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Response of garlic to micronutrients

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Abstract

A field experiment was conducted on Typic Heplustptes soils of Vegetable Research Farm, Faculty Of Agricultural, University of Rajshahi to study the response of garlic to multi-micronutrients formulation mixture fertilizers in calcareous soils. The results revealed that higher bulb(6712, 5762 and 6237 kg ha-1) and dry leaves (1370, 1181 and 1275 kg ha-1) yields and pooled results, respectively, as well as Fe, Mn, Zn and Cu uptake by bulb and dry leaves of garlic were registered with soil application of FeSO4 @ 15 kg ha-1 and ZnSO4 @ 8 kg ha-1 as per soil test value (STV),follow by soil application of multi-micronutrients Grade-V @ 40 kg ha-1(T7) and foliar multi-micronutrients supplementation through 1.0 % spray having Fe-4.0%,Mn-0.1%,Zn-5.0%, Cu-0.5% and B-0.5 % grade-IV (T5) at 60, 75 and 90 days after sowing (DAS).These all the treatment were statistically at par with each other but significantly superior over control. The magnitude of increased in fruit yield were 22.8 and 14.8 and 14.2 % owing to soil application of FeSO4 @15kg ha-1 + ZnSO4 @ 8 kg ha-1 (STV-T8) and soil application of micronutrients mixture grade- V @ 40 kg ha-1(T7) and micronutrients mixture grade-IV spray @ 1.0 % (T5) at 60,75 and 90 days after sowing (DAS), respectively, over control. Significantly higher value of bulb height (2.3 cm), plant height (26.5 cm), No of cloves per bulb (10.9) and bulb girth (1.9 cm) were also recorded with soil application of FeSO4 @ 15 kgha-1 and ZnSO4 @ 8 kgha-1 as per soil test value (STV), follow by foliar multi-micronutrients mixture Grade IV (T5). These both the treatments were statistically at par with each other but significantly superior over control. The soil application of multi-micronutrients mixture as per STV, soil application of multi-micronutrients @ 40 kg ha-1 and foliar spray 1.0% grade -IV were found beneficial and economical in increasing garlic yield.

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Introduction

Intensive cropping, imbalanced fertilization and no use of micronutrients, less or no use of organic manures have resulted the depletion of soil fertility in Bangladesh. Consequently, micronutrients statuses have been decreasing day by day and finally fertility status of Bangladesh soils have been declining. A good soil should have an organic matter content of more than 3 %. But in Bangladesh, most soils have less than 1.5 %, some soils have less than 1 % matter content (BARC, 2005).

There are 30 AEZs, 88 sub-zones and agro-ecological units in Bangladesh (Bhuiya *et al.* 2005). The experimented area belongs to High Ganges River Floodplain soils (AEZ 11) which is one of the most important calcareous soils of Bangladesh containing large amount of $CaCO_3$ as well as high concentration of available Ca^{2+} in that soil. The pH is generally ranges from 7.6-8.5 but in most of the upland soils ranges between 8.0-8.5 (Alam, 2006). Normally, zinc (Zn) and B become less available to plants with increasing soil pH. Requirement of B for plant growth and yield is greater when Ca availability is high (Tisdale *et al.* 1995). Boron (B) requirements are common on upland crops in humid regions and also in calcareous soil. Deficiencies of B are widespread in humid regions by leaching losses (Troeh *et al.* 1993). It is wide spread and often incipient that B deficiency seems to exist in Bangladesh soils (Protch and Islam, 1984). Micronutrients are equally important in plant nutrition as macronutrients though they simply occur in plants and soils in much lower concentrations. Plants grown in micronutrients-deficient soils exhibit similar reductions in productivity as those grown in macronutrient-deficient soils. The information regarding the use of Zn, Cu, B, Mn, Mo alone or in combination with NPK for production of garlic under Bangladesh condition is scant (Baquee, 1998).

Zinc (Zn) deficiency causes rosetting or clustering of small leaves at the top of the plant. Eventually, older leaves exhibit brown spots or leaf tips turn yellow-orange progressing to the entire leaf. Content of Mo in plant is normally low which also structural component of nitrogenase enzyme is. Water lodging, wilting and increased incidence of disease is observed due to reduced lignifications with low Cu.

