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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 249-251

www.thepharmajournal.com
Received: 19-11-2021
Accepted: 21-12-2021

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Effect of micronutrients on growth, yield and quality of garlic (*Allium sativum* L.)

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Abstract
The present study entitled "Effect of micronutrients on growth, yield and quality of Garlic (*Allium sativum* L.)" was carried out during November, 2020 to April, 2021 in Research field, Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design (RBD), with 16 treatments. Three micronutrients namely Zinc, Boron and Iron were applied at different levels. 16 treatments viz. T_0 - control, T_1- Zinc @ 0.5%, T_2 - Boron @ 0.1%, T_3 – Iron @ 0.5%, T_4 - Zinc @ 1.0%, T_5 - Boron @ 0.2%, T_6 - Iron @ 1.0%, T_7 - Zinc @ 1.5%, T_8 - Boron @ 0.3%, T_9 - Iron @ 1.5%, T_{10} -Zinc @ 2%, T_{11} - Boron @ 0.4%, T_{12} - Iron @ 2%, T_{13} - Zinc @ 2.5%, T_{14} - Boron @ 0.5%, T_{15} - Iron @ 2.5% were applied during the research work on Garlic (Bhima Purple cv.). The study revealed that all the characters were significantly affected by the application of the treatments. On the basis of present investigation, it is concluded that the application of T_{13} (Zinc @ 2.5%) treatment was found best in terms of plant growth and yield *viz*., plant height (56.42 cm), number of leaves per plant (19.25), length of leaf (36.42 cm), neck thickness (10.06 mm), polar diameter (5.95 cm), equatorial diameter (6.05 cm), average weight of bulb (31.20 g), number of cloves/bulb (), bulb yield/ plot (1.3 kg), total yield (125.60 q/ha), TSS (36.89%) and ascorbic acid (18.10%) in garlic. From the findings of the present study, it is concluded that application of treatment T_{13} Zinc @ 2.5% has given the best result as compared to other treatments in garlic. Zinc plays a considerable role in various enzymatic and physiological activities and performs many catalytic functions in plant system. Zinc is also an important micronutrient concerned in metabolic processes. Therefore, application of Zinc @ 2.5% will provide better plant growth and yield and will be economically benefitted.

Keywords: garlic, micronutrients, growth, yield, development

Introduction
Garlic (*Allium sativum* L.) is the most widely used cultivated *Allium* species after onion belonging to the family *Alliaceae* having chromosome no 2n = 16. It is the second most widely used bulb crop next to onion (Rubatzky and Yamaguchi, 1997). Garlic is native to Central Asia and northeastern Iran. Fresh garlic bulb contains about 62.8% moisture, 6.3% protein, 0.1% fat, 0.8% fiber and is a good source of carbohydrates (29.0 g), calcium, phosphorus, potassium, magnesium, sulphur and vitamins A and C (Mahmood *et al*., 2000) [3]. In addition to higher nutritive value as compared to other bulb crops, it contains garlicin and allistatin antibiotics (Maly *et al*., 1998) [4]. Its pungency, strong flavour and keeping quality are found to be associated with its diallyl disulphide content (Shankaracharya, 1974) [7].
Crop roots are unable to absorb some important nutrients such as zinc, because of soil properties, such as high pH, lime or heavy texture, thus, in this situation, foliar spraying is better as compared to soil application. Zinc is essential for nitrogen metabolism and also found to be responsible for large size of bulbs, which might be due to improved physiological activities like photosynthesis during which food manufactured by plant is translocated in bulb.
Iron is an essential micronutrient which plays critical role in metabolic processes such as respiration and photosynthesis and is a prosthetic group constituent of many enzymes. Boron is one of the most widely applied micro-nutrient although it is required in very small quantity. It has different role in plant metabolic activities. Cell division, nitrogen and carbohydrates metabolism and water relation in plants are controlled by boron.

Materials and Methods
The present investigation entitled "Effect of micronutrients on growth, yield and quality of Garlic (*Allium sativum* L.)" was carried out in Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the rabi season (2020-2021).

