Biological Forum – An International Journal **14(1): 932-935(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Sulphur Levels and different Micronutrients on Growth attributes of Garlic (*Allium sativum* L.)

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(Received 09 November 2021, Accepted 08 January, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The field experiment was conducted at the Horticulture Farm, SKN College of Agriculture, Jobner, Jaipur (Rajasthan) during *Rabi* seasons 2019-20 and 2020-21. 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 susceptibility of crop to both biotic and abiotic factors. Imbalanced nutrition is treated as one of the major abiotic factors which adversely affects growth and yield of garlic. 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. The result showed that soil application of sulphur 60 kg/ha and foliar application Zinc sulphate @ 0.6% was recorded maximum plant height at 60 and 90 DAS, number of leaves at 60 and 90 DAS 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, Chlorophyll, Number of leaves and Pooled analysis.

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). It is originated from Central Asia and later spread to Mediterranean region (Simon, 2001 and Kigori *et al*., 2005). Garlic have high nutritive value as compared to other bulbs crops. It is a richest source of carbohydrates, sugar, protein, minerals, potassium, calcium, sulphur, fat, phosphorus, fiber and iodine. Per hundred grams of edible part of garlic contains 59 percent moisture, 6.4 g protein, 1469 kilo calories energy, 0.5 g fats, 33.1 g carbohydrates, 1.5 g fiber, 181 mg calcium, 153 mg phosphorus, 1.7 mg Iron, 17 milligram Sodium, 401 mg potassium, 0.08 mg vitamin B_2, 0.25 mg thiamine, 0.06 milligram nicotinamide and 10.8 milligram ascorbic acid (Lorenz and Maynard, 1988). Garlic is cultivated throughout the India occupying an area of 274.10 thousand ha with production of 1271.30 thousand MT and productivity of 4.64 MT (Anonymous, 2020). The major garlic producing states are Madhya Pradesh, Rajasthan, Uttar Pradesh and Gujarat. In Rajasthan, it is extensively grown in Baran, Jhalawar, Kota, Bundi, Chittorgarh, Jodhpur, Jaipur and Sikar districts occupying an area of approximately 60 thousand ha with total production of 300 thousand MT and average productivity of 5.0 MT per ha. (Anonymous, 2020).

Nutrient are the product of the magnitude of impacts crop yield per unit area. Plant requires essential nutrients for functioning growth and production. 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. In micronutrients boron is considered as an most superior micronutrients for bulb crops, although it is required in small quantity and regulates the reproductive growth of plants, physiological and biochemical carbohydrate

metabolism and water relation in plant growth (Brady, 1990).

Zinc is also an important micronutrient constituent of several enzymes concerned in metabolic processes, foods/grain production and rate of maturity in plants. It is essential for synthesis of tryptophan, which is originator of IAA. It plays an important role in conversion of starch in plants (Alloway *et al.*, 2008). Iron is indispensable for photosynthesis and 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, physiological and biochemical pathways in plant, respiration, photosynthesis. Molybdenum is very essential nutrient for plants, which plays a important role in enzymes activity as nitrogenase, catalase and peroxidase (Marschner, 1995; Campbell, 1999).

Among the macronutrients, sulphur is one of a major plant nutrient essential for building up s-containing amino acids namely cystine, cysteine & methionine and is involved in building 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 was laid out at Horticulture farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during *Rabi* seasons 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-IIIA (Semi- Arid Eastern Plain Zone) of Rajasthan.

The experiment comprised of four treatments of Sulphur (Control, S @ 20 kg/ha, S @ 40 kg/ha & S @ 60 kg/ha) and five treatments of micronutrients (Control, Zinc sulphate @ 0.6%, ferrous sulphate @ 0.2%, Borax @ 0.5% & ammonium molybdate @ 0.5%) and thereby making 20 treatment combinations. Each treatment replicated thricely. The treatments were allotted randomly to different plots using random number. Five competitive plants were selected in each plot to record observation on various characters *viz*, plant height, number of leaves etc.