Abode of Garlic (*Allium sativum* L.) from Medditerranean region (Thompson and Kelly, 1957) used as spices in Bangladesh which belong to Alliaceae family. Garlic contents allicin which dwindles cholesterol in human blood. In respect of garlic, FAO (2007) reported that China produced the highest 12064662 MT, India 645000 MT where Bangladesh possessed sixth in position 176710 MT.

The yield garlic are very lower than those of other countries because of our farmer's inadequate knowledge about benefits of micronutrients. This research work will be very helpful to solve the persistent problems of the micronutrient deficiency garlic to some extent. Under these circumstances, the present study was undertaken with the following objectives:

- To increase the production of garlic by management of micronutrients.

Materials and methods

The experiment was carried out in a farmer's field at Shympur, Rajshahi in Bangladesh. Indigenous garlic variety was planted during November 2008 to April 2009. Materials and methods include a brief description of experimental site and scientific method that was adopted to fulfill the experiments.

Experimental site

The experiment was carried out in the field of a farmer situated at Shyampur Rajshahi, during the Rabi season. Cropping pattern was intensive in this region. Rajshahi district is situated between in the latitude 24° 21′ 50″ and longitude 80° 36′ 05 ″ (Map of Bangladesh). The experiment was extended from November 2008 to April 2009.

Characteristics of soil

The soil texture of the experimental site was "Silty Loam", land was medium high and belongs to the

Agro-Ecological Zone-11 which was originated from "High Ganges River Floodplains" deposits, having "Calcareous Dark Grey Floodplain soils" (FAO, 1988). To determine the soil characteristics of the different experimental sites, soil sample was collected at a depth 0-18 cm before the application of manures and fertilizers, and were analyzed of soil texture by Hydrometer method and other parameters by Hunter (1984).

Climate

garlic grow in mild climate without extremes of hot or low temperatures even though it can be grown under a wide range of climatic conditions. Rainfall was totally absent from November 2008 to February 2009. Average temperature was 29.33° C.

Land preparation

The land was opened by a disc plough and it was exposed to the sun for 7 days prior to next ploughing. There after the land was ploughed and cross ploughed by country plough several times to obtain good tilth. Deep ploughing and good tilth was needed for getting better yield of bulb crops (Ahmed, 1988). Each plouging was followed by leveling in order to break the soil clods into small pieces. All weeds and stubbles were removed.

Fertilization

Urea, triple super phosphate and potassium sulphate and gypsum respectively. Total amount of TSP, one third of urea and potassium sulphate gypsum as basal dose during land preparation. The rest quantities of urea were top dressed after 30 and 60 DAP. Quantity of basal doses were applied to the field as N, P, K and S following 150, 50, 100, and 20 kg/ha respectively.

Experimental design and layout

The experiment was laid out in RCBD with three replications. Each block was divided into seven plots where seven treatments were allotted at random. Thus, there were 33 (11 x 3) unite plots altogether in the experiment. The size of the plot was 1 m x 1 m and 15 cm width drain was made between two adjacent plots. The plots were raised up to 15 cm.

Collection of bulbs and planting time

An indigenous local variety of garlic was used as mother cloves. The bulbs were planted in soil at 6th November in a farmer's field located at the eastern side of wheat research centre Shyampur, Rajshahi.

Planting methods

Bulbs were transplanted 15 × 10 cm line spacing. Thirty six small and healthy bulbs were planted in each unit plot. The unit plot size was 1 m × 1 m. The cloves were dibbled at 5 cm depth of soil. Emergence of onion seedlings commenced six days after sowing. Emergences of seedlings were 100 %.

Temperature was high so that light sprinkling of water was given in each plot to manage moisture of soil. There were six shallow furrows per plot. Clods were grinded in lines continuously by hand and covered with loose soil.

Application of micro-nutrients

The micronutrients were applied with basal dose. Ashes and sand were mixed with micronutrients for equal distribution to soil of each plot. Only urea was given as splitting.