The experiment was laid out in randomized block design with three replications and sixteen treatment combinations including control (water spray). The cloves of garlic cv. Bhima purple were planted during the third week of November in 15 x 15 cm spacing. Three micronutrients namely zinc as zinc sulphate @ 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, boron as borate @ 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, and iron as ferrous sulphate @ 0.5%, 1.0%, 1.5%, 2.0%, 2.5% were applied as foliar spray. First irrigation was given immediately after planting. The observations on growth parameters like plant height, number of leaves, leaf length was recorded at 30, 60 and 90 DAS. Five bulbs were randomly selected from each replication for further evaluation.

Results and Discussions

The research results statistically provided us with the evidence of improving growth, yield and quality traits of garlic in response to essential micronutrients.

The results regarding to plant height of garlic as shown in table 1 were significantly influenced by the application of Zinc. The maximum and significant plant height of 51.04 cm was observed with treatment T_{13} Zinc @ 2.5% while the minimum plant height of 41.66 cm was recorded with treatment T_0 Control. This might be because zinc is an essential trace element involved in many enzymatic reactions and is necessary for their good growth and development. The maximum (6.60) number of leaves per plant was noted when treatment T_{13} Zinc @ 2.5% was applied while the minimum (6) number of leaves per plant was observed with T_0 Control. This maybe because zinc increases the vegetative growth and development of the plant which resulted in more number of leaves per plant. Manhaj *et al*., (2005) [7] found that number of leaves per plant of garlic was significantly increased by application of zinc. Similar results were observed by Singh *et al.*, (2005) [8] and Quddus *et al*., (2009) [9]. The maximum leaf length of 43.87 cm was observed with treatment T_{13} Zinc @ 2.5% while the minimum average leaf length of 34.09 cm was recorded with T_0 Control. This maybe because zinc is a key component of many enzymatic and protein synthesis and plays a vital role in many biochemical processes such as hormone production and leaf elongation. Application of zinc significantly increased the neck thickness of the bulb with the maximum (10.06 mm) neck thickness of bulb recorded with treatment T_{13} Zinc @2.5% while the minimum (6.65 mm) neck thickness of bulb was observed with T_0 Control. The maximum polar diameter of 5.95 cm was recorded with treatment T_{13} Zinc @ 2.5% while the minimum polar diameter of 3.35cm was recorded with T_0 Control. The maximum (6.05 cm) equatorial diameter was recorded with treatment T_{13} Zinc @ 2.5% while the minimum (3.27 cm) equatorial diameter were recorded with T_0 Control. This maybe because zinc plays an important role in many biological processes such as biosynthesis of protein and carbohydrates which would ensure higher individual bulb weight and eventually larger bulb diameter. Similar results were found by Arif *et al*., (2016) [2] and Alam *et al*., (2019) [1]. The maximum average bulb weight of 31.20 g was recorded with treatment T_{13} Zinc @ 2.5% while the minimum bulb weight of 22.22 g was recorded with T_0 Control. The maximum number of cloves per bulb (36.42) was recorded with treatment T_{13} Zinc @ 2.5% while the minimum number of cloves per bulb (27.55) were recorded with T_0 Control. Maximum and significant marketable bulb yield per plot (1.373 kg) was recorded with treatment T_{13} Zinc @ 2.5% while the minimum marketable bulb yield per plot (0.978kg) was recorded with T_0 Control. The maximum total yield of bulb (125.60 q/ha) was observed with treatment T_{13} Zinc @ 2.5% while the minimum total yield of bulb (98.33 q/ha) was recorded with T_0 Control. The maximum total soluble solids (36.89%) were recorded with treatment T_{13} Zinc @ 2.5% while the minimum total soluble solids (31.01%) were recorded with T_0 Control. The maximum ascorbic acid (18.10 mg/100g) was recorded with treatment T_{13} Zinc @ 2.5% while the minimum ascorbic acid (10.45 mg/100g) was recorded with T_0 Control.

Table 1: Effect of different levels of micronutrients (Zinc, Boron and Iron) on growth parameters of Garlic (*Allium sativum* L.)

