The Pharma Innovation Journal 2022; 11(12): 2045-2048

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 2045-2048

www.thepharmajournal.com
Received: 09-09-2022
Accepted: 14-10-2022

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Effects of micronutrients on growth, yield & storage of garlic (*Allium sativum* L.)

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Abstract
The research work entitled "Effects of Micronutrients Application on Growth, Yield and Storage Quality of Garlic (*Allium sativum* L.)" was conducted at Farm of STRU, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, during *rabi* 2019-2020 season. The experiment was laid out in RBD with four replications & five treatments of micronutrients i.e., T_0 – Control, T_1 – Soil application of $ZnSO_4$ @ 10 kg/ha at planting, T_2 – Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP, T_3 – Soil application of borax @ 10 kg/ha at planting and T_4 – Foliar application of boron @ 0.25% at 45, 60 and 75 DAP.

Treatment T_2 exhibited maximum growth parameters like plant height (54.78 cm) at 60 DAP and (61.30 cm) at 75 DAP, number of leaves (10.35) at 60 DAP and (12.6) at 75 DAP, plant fresh weight (27.38 gm) at 60 DAP & (52.17 gm) at 75 DAP, plant dry weight (5.50 gm) at 60 DAP and (9.20 gm) at 75 DAP and chlorophyll values of SPAD meter (66.37) at 60 DAP and (61.97) at 75 DAP followed by T_1. Yield parameters like bulb diameter (5.20 cm), number of cloves/bulbs (19.41), bulb weight (33.63 gm), clove diameter (1.34 cm), clove length (3.06 cm), clove weight (3.54 gm), yield per plot (32.63 kg) and yield per hectare (129.10 q) were found significant in T_2.The maximum ascorbic acid (10.92 mg/100 g) and Minimum storage loss also found in treatment T_2 but the days required for maturity was not influenced by micronutrients application.

Keywords: Micronutrients, yield, storage quality, garlic

Introduction
Garlic (*Allium sativum* L.) belongs to the Allium genus of onions. Onion, Shallot, Leek, Chive, and Chinese onion are all near relatives. It's native to Central Asia and northeastern Iran, and it's been used as a seasoning for thousands of years over the world. It was known to ancient Egyptians and has been used as both a food flavoring and a traditional medicine. Garlic is well-known for its ability to enhance flavour and also has a variety of medical applications. Garlic is a carminative and a stomach stimulant, so it aids digestion and absorption of food, according to the ayurveda philosophy. Allicin, a component of garlic aqueous extract, lowers cholesterol levels in the blood. While garlic is a strong source of selenium, phosphorus, vitamin B1, and calcium, it is the sulphur compounds in garlic that serve as its showcase ingredients in terms of general health benefits. The sulfur-containing compounds found in this allium vegetable have been shown to benefit our cardiovascular system, immune system, inflammatory system, digestive system, endocrine system, and detoxification system, among other body systems.

The relative relevance of micronutrients in field crop development, particularly in bulbous spice production, is constantly a topic of debate, yet it is a well known truth that optimal yields are not achievable without N, P, K fertilizers and secondary nutrients. High and balanced nutrient application is required to achieve increased crop yields. Micronutrients are important for increasing agricultural productivity. In addition to enhancing yields, micronutrient administration, particularly Zn and Boron, can improve crop quality by increasing protein and carbohydrate content. Most planters use the recommended fertilizer doses to increase output, but they may not realize that one or more micronutrients are also limiting their yields.

Keeping the view of above points on experiment was conducted to assess the efficacy of micronutrients in growth and yield of garlic.

Materials and Methods
The experiment was conducted at Farm of Seed Technology Research Unit, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra State, during rabi 2019-2020 season.