Experimental treatments

Treatments were applied as Randomized Complete Block Design (RCBD). The treatments are as follows:

Intercultural operations

Garlics are closely planted crop. Manual weeding is tedious, expensive and often damages the plants. In East Java, two weedings at 30 and 60 days after planting led to the highest yield of fresh bulbs (Aliudin, 1979). Over-crowded extra seedlings were thinned out twice.

Irrigation

Irrigation was applied by observing the soil moisture condition. However, each top-dressing was followed by irrigation. This practice was done carefully of each unit plots. Irrigation was done at 15, 30, 45, 60 days after planting to onion and garlic. It was also done at 80, 90 DAP for garlic.

Weed control

Garlics were planted closely and they are shallow rooted crops. Thus hand-weeding is difficult which may also damage the crop. Manual weeding is also becoming expensive. Therefore, it is suggested to use chemical weedicides along with one hand–weeding at critical stage.

Harvesting

Garlics were harvested on April 2009. Data on yield and yield components were analyzed statically using Duncun's Multiple Range test (DMRT) by MSTAT-C soft wire. Means were separated.

Collection of data

Ten plants were selected randomly from each unit plot to collect the experimental data. The plants in the outer rows and the extreme end of the middle rows were excluded to avoid the boarder effect. The following observations were made regarding plant growth, yield and yield attributes as affected by the different micro-nutrient elements in different concentrations.

Number of leaves

All leaves of plants were counted separately from ten plants of each plot selected randomly. Mean value was recorded from collected data and this data was finalized for analysis.

Plant height

Plant height was measured from the lower to tip of the leaves and lengths of well-developed leaves were also considered. Data for onion and garlic were observed separately.

Fresh weight of leaves

After harvesting following data were recorded. Fresh leaves were cut by sharpen knife and weighted at balance. Data of garlic were noted in the same manner.

Fresh weight of bulbs

After uprooting the bulbs were separated from soil clods and separated by knife. Five or more than five bulbs were balanced simultaneously. Then average number was taken for final analysis.

Fresh weight of roots

Roots of five bulbs were detached by scissors and were measured by balance and average mean number was taken. Data Fresh weights of garlics were measured in C.G.S unit.

Diameter of bulb

Diameters of bulbs were measured by slide calipers. Bulbs were selected randomly and mean value was taken for analysis. Care was taken so that slanting diameter was strictly avoided. Leaves, roots, bulbs were detached by sharp knife at harvest and fresh weight were taken.

Splitting of cloves of garlic

Cloves of Garlic were also splitted carefully. Mean value were calculated from several number of bulbs. Splitting of cloves was counted and data were noted down separately.

Yield

Total bulbs harvested from each plot were air dried with top and total weight of bulbs after detopping was taken with a balance. This was equal to the yield from 1 m^2 plot and was easily converted into suitable unit. Plot yield was converted to t/ha by following arithmetic rules. All leaves were removed from the plants and the weight of the roots was taken from the plants and the weight of the roots was taken from the plants and weight of the roots was taken from separately for recording.

Dry weight of leaves

After harvesting bulbs a specific amount of fresh leaves were dried in sun for few days because it was bright sunny day. After sun drying dry leaves were taken in oven drier and final weight was calculated for analysis.

Dry weight of bulbs

Firstly bulbs were spillitted in to several pieces and it was taken to poly bag holding its identical label. Then

it was dried in sun. After proper drying the sample was taken to oven drier.

Dry weight of roots

Immediately after harvesting roots were cleaned. Then 100g of roots were weight and were cutted into small pieces. Then those were air dried under laboratory condition. The air dried samples were then dried for 48 hours at normal pressure and 70°C ± 2°C in an oven. After drying, it was weighted on an electrical balance.

Statistical analysis

The recorded data were statistically analyzed using MSTAT-C package programme.. The means for all the treatments were calculated and the analysis of variance of the characters and nutrient content under study were performed by F-variance test. The differences among the treatment means were evaluated By Duncan's Multiple Range Test (Russel, 1996).

Results and discussions

Response of micronutrients on growth and yield of garlic

Response of micronutrients on vegetative growth and yield of garlic due to application of different elements were following.

