 90 DAS (37.43 and 59.33 cm), number of leaves per plant both at 60 and 90 DAS (6.20 and 7.72), and chlorophyll content at 60 DAS (1.18 mg/g in leaves) was recorded under foliar application of zinc sulphate @ 0.6% (M_1) which was found statistically at par with foliar application of borax @ 0.5% (M_3) and the minimum value of growth parameters *i.e.* plant height both at 60 and 90 DAS (32.05 and 50.69 cm), number of leaves per plant both at 60 and 90 DAS (5.26 and 6.63), neck thickness (50.69 cm) and chlorophyll content at 60 DAS (32.05 mg/g in leaves) were recorded under control, respectively. The same trends were also recorded by various scientists El-Tohamy *et al*. (2009) [16] in onion, Rohidas *et al*. (2010) [23] in garlic, Abd-El-Samad *et al*. (2011) [9] in

onion, Abedin *et al*. (2012) [10] in onion and Gurmani *et al*. (2012) [17] in tomato. Acharya *et al*. (2013) [12] in onion, Manna and Maity (2016) [21] in onion, Aske *et al*. (2017) [11] in garlic, Sethupathi (2019) [24], Biswas *et al*. (2020) [13] in onion and Jaiswal *et al*. (2020) [20] in garlic.

Table 1: Effect of sulphur and micronutrients on plant height of garlic

Treatments	Plant height (cm)					
	60 DAS			90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
A. Sulphur						
S_0 (Control)	32.86	30.89	31.88	50.08	48.01	49.05
S_1 (Sulphur 20 kg/ha)	35.24	33.49	34.37	54.10	52.16	53.13
S_2 (Sulphur 40 kg/ha)	37.56	35.96	36.76	57.95	56.17	57.06
S_3 (Sulphur 60 kg/ha)	38.97	36.98	37.98	59.35	57.46	58.41
SEm±	0.76	0.82	0.56	1.31	1.39	0.96
CD (P=0.05)	2.18	2.34	1.58	3.75	3.99	2.69
B. Micronutrients						
M_0 (Control water spray)	33.00	31.10	32.05	51.78	49.60	50.69
M_1 (Zinc sulphate @ 0.6%)	38.38	36.54	37.46	60.21	58.45	59.33
M_2 (Ferrous sulphate @ 0.2%)	35.77	34.13	34.95	54.22	52.64	53.43
M_3 (Borax @ 0.5%)	38.05	36.23	37.14	57.69	55.75	56.72
M_4 (Ammonium molybdate @ 0.5%)	35.59	33.65	34.62	52.95	50.82	51.88
SEm±	0.85	0.92	0.63	1.47	1.56	1.07
CD (P=0.05)	2.44	2.62	1.76	4.20	4.46	3.01

Table 2: Effect of sulphur and micronutrients on number of leaves of garlic

Treatments	Number of leaves					
	60 DAS			90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
A. Sulphur						
S_0 (Control)	5.52	4.92	5.22	7.03	6.17	6.60
S_1 (Sulphur 20 kg/ha)	5.96	5.39	5.68	7.55	6.67	7.11
S_2 (Sulphur 40 kg/ha)	6.37	5.83	6.10	8.06	7.14	7.60
S_3 (Sulphur 60 kg/ha)	6.53	5.96	6.25	8.26	7.29	7.78
SEm±	0.12	0.12	0.09	0.17	0.15	0.11
CD (P=0.05)	0.35	0.36	0.25	0.48	0.44	0.32
B. Micronutrients						
M_0 (Control water spray)	5.52	5.00	5.26	7.05	6.20	6.63
M_1 (Zinc sulphate @ 0.6%)	6.50	5.91	6.20	8.20	7.25	7.72
M_2 (Ferrous sulphate @ 0.2%)	6.04	5.45	5.74	7.64	6.78	7.21
M_3 (Borax @ 0.5%)	6.46	5.85	6.15	8.14	7.17	7.65
M_4 (Ammonium molybdate @ 0.5%)	5.96	5.42	5.69	7.60	6.69	7.14
SEm±	0.14	0.14	0.10	0.19	0.17	0.13
CD (P=0.05)	0.40	0.40	0.28	0.53	0.49	0.36

Table 3: Effect of sulphur and micronutrients on chlorophyll content of leaves

Treatments	Chlorophyll content (mg/g)		
	60 DAS		
	2019-20	2020-21	Pooled
A. Sulphur			
S_0 (Control)	0.82	0.88	0.85
S_1 (Sulphur 20 kg/ha)	1.11	1.15	1.13
S_2 (Sulphur 40 kg/ha)	1.19	1.23	1.21
S_3 (Sulphur 60 kg/ha)	1.21	1.27	1.24
SEm±	0.022	0.023	0.016
CD (P=0.05)	0.063	0.066	0.045
B. Micronutrients			
M_0 (Control water spray)	0.87	0.90	0.88
M_1 (Zinc sulphate @ 0.6%)	1.18	1.25	1.22
M_2 (Ferrous sulphate @ 0.2%)	1.15	1.20	1.18
M_3 (Borax @ 0.5%)	1.12	1.19	1.16
M_4 (Ammonium molybdate @ 0.5%)	1.09	1.12	1.11
SEm±	0.024	0.026	0.018
CD (P=0.05)	0.070	0.074	0.050

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. Although, sulphur application at 40 kg/ha along with foliar application of zinc sulphate at 0.6 % was found at par to it.

Acknowledgement
The authors are thankful to SKN Collage of Agriculture Jobner, Jaipur for providing necessary facilities in carrying out the present investigation.