Parbhani comes under subtropical and is situated at 408.5 cm above the sea level Geographically it is situated between 19°16'N latitude 76°47' longitude. Soil type of experimental plot was fairly uniform medium black cotton type, with uniform texture and well drained, the plot was ploughed and then harrowed to bring the soil to fine tilth. The chemical properties of soil were determined by taking soil sample from 0 to 25 cm deep strata of soil at random all over the experimental area before layout of the experiment. The soil chemical properties were organic carbon (0.53%), soil pH (7.55), $CaCO_3$ (1.2%), available nitrogen (225.18 kg/ha), available phosphorous (10.82 kg/ha), available potassium (795.76 kg/ha), electrical conductivity (0.26 dSm^{-1}), copper (3.466 ppm), ferrous (8.450 ppm), manganese (13.098 ppm) and zinc (1.294 ppm). The experiment was laid out in RBD with four replications and five treatments which are T_0 (Control), T_1 (Soil application of $ZnSO_4$ @ 10 kg/ha), T_2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP), T_3 (Soil application of borax @ 10 kg/ha), T_4 (Foliar application of boron @ 0.25% at 45, 60 and 75 DAP). The variety used for planting is Agrifound white (G-41). Experimental land was ploughed and harrowed and bring the soil to fine tilth. Layout was made as per required dimension and the individual plot consisting ridges and furrows were made in size 5m × 5m by leaving 1m gap between two replications and 0.5m between each plot.

Healthy, uniform cloves were planted at a spacing of 15cm x 10 cm. Immediately after planting light irrigation was given and followed after three days. Later on, irrigation was given as per the requirement. The irrigation was stopped 20 days before harvesting. Gap filling was carried out after 8 days of sowing to maintain required plant population per plot. A sample of five plants from each plot were drawn randomly. Also, in each plot five plants were tagged to record on farm observations like plant height, number of leaves, fresh weight, dry weight and chlorophyll content. The observation of plant was recorded at regular intervals throughout their life cycle to measure the relationship between growth attributes and finally yield. Such measurements were made at successive intervals of plant growth 45, 60, 75 DAP. The yield characters like bulb diameter, number of cloves, bulb weight, diameter of clove, length of clove and weight of clove are measured after harvesting by selecting random 5 bulbs from each plot. The days required for maturity are counted from date of planting to 60% top fall. The estimation of ascorbic acid in fresh bulb was carried out by direct visual titration with 2, 6 dichlorophenol indophenol. (A.O.A.C., 1975) [22]. After harvesting the bulb were analyzed for storage quality for that purpose 5 kg of bulbs from each plot was collected and kept for storage separately for 3 months and monthly observations of weight loss were taken to calculate weight loss percentage.

Weight loss was calculated monthly according to the following formula

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{weight of bulbs for sampling dates}}{\text{Initial weight of bulb}} \times 100$$

The projected yield per hectare was calculated on the basis of yield per plot. The statistical analysis of data collected was done by following standard procedure described by Panse and Sukhatme (1967) [10]. The analysis of variance was carried out according to simple Randomized Block Design.

Results and Discussion

Growth parameters

In case of plant height the treatment T2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP) exhibited increasing plant height (54.78 cm & 61.30 cm) and found significantly superior over rest of the treatments at 60 and 75 DAP. Treatment T1 (Soil application of $ZnSO_4$ @10 kg/ha at planting) exhibited increasing plant height (48 cm) and found significantly superior over rest of the treatments under study at 45 DAP and significantly lowest height (40.88 cm, 47.00 cm & 52.68 cm) was found in treatment T0 (Control) at 45, 60 and 75 DAP. Similar trend was seen in Number of leaves the treatment T2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP) exhibited maximum number of leaves (10.35 & 12.60) and found significantly superior over rest of the treatments at 60 and 75 DAP. But at 45 DAP the treatment T1 (Soil application of $ZnSO_4$ @10 kg/ha at planting) exhibited maximum number of leaves (7.6) and found significantly superior over rest of the treatments and lowest number of leaves (6.35, 9.15 & 10.55) was found in treatment T0 (Control) at 45, 60 and 75 DAP. The days required for maturity was not influenced by any treatments significantly.

Biochemical parameters

Significantly highest ascorbic acid content was observed in T2 (10.92) than rest of the treatments while lowest ascorbic acid (8.51) content was found in treatment T0 (Control).