Treatments	Growth Parameters					
	Plant height (cm)	Number of leaves	Leaf length (cm)	Neck thickness (mm)	Polar diameter (cm)	Equatorial diameter (cm)
T_0	41.66	6	34.09	6.65	3.35	3.27
T_1	48.87	6	39.28	8.56	4.24	4.18
T_2	47.24	6.13	38.06	8.67	4.88	4.81
T_3	47.87	6.47	38.47	9.10	4.27	4.21
T_4	49.27	6.47	38.81	9.46	4.50	4.45
T_5	47.12	6.20	39.38	8.92	4.51	4.47
T_6	48.70	6.40	40.07	8.55	5.30	5.24
T_7	47.83	6.47	39.92	9.57	4.73	4.65
T_8	50.54	6.40	38.29	8.18	4.57	4.50
T_9	48.93	6.07	39.67	9.13	4.72	4.66
T_{10}	46.41	6.13	37.54	8.54	4.67	4.63
T_{11}	49.45	6.13	39.91	8.09	5.38	5.32
T_{12}	48.27	6.20	39.63	8.61	5.05	4.96
T_{13}	51.04	6.60	43.87	10.06	5.95	6.05
T_{14}	50.95	6.53	40.22	9.61	5.40	5.34
T_{15}	49.05	6.07	39.33	7.80	4.31	4.27
S.Ed. (±)	0.49	1.14	1.40	0.391	0.219	0.220
C.D at 5	1.00	2.32	2.86	0.798	0.448	0.449
C.V	1.24	3.56	4.72	5.492	5.670	5.748

Table 2: Effect of different levels of micronutrients (Zinc, Boron and Iron) on yield and quality parameters of Garlic (*Allium sativum* L.)

Treatments	Yield and Quality parameters					
	Weight of bulb (g)	**Number of cloves per bulb**	**Bulb yield per plot (kg)**	**Total yield of bulb (q/ha)**	**Total soluble solids (%)**	**Ascorbic acid (mg/100g)**
T_0	22.22	27.53	0.978	98.33	31.01	10.45
T_1	26.29	34.07	1.157	108.01	35.41	13.16
T_2	27.42	34.07	1.206	112.58	33.51	12.71
T_3	27.20	33.75	1.197	111.10	33.54	14.32
T_4	27.86	32.31	1.226	116.88	34.64	15.52
T_5	27.69	32.97	1.219	114.99	33.00	14.65
T_6	27.76	34.21	1.222	116.45	34.87	13.36
T_7	26.57	33.88	1.169	110.69	33.10	12.45
T_8	27.02	32.02	1.189	113.13	34.71	13.77
T_9	27.69	32.97	1.218	116.94	35.44	14.07
T_{10}	27.62	33.08	1.215	115.23	34.04	14.66
T_{11}	24.86	33.30	1.094	106.61	34.45	12.47
T_{12}	25.73	33.04	1.132	105.32	32.83	13.72
T_{13}	31.20	36.42	1.373	125.60	36.89	18.10
T_{14}	29.97	35.53	1.319	121.34	35.66	16. 56
T_{15}	27.21	32.03	1.197	113.15	33.52	15.62
S.Ed. (±)	1.209	1.269	0.053	4.721	1.051	0.742
C.D at 5	2.468	2.592	0.109	9.642	2.147	1.514
C.V	5.453	4.682	5.454	10.611	3.768	6.441

Conclusion

It can be concluded from the findings of the present investigation that application of T_{13} Zinc @ 2.5% treatment was significantly superior in terms of vegetative growth like plant height, number of leaves per plant, leaf length, neck thickness, polar diameter, equatorial diameter and yield parameters like weight of bulb, number of cloves per bulb, bulb yield per plot, total yield of bulb, total soluble solids (TSS) and ascorbic acid of garlic. Hence, application of T_{13} Zinc @ 2.5% on garlic plants can be recommended for better growth, yield and quality of garlic under Prayagraj agro-climatic conditions.

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