References

1. Alloway TP, Gathercole SE, Kirkwood HJ, Elliott JG. Evaluating the validity of the automated working memory assessment. Educational Psychology. 2008;28:725-734.
2. Brady NC. The nature and properties of soil. 10th edition, A.K. Ghosh. Printing-Hall of India Pvt. Ltd., New Delhi, 1990, 383.
3. Campbell WH. Nitrate reductase structure, function and regulation. Binding the gap between biochemistry and physiology. Annual Review of Plant Physiology and Plant Molecular Biology. 1999;50:277-303.
4. Hamma IL, Ibrahim U, Mohammed AB. Growth, yield and economic performance of garlic (*Allium sativum* L.) as influenced by farm yard manure and spacing in Zaria, Nigeria. Journal of Agricultural Economics and Development. 2013;2(1):001-005.
5. Kigori JM, Magaji MD, Yakudu AI. Productivity of two garlic (*Allium sativum* L.) cultivars as affected by different levels of nitrogenous and phosphorus fertilizers in Sokoto, Nigeria. Proceeding of 41st Annual Conference on Bulletin of the Science Association of Nigeria, Usmanu Danfodiyo University, Sokoto. 2005.
6. Lorenz OA, Maynard DN. Knott's handbook for vegetable growers. A Wiley International Science Publication of John Wiley and Sons. 1988;3:456.
7. Marschner H. Mineral nutrition of higher plant. 2nd (ed.), Academic Press Limited. Text Book. pp.864.
8. Simon, W. 2001. The origin and distribution of garlic. USDA Vegetable Crops Research Unit, USA, 1995, 1-3.
9. Abd El-Samad EH, Khalifa RKHM, Lashine ZA, Shafeek MR. Influence of urea fertilization and foliar application of some micronutrients on growth, yield and bulb quality of onion. Australian Journal of Basic and Applied Science. 2011;5(5):96-103.
10. Abedin MJ, Alam MN, Hossain MJ, Ara NA, Haque KMF. Effect of micronutrients on growth and yield of onion under calcareous soil environment. International Journal of Biosciences. 2012;2(8):95-101.
11. Aske V, Jain PK, Lal Narayana, Shiurkar G. Effect of micronutrients on yield, quality and storability of onion cv. Bhima super. Trends in Biosciences. 2017;10(6):1354-1358.
12. Acharya K, Venktesh T, Saraswati. Response on growth, yield and quality parameters of multiplier onion (*Allium cepa* L var, *aggregatum* Don.) var. CO (On) 5 with different doses and method of zinc and boron application. International Journal of Agronomy and Agricultural Research. 2013;6:59-67.
13. Biswas P, Das S, Bar A, Maity TK, Mandal AR. Effect of micronutrient application on vegetative growth and bulb yield attributes of rabi onion (*Allium cepa* L.). International Journal of Current Microbiology and Applied Sciences. 2020;9(3):556-565.
14. Chattoo MA, Magray MM, Parray AHF, Shah MD, Bhat AT. Effect of sulphur on growth, yield and quality of garlic (*Allium sativum* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(5):2894-2896.
15. Choudhary K, Choudhary MR. Response of sowing date and sulphur levels on growth and yield of garlic (*Allium sativum* L.). International Journal of Agriculture Sciences. 2018;10(8):5791-5793.
16. El-Tohamy WA, Khalid AKH, El-Abagy HM, Abou-Hussein SD. Essential oil, growth and yield of onion (*Allium Cepa* L.) in response to foliar application of some micronutrients. Australian Journal of Basic and Applied Sciences. 2009;3(1):201-205.
17. Gurmani AR, Din JU, Khan SU, Andaleep R, Waseem K, Khan A. Soil Application of zinc improves growth and yield of tomato. International Journal of Agriculture and Biology. 2012;14:91–96.
18. Hariyappa N. Effect of potassium and sulphur on growth, yield and quality parameters of onion (*Allium cepa* L.), M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad. 2003.
19. Jaggi RC. Sulphur levels and sources affecting yield and yield attributes in onion (*Allium cepa* L.). Indian Journal of Agricultural Sciences. 2005;75(3):154-156.
20. Jaiswal RK, Ali SA, Niwariya J, Mewara N. Effect of sulphur and zinc on growth and yield of kharif onion (*Allium cepa* L.). The Pharma Innovation Journal. 2020;9(1):359-362.
21. Manna D, Maity TK. Growth, yield and bulb quality of onion (*Allium cepa* L.) in response to foliar application of boron and zinc. Journal of Plant Nutrition, 2016;39(3):438-441.
22. Raghavendra BH, Umamaheswarappa P, Srinivasa V, Salimath S, Hanumantappa M. Effect of different sources and levels of sulphur on yield and yield attributes in onion under central dry zone of Karnataka. International Journal of Ecology and Environmental Sciences. 2020;2(4):766-768.
23. Rohidas SB, Bharadia PS, Jature SD, Ghate KB. Effect of micronutrient on growth and yield of garlic (*Allium sativum* L.) var. G-41. Asian Journal of Horticulture. 2010;5(2):517-519.
24. Sethupathi S. Effect of zinc and boron on yield and quality of onion (*Allium cepa* L.) in alfisols of tamirabarni tract. *Madras Agricultural* Journal. 2019;106(4-6):293-296.
25. Singh SK, Kumar M, Seema Singh PK, Yadav LM, Effect of sulphur sources and levels on growth, yield and quality of onion. Current Journal of Applied Science and Technology. 2019;33(2):1-4.