At 45 DAP, the treatment T1 (Soil application of $ZnSO_4$ @10 kg/ha at planting) exhibited maximum chlorophyll SPAD value (67.95) and found significantly superior over rest of the treatments under study and the lowest chlorophyll SPAD value (60.34) was observed in the treatment T0 (Control). At 60 DAP and 75 DAP, the treatment T2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP) exhibited maximum chlorophyll SPAD value (66.37, 61.97) and the lowest chlorophyll SPAD value (58.54, 52.77) was found in T0 (Control).

Table 1: Effects of micronutrients on growth and biochemical parameters

Sr. No.	Treatments	Plant Height			Number of Leaves			Days required for maturity	Ascorbic acid (mg/100 g)
		45 (DAP)	60 (DAP)	75 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)		
1	T_0 – Control	40.88	47.00	52.68	6.35	9.15	10.55	116.50	8.51
2	T_1 – Soil application of $ZnSO_4$ @ 10 kg/ha at planting.	48.00	50.65	57.30	7.6	9.40	11.65	113.25	9.53
3	T_2 – Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP.	41.85	54.78	61.30	6.8	10.35	12.60	111.75	10.92
4	T_3 – Soil application of borax @ 10 kg/ha at planting.	44.45	49.53	53.38	6.88	9.35	11.15	116.75	9.30
5	T_4 – Foliar application of boron @ 0.25%	41.83	50.04	55.40	6.45	9.39	11.21	115.50	9.46

	at 45, 60 and 75 DAP.								
	S.E.±	1.15	1.44	1.49	0.23	0.25	0.29	2.93	0.38
	C.D. at 5%	3.54	4.44	4.58	0.71	0.77	0.91	NS	1.19

Table 2: Effects of micronutrients on Fresh weight and Dry weight

Sr. No.	Treatments	Fresh Weight of Plant (gm)			Dry Weight of Plant (gm)			Chlorophyll SCMR Values (SPAD)		
		45 (DAP)	60 (DAP)	75 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)
1	T_0 – Control	9.05	17.7	32.87	1.00	2.83	5.21	60.34	58.54	52.77
2	T_1 – Soil application of $ZnSO_4$ @ 10 kg/ha at planting.	14.62	25.49	47.27	2.10	3.92	7.87	67.95	61.32	57.29
3	T_2 – Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP.	10.03	27.38	52.17	1.11	4.50	9.20	61.02	66.37	61.97
4	T_3 – Soil application of borax @ 10 kg/ha at planting.	12.59	19.79	38.44	1.82	3.00	6.47	62.63	59.04	54.52
5	T_4 – Foliar application of boron @ 0.25% at 45, 60 and 75 DAP.	10.23	22.97	42.18	1.10	3.39	7.04	60.28	60.89	56.89
	S.E.±	0.65	1.16	1.55	0.06	0.14	0.37	1.70	1.62	1.47
	C.D. at 5%	1.99	3.56	4.75	0.19	0.45	1.14	5.23	4.98	4.51

Yield parameters

The maximum bulb diameter (5.20 cm), maximum number of cloves/bulb (15.33), maximum weight of bulb (33.63 g), maximum diameter of clove (1.34 cm), maximum length of clove (3.06 cm), maximum weight of clove (3.54 gm), highest bulb yield per plot (32.63 kg) and yield per hectare (129.10 q) were recorded in the treatment T2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP) which was superior over all other treatments under study and while lowest values for parameters was recorded in T0(Control).

Table 3: Effects of micronutrients on yield Parameters

Sr. No.	Treatments	Bulb Diameter (cm)	Number of Cloves	Bulb Weight (gm)	Diameter of Clove (cm)	Length of Clove (Cm)	Weight of Clove (gm)	Yield Per Plot (kg)	Yield Per Hectare (q)
1	T_0 – Control	3.91	15.33	26.37	1.09	2.28	2.63	27.80	111.20
2	T_1 – Soil application of $ZnSO_4$ @ 10 kg/ha at planting.	4.59	17.33	30.89	1.2	2.74	2.86	29.75	119.50
3	T_2 – Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP.	5.20	19.41	33.63	1.34	3.06	3.54	32.63	129.10
4	T_3 – Soil application of borax @ 10 kg/ha at planting.	4.22	16.75	28.11	1.15	2.67	2.77	28.48	113.90
5	T_4 – Foliar application of boron @ 0.25% at 45, 60 and 75 DAP.	4.45	16.80	29.27	1.12	2.69	2.80	29.15	116.70
	S.E.±	0.16	0.60	0.86	0.04	0.09	0.11	0.92	3.10
	C.D. at 5%	0.49	1.85	2.64	0.13	0.29	0.35	2.83	9.52