RESULTS AND DISCUSSION

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

A. Effect of Sulphur

The data presented in the Table 1, showed that different sulphur levels significantly increased the plant height (cm) at 60 and 90 DAS, number of leaves per plant at 60 and 90 DAS and chlorophyll content in leaves during experimentation. The maximum plant height was obtained with the treatment S_3- sulphur @ 60 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), number of leaves per plant (6.53, 5.96 and 6.25 at 60 DAS and 8.26, 7.29 and 7.78 at 90 DAS) and chlorophyll content in leaves (1.21, 1.27 and 1.24) in 2019-2020 and 2020-2021 as well as under pooled analysis, which was statistically at par with the treatment S_2 (Sulphur @ 40 kg/ha) in 2019-20, 2020-21 and in pooled analysis.

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

The result of experiment showed that the plant height, number of leaves/plants, 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/plants both at 60 and 90 DAS (6.25 and 7.78), and chlorophyll content at 60 DAS (1.24 mg/g), 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 (0.85 mg/g) were recorded under control, respectively which were at par with S_2 (Sulphur @ 40 kg/ha). The marked

increase in all these growth parameters might be due to the fact that sulphur deficiency prevents utilization of nitrogen and brings about accumulation of soluble nitrogen in the plant leaves (Srinidhi, 2000). Further, sulphur being an integral constituent of several enzymes and amino acids of which nitrogen is also an essential constituent, might have helped in increasing the net assimilation rate of nitrogen and ultimately improved the growth parameters. These results are also in close conformity with the findings of Chattoo *et al.* (2018), Choudhary *et al*. (2018) in garlic, Hariyappa (2003), Jaggi (2005); Singh *et al.* (2019); Raghavendra *et al.* (2020) in onion, respectively.

B. Effect of Micronutrients

Data further indicated that application of different micronutrients also significantly enhanced the plant height (cm) at 60 and 90 DAS, number of leaves/plant at 60 and 90 DAS and chlorophyll content in leaves in 2019-20, 2020-21 and pooled analysis. Application of zinc sulphate @ 0.6% (M_1) significantly affected the plant height (cm) at 60 and 90 DAS, number of leaves per plant at 60 and 90 DAS and chlorophyll content in leaves in garlic over rest of the treatments except borax @ 0.5% (M_3) which was statistically at par to it during experimentation.

The results of present experiment clearly indicates that application of micronutrients significantly increased the plant height, number of leaves/ plant and chlorophyll content as compared to control. On the basis of pooled mean the plant height both at 60 and 90 DAS (37.46 and 59.33 cm), number of leaves/plant both at 60 and 90 DAS (6.20 and 7.72) and chlorophyll content at 60 DAS (1.22 mg/g) was recorded highest in application of $ZnsO_4$@ 0.6% (M_1) which was found statistically at par with borax @ 0.5% (M_3) and the minimum 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 (5.26 and 6.63) and chlorophyll content in leaves at 60 DAS (0.85 mg/g) were recorded under M_0 (control), respectively.

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

The foliar spray of micronutrients increases in plant growth parameters. The micronutrients resulted in the maximum value of vegetative growth because micronutrients also play an essential role in improving plant growth through the biosynthesis of endogenous hormones which are responsible for promoting of plant growth, strengthening of plant cell wall and translocation of carbohydrates from leaves to other parts of the plants.

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

The same trends were also recorded by various scientists El-Tohamy *et al*. (2009) in onion, Rohidas *et al.* (2010) in garlic, Abd-El-Samad *et al*. (2011) in onion, Abedin *et al*. (2012) in onion and Gurmani *et al*. (2012) in tomato. Acharya *et al*. (2013) in onion, Manna and Maity (2016) in onion, Aske *et al*. (2017) in garlic, Sethupathi (2019); Biswas *et al.* (2020) in onion and Jaiswal *et al.* (2020) in garlic.

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.
Conflict of Interest. None.

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How to cite this article: Praveen Choyal, O.P. Garhwal, Manju Netwal and Radhe Shyam Kherwa (2022). Effect of Sulphur Levels and different Micronutrients on Growth Attributes of Garlic (*Allium sativum* L.). *Biological Forum – An International Journal*, *14*(1): 932-935.