Number of leaves

It was observed that leaves number at 40, 55 and 70 DAP of garlic was not significant. The number of leaves at 85, 100 and 115 DAP was significant at 1 % level. Single effects of T_2 (Zn), T_3 (B) was examined but combination of T_4 (Zn + B) gave the highest leaves number 16.58. The value (16.58) was followed by T_3. T_2 (Zn) showed the third highest result. Therefore, calcareous soil of Bangladesh (AEZ 11, High Ganges River Floodplains) showed significant effect on leaves number of garlic at T_2, T_3 or simultaneous effect (T_4) of that treatment. NPKS fertilizers were used as basal dose so the control plot produced 13.66 leaves per plant which was not so much variable than other treatments combination. Similar observations were also experimented by Ranjan *et al.* (2005). The additional supply of micronutrients accumulated more reserve substances in the leaves which perhaps enhanced the number of leaves. Chlorosis were observed from T_1 (control) plot which was observed by Agarwala *et al.* (1979).

Plant height

The effect of micronutrients on garlic were analyzed non-significant at 40, 55 and 70 DAP. The effect of micronutrients was found significant at 85, 100 and 115 DAP. significant value. The highest plant height was found in T_4 (58.63 cm, Table 8) and the lowest plant height was found T_{11} (52.03 cm) followed by T_2 (57.62 cm). However, T_2 (Zn) plays important role in plant height of garlic. This result was also similar to Ranjan *et al.* (2005). They stated that Zn, B was important micronutrients for vegetative growth and yield of garlic.

Table 1. The treatments of micronutrients.

Treatments	Rates (kg/ha)					
	Zn	B	Mo	Mn	Cu	Cl
T_1 = Control	-	-	-	-	-	-
T_2 = Zn	3	-	-	-	-	-
T_3 = B	-	3	-	-	-	-
T_4 = Zn+B	3	3	-	-	-	-
T_5 = Zn+B+Mo	3	3	0.5	-	-	-
T_6 = Zn+B+Mn	3	3	-	4	-	-
T_7 = Zn+B+Cu	3	3	-	-	1	-
T_8 = Zn+B+Cl	3	3	-	-	-	20
T_9 = Zn+B+Mo+Mn	3	3	0.5	4	-	-
T_{10} = Zn+B+Mo+Mn+Cu	3	3	0.5	4	1	-
T_{11} = Zn+B+Mo+Mn+Cu+Cl	3	3	0.5	4	1	20

Fresh weight of leaves

Influence of micronutrients on fresh weight leaves of garlic was not significant. The maximum fresh weight of leaves per plant (7.21 g) was produced by the plant having T_4 (Zn + B) treatments (Table 9) while the minimum (5.52 g,) was marked in T_1. The increased weight of leaves was probably due to combination of Zn and B in calcareous soil. T_2 (Zn) produced (6.91 g,) which was followed by T_3 (B) 6.59 g. Although T_2 and T_3 influenced the leaves number of garlic separately, it was revealed that the combination of higher levels of T_4 played significant role on vegetative growth of the plant. The same result using Zn and B were observed by BARI, report 2007-08.

This report depicted that vegetative growth of garlic was increased due to application of the concerned micronutrient especially Zn and B.

Table 2. Effect of micronutrients on leaves number per plant of garlic.