Storage Parameter

Physiological Weight Loss During Storage (%)

In case of storage weight loss at 30, 60 and 90 days after harvesting the minimum physiological loss in weight was recorded in treatment T2 (Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP) while maximum physiological loss in weight was recorded in treatment T0 (Control).

Table 4: Effects of micronutrients on Weight loss during storage

Sr. No.	Treatments	Weight Loss During Storage (%)		
		30 (DAH)	60(DAH)	90(DAH)
1	T_0 – Control	6.46	11.26	14.79
2	T_1 – Soil application of $ZnSO_4$ @ 10 kg/ha at planting.	4.69	9.16	11.67
3	T_2 – Foliar application of $ZnSO_4$ @ 0.5% at 45, 60 and 75 DAP.	3.77	7.71	10.07
4	T_3 – Soil application of borax @ 10 kg/ha at planting.	5.39	10.17	12.85
5	T_4 – Foliar application of boron @ 0.25% at 45, 60 and 75 DAP.	4.71	9.70	11.70
	S.E.±	0.28	0.44	0.51
	C.D. at 5%	0.87	1.36	1.59

The above superior results of vegetative characters and biochemical parameters of zinc over boron as shown in Table no 1 and 2 might be due to because It is effective for the synthesis of plant hormones like auxin and carbohydrate formation (Pankaj *et al*., 2018) [9]. It plays a fundamental role in several critical functions in the cell such as protein metabolism, gene expression, structural and functional integrity of bio-membranes and photosynthetic metabolism (Sanju *et al*., 2003) [12]. The above findings are in confirmation with Sharangi *et al*. (2003) [16] in garlic, Srivastava *et al*. (2005) [19] in garlic, Rohidas *et al*. (2010) [11] in garlic, Ballabh and Rana. (2012) [5] in onion, Manna (2013) [8] in onion, Choudhary *et al*. (2014) [6] in garlic, Arif *et al*. (2016) [2] in garlic.

The result presented in Table no. 3 which shows that the zinc sulphate found superior for increasing yield parameters over boron this might be due to Zinc is one of the seven micronutrients vital for the crop growth. Zinc plays a considerable role in various enzymatic and physiological activities and performs many catalytic functions in plant system besides alteration of carbohydrates, chlorophyll and protein synthesis. 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]. Zinc is crucial for plant growth because it controls the synthesis of indoleacetic acid, which noticeably regulates plant growth and also active many enzymatic reactions which is necessary for chlorophyll synthesis and carbohydrate formation (Vitosh, 1994) [20]. Zinc is alsoimproving physiological activities like photosynthesis during which food manufactured by the plant and translocated in the bulb that results in larger size of bulb which in result increases weight of bulb and yield of garlic crop.

The above findings are in confirmation with Gupta *et al*. (2000) [7], Selvaraj *et al*. (2002) [14], Sharangi *et al*. (2003) [16], Rohidas *et al.* (2010) [11], Choudhary *et al.* (2014) [6], Arif *et al.* (2016) [2] in garlic and Ballabh and Rana (2012) [5], Manna (2013) [8], Shukla *et al.* (2015) [18], Sethupathi (2019) [15] in onion.

This effect of zinc might be due to zinc helps to accumulate a relatively higher amount of metabolites in bulbs, thus maintaining them firm and healthy. The above results are similar with findings of Yatsenko *et al.* (2020) [21] in garlic and Aske *et al.* (2017) [3] Shrinath (2004) [17] in onion.

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