Treatments	40 DAP	55 DAP	70 DAP	85 DAP	100 DAP	115 DAP
T_1 = Control	4.59 a	4.87 ab	7.45 ab	7.73 d	11.42 de	13.66 c
T_2 = Zn	4.60 a	5.23 a	8.22 ab	8.90 a	13.46 ab	15.33 bc
T_3 = B	4.15 a	4.86 ab	7.49 ab	8.51 abc	13.10 ab	16.58 ab
T_4 = Zn+B	4.31 a	4.71 ab	8.58 a	8.78 ab	13.83 a	18.20 a
T_5 = Zn+B+Mo	4.11 a	4.57 b	7.76 ab	8.18 cd	12.79 abc	13.92 c
T_6 = Zn+B+Mn	4.22 a	4.97 ab	7.71 ab	8.30 bcd	13.12 ab	14.11 c
T_7 = Zn+B+Cu	4.34 a	4.79 ab	7.66 ab	8.22 bcd	12.90 abc	14.27 c
T_8 = Zn+B+Cl	4.25 a	4.84 ab	7.86 ab	8.25 bcd	12.42 bcd	14.23 c
T_9 = Zn+B+Mo+Mn	4.39 a	4.97 ab	7.29 b	8.28 bcd	11.97 cde	13.69 c
T_{10} = Zn+B+Mo+Mn+Cu	4.08 a	4.85 ab	7.57 ab	7.89 d	11.29 e	14.17 c
T_{11} = Zn+B+Mo+Mn+Cu+Cl	4.40 a	4.57 b	7.12 b	7.79 d	12.42 bcd	14.36 c
CV %	8.43	6.46	7.86	3.60	4.46	7.21

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level; each parameter represents 30 plants; DAP =Days After Planting.

Fresh weight of bulbs

Fresh weight of garlic bulbs were not found significant at 5% level but significant at 1 % level. The highest value was observed in T_4 (18.97 g) and the lowest value was recorded in control T_1 (15.74 g, Table 9). T_3 (B) produced 18.80 g and 18.56 g fresh weight of bulb was followed by T_2. Response of T_5, T_6, T_{10} and T_{11} were statistically identical. EL Gamelli (2000) studied that fresh weight of bulbs were positively affected by application of micronutrients and the tested foliar fertilizers which is related to this experiment. Similar result was found from Maurya and Lal (1975) and they reported that the yield and bulb quality significantly increased by the application of Zn at 1, 2 and 3 ppm.

Fresh weight of roots

Results of different micronutrients on fresh weight roots of garlic were analyzed and were found highly significant. The highest value (1.22 g, Table 9) was recorded in T_4 and was followed by T_2 1.18 g T_3 (1.08 g).while the lowest value (0.92 g) was obtained from control (T_1). Fresh weight of roots per plant of garlic resulted maximum from the treatment T_4. The effect of other treatments were non-significant. However, variation was not observed significant to other treatments.

Number of cloves of garlic

Influences of micronutrients exhibited not significant variation in respects of garlic's clove. The maximum number (23.57, Table 10) was observed in T_3 (B) while T_9 produced the minimum number (21.28) of cloves per bulb of garlic. T_2 (Zn) produced 23.23 cloves per bulb whereas 23.51 cloves per bulb was remarked in T_4. BARI-report (2005-2008) forecasted that the application of B had significant variation on cloves number per bulb. Similar result was observed by Phor

et al. (1995). They showed the highest numbers of cloves were obtained from Zn. This result was similar to this experiment.

Diameter of bulb

Response of micronutrients exhibited not significant variation in respect of diameter of garlic bulb. The highest diameter of garlic was obtained from treatment T_4 (3.75 cm, Table 10) and the value (3.65 cm) was respectively by T_6 (Zn + B + Mn). The lowest diameter of garlic was observed from the control T_1 (3.26 cm). Effect of T_2 was 3.64 cm. Response of T_3 was 3.49 cm. Among the treatments T_4 was noticed the largest diameter of bulb producing elements but no statistical variation among the diameter of bulbs. Because analysis showed same rank for all the treatments. Sharangi *et al.* (2003) also found the same result and they observed synergistic relationship with Zn, B in yield contributing character of garlic.

Table 3. Effect of micronutrients on plant height of garlic

Treatments	40 DAP (cm)	55 DAP (cm)	70 DAP (cm)	85 DAP (cm)	100 DAP (cm)	115 DAP (cm)
T_1 = Control	33.62 cd	40.49 a	41.31 a	41.79 d	44.04d	52.20 c
T_2 = Zn	36.17 ab	36.10 a	41.42 a	47.26 a	50.15a	57.62 a
T_3 = B	36.00 ab	40.08 a	40.46 a	45.18 abc	47.30b	56.49 ab
T_4 = Zn+B	37.05 a	39.84 a	40.76 a	45.91ab	50.00a	58.36 a
T_5 = Zn+B+Mo	32.10 de	38.78 a	39.42 a	45.37 abc	45.58 bcd	52.91c
T_6 = Zn+B+Mn	35.40 abc	39.38 a	39.53 a	42.93 d	47.20 b	56.24 ab
T_7 = Zn+B+Cu	31.20 e	38.42 a	39.65 a	44.03 bcd	46.13 bc	54.11 bc
T_8 = Zn+B+Cl	36.44 ab	40.90 a	40.99 a	43.15 cd	46.86 bc	54.27 bc
T_9 = Zn+B+Mo+Mn	36.12 ab	39.52 a	41.07 a	43.45 bcd	47.13 bc	53.24 c
T_{10} = Zn+B+Mo+Mn+Cu	37.52 a	40.23 a	41.06 a	41.85 d	44.25 d	53.07 c
T_{11} = Zn+B+Mo+Mn+Cu+Cl	34.47 bc	38.83 a	39.83 a	42.16 d	45.22 cd	52.03 c
CV %	3.37	8.61	6.46	3.05	2.18	2.46

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level; each parameter represents 30 plants; DAP =Days After Planting.

Table 4. Effect of micronutrients on fresh weight leaves, bulbs and roots (g) of garlic.

Treatments	Fresh weight of leaves (g)	Fresh weight of bulbs (g)	Fresh weight of roots (g)
T_1 = Control	5.52 d	15.74 d	0.92 c
T_2 = Zn	6.91 ab	18.56 abc	1.18 a
T_3 = B	6.59 abc	18.80 ab	1.08 b
T_4 = Zn+B	7.21 a	18.97 a	1.22 a
T_5 = Zn+B+Mo	5.94 bcd	17.07 abcd	1.00 bc
T_6 = Zn+B+Mn	6.08 bcd	17.18 abcd	0.98 c
T_7 = Zn+B+Cu	6.39 abcd	16.46 cd	0.96 c
T_8 = Zn+B+Cl	6.38 abcd	16.67 bcd	0.99 bc
T_9 = Zn+B+Mo+Mn	5.90 cd	16.58 cd	0.97 c
T_{10} = Zn+B+Mo+Mn+Cu	6.09 bcd	17.11 abcd	0.97 c
T_{11}= Zn+B+Mo+Mn+Cu+Cl	6.02 bcd	16.93 abcd	0.96 c
CV %	7.93	6.44	5.09

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level; each parameter represents 30 plants; DAP =Days After Planting.

Yield per hectare

Various micronutrients showed significant variation on the total yield of garlic. The highest result was examined in T_3 (6.38 t/ha, Table 10). This was possibly due to the fact that optimum doses play significant role in the production of garlic. The downward trend was observed in control (T_1) treatment (5.36 t/ha). Afterward value was 6.06 t/ha followed by T_4 (Zn + B). Production rate of other combinations (T_2, T_5, T_8, T_{10} and T_{11}) were statistical identical. Chemisiri *et al.* (1995) carried out a field experiment on the effect of boron sources on garlic productivity. They found that the highest yield (6.13 t/ha) was obtained at 825 g B/ha.

This treatment also produced the largest and heaviest garlic cloves. Combinations of Zn and B resulted (608.09 g) yield of garlic per plot. The rate (3 kg/ha) of Zn produced 581.80 g of garlic per plot. The result was so much interrelated with Francois (1991) in respect of garlic. Sharangi *et al.* (2003) obtained the same result treating Zn and B separately.

Table 5. Effect of micro-nutrients on cloves, diameter of bulbs and yield of garlic.

Treatments	Cloves/bulb (number)	Diameter of bulb (cm)	Yield t/ha
T_1 = Control	21.38 ab	3.26 a	5.36 d
T_2 = Zn	23.23 a	3.64 a	5.82 abcd
T_3 = B	23.57 a	3.49 a	6.38 a
T_4 = Zn+B	23.51 a	3.75 a	6.06 ab
T_5 = Zn+B+Mo	22.54 ab	3.49 a	5.79 abcd
T_6 = Zn+B+Mn	22.88 a	3.65 a	5.62 bcd
T_7 = Zn+B+Cu	23.11 a	3.36 a	5.93 abc
T_8 = Zn+B+Cl	20.44 b	3.45 a	5.58 bcd
T_9 = Zn+B+Mo+Mn	21.28 ab	3.21 a	5.47 cd
T_{10} = Zn+B+Mo+Mn+Cu	22.59 ab	3.49 a	5.76 abcd
T_{11} = Zn+B+Mo+Mn+Cu+Cl	22.53 ab	3.45 a	5.82 abcd
CV (%)	5.20	7.63	4.76

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level; each parameter represents 30 plants; DAP =Days After Planting.

Maurya and Lal (1975) found that garlic responded well to Zn nutrition (1-3 ppm) regarding in yield and bulb quality. Phor *et al.* (1995) studied about the effects of Zn on the growth and yield of garlic.

They experimented that the effect of Zn at 0, 2.50 or 5 kg $ZnCl_2$ on the growth and yield of garlic. Plant growth and yield increased at increased rates of Zn. The highest yield was observed from the application of Zn @ 5 kg/ha.

Dry weight of leaves

The dry weight of leaves of garlic was statistically highly significant. The highest value was found from the treatments T_4 (1.78 g, Table 11). In case of all other treatments combinations the value, T_3 was noted 1.73 (g), afterwards 1.69 g leaves per plant was obtained from T_2 which was followed by T_9, T_6 and T_7 respectively. However, the lowest value was found T_{11} (1.08 g,). Lal and Maurya (1981) stated that dry weight of leaves; roots and bulbs were excellence in plants receiving Zn at 3 ppm in respect of onion which is closely related to this experiment.

Dry weight of bulbs

The dry weight of garlic bulbs was not statistically significant. Influence of micronutrients on production of dry weight bulb of garlic showed maximum result by the treatments of T_4 (4.763 g) while the downward value (3.42 g, Table 11) was observed from T_1. Dry

weight of garlic bulbs varied from 3.42 g to 4.56 g. Impact of T_2 and T_3 was statistically identical. Singh and Tiwari (1995) mentioned that percent dry matter was significantly increased by micronutrients especially Zn. Effect of T_2 was found 4.56 g per bulb. Impact of B in yield per plot was found 4.33 g. All the micronutrients combinations were not statistically significant on dry weight of bulbs.

Table 6. Effect of micronutrients on dry weight of garlic.

Treatments	Dry weight of leaves (g)	Dry weight of bulbs(g)	Dry weight of roots (g)
T_1 = Control	1.51 bcd	3.42 c	0.37 a
T_2 = Zn	1.69 abc	4.56 ab	0.38 a
T_3 = B	1.73 ab	4.33 ab	0.36 a
T_4 = Zn + B	1.78 a	4.76 a	0.39 a
T_5 = Zn + B + Mo	1.49 cd	4.04 bc	0.37 a
T_6 = Zn + B + Mn	1.62 abcd	4.29 ab	0.38 a
T_7 = Zn + B + Cu	1.57 abcd	3.97 bc	0.37 a
T_8 = Zn + B + Cl	1.63 abcd	4.02 bc	0.34 a
T_9 = Zn + B + Mo + Mn	1.69 abc	4.07 b	0.36 a
T_{10} = Zn + B + Mo + Mn + Cu	1.41 d	4.21 ab	0.36 a
T_{11} = Zn + B + Mo + Mn + Cu+Cl	1.08 e	4.19 ab	0.36 a
CV (%)	7.57	8.07	6.46

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level; each parameter represents 30 plants; DAP =Days After Planting.

Dry weight of roots

Dry weights of roots of garlic were not significantly affected by the treatments. In case of all the treatments dry weight of roots was found with treatment combinations of T_4 (Zn + B) (0.39 g Table 11) and the downward value was found by the treatment T_{11} (0.36 g), although they were statistically in similar. Treatment T_2 (Zn) have produced 0.38 g, where dose of B produced 0.36 g. The influence of all the treatments showed statistically same lettering in DMRT analysis. Singh and Tiwari (1995) stated that dry matter of roots were significantly affected by micronutrients especially Zn. This experimented result was positive to their statements.

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