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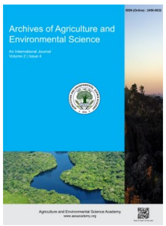

ORIGINAL RESEARCH ARTICLE

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Effects of micronutrients on bulb growth, yield and quality of local and high yielding onion (*Allium cepa* L.) cultivars in Bangladesh

Md. Harun Ar Rashid* and **Md. Tariqul Islam**

Department of Horticulture, Bangladesh Agricultural University, Mymensingh 2202, BANGLADESH
*Corresponding author's Email: harun_hort@bau.edu.bd

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ABSTRACT

Micronutrients have important functions on onion production. An experiment was conducted at the Landscape section and Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from October, 2017 to March, 2018 to investigate the effects of micronutrients on bulb growth, yield and quality of local and high yielding (HY) onion cultivars in Bangladesh. The experiment comprised three onion cultivars *viz*., Taherpuri (local), BARI Piaz 1 (HY) and BARI Piaz 4 (HY), and five micronutrients *viz*., Control (no micronutrient), Boron (B) @ 0.2 g/plot, Zinc (Zn) @ 0.5 g/plot, Copper (Cu) @ 0.2 g/plot and B+Zn+Cu @ (0.2+0.5+0.2 g/plot). The two-factor experiment was laid out in randomized complete block design with three replications. Results revealed that onion cultivars and micronutrients had significant influence on the parameters studied. BARI Piaz 4 along with the application of B+Zn+Cu @ 0.2+0.5+0.2 g/plot produced the highest bulb size, increased plant height, number of leaves, fresh weight of bulb, per cent dry matter content of bulbs and bulb yield compared to other onion cultivars and micronutrient treatments. The highest bulb yield (16.07 t/ha) was recorded in B+Zn+Cu, while the lowest bulb yield (8.92 t/ha) was found from control. Highest gross yield of onion (20.67 t/ha) was recorded from BARI Piaz 4 with B+Zn+Cu @ 0.2+0.5+0.2 g/plot. Therefore, it can be concluded that combined treatment of BARI Piaz 4 and B+Zn+Cu @ @ 0.2+0.5+0.2 g/plot was found to be better in respect of bulb growth and yield, and Taherpuri for quality of onion.

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INTRODUCTION

Onion (*Allium cepa* L.) belonging to the family Alliaceae, is one of the most important and popular vegetable and spice crops cultivated worldwide (Mishra *et al*., 2013). Onion is famous for its characteristics flavour and it is widely used to increase the taste of foods like gravies, soups, stew stuffing, fried fish and meat (Rashid *et al*., 2016). The main edible portion is the bulb, which is a modified organ consisting of thickened fleshy scale leaves and stem plate. The countries of Iran, Afghanistan and the northern regions of Turkmenistan, Uzbekistan and Tajikistan are to be thought the origin of onion (Purseglove, 1972; Brewster, 1994). The major onion producing countries of the world are India, China, USA, Iran, Russia, Turkey, Egypt, Pakistan, Brazil and Algeria (FAOSTAT, 2016a).
Among the spice crops grown in Bangladesh, onion ranks top in respect of both area and production (BBS, 2017). In Bangladesh, onion is mainly produced in winter season. It is grown almost all parts of the country such as Faridpur, Dhaka, Mymensingh, Pabna, Comilla, Rahshahi, Jessore and Rangpur Districts (BBS, 2017). Total production of onion in Bangladesh is 9,85,000 tons from an area of 2,16,200 hectares with the the average yield of 9.5 tons/ha (BBS, 2017), which is very low compared to the average yield (30-40 t/ha) of other onion growing countries in the world. The demand of onion in Bangladesh is increasing day by day and every year Bangladesh has to import a lot of onion to

fulfill the shortage of demand of the country from India and China (Hossain and Islam, 2006). But due to limitation of land and climate, introduction and cultivation of high yielding exotic varieties is not possible in Bangladesh. The only possible way to increase the per hectare yield of onion is through manipulating existing method of cultivation such as planting geometry, manure and fertilizer application, irrigation, use of growth regulators and other cultural management practices (Kokobe *et al*., 2013; Rashid *et al*., 2010). Efforts are being made to popularize the onion cultivation through innovative production technology during winter season, which is greatly influenced by agronomic practices (Mondal *et al*., 1986).

Micronutrients are just as important as the macronutrients in respect of their functions in plants and are required in smaller quantities. The micronutrients required by plants include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni). The availability of these nutrients in soil depends on the soil and the environment. Boron is an essential micronutrient required for normal plant growth and development. It is a very sensitive element and plants differ widely in their requirements but the ranges of deficiency and toxicity are narrow. It maintains a balance between sugar and starch in plant body. It translocates sugar and carbohydrates in different parts of the plant body. It is important in pollination and seed reproduction also. It is necessary for normal cell division, cell wall formation, nitrogen and carbohydrate metabolism and water relation. Zinc is involved in a diverse range of enzyme system, auxin metabolism, influence on the activities of dehydrogenase and carbonic anhydrate enzymes, synthesis of cytochrome and stabilization or ribosomal fractions (Tisdale *et al*., 1984). Copper is necessary for carbohydrate and nitrogen metabolism. Inadequate copper results in stunting of plants. Copper also is required for lignin synthesis, which is needed for cell wall strength and prevention of wilting. Hence, it plays a good role in photosynthesis. Nutrient management is a critical component for successful onion production. Growers should carefully follow recommendations for micronutrients to avoid unnecessary costs and possible toxic effects or deleterious interactions with other nutrients. It has been reported that the application of zinc and boron significantly increased the plant height of onion (BARI, 2008). Furthermore, micronutrients help increase the efficiency of the use of macronutrients. Unfortunately micronutrients have received less attention in fertilizer management research, development and extension in Bangladesh. Traditionally, emphasis has been given to macronutrients such as N, P and K fertilizers, though micronutrients can also increase yield and quality of vegetable and spice crops. The present study has therefore been undertaken to investigate the effects of micronutrients on bulb growth, yield and quality of local and high yielding (HY) onion cultivars in Bangladesh.

MATERIALS AND METHODS

Experimental site, climate and soil

The experiment was conducted at the Landscape section and Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from October, 2017 to March, 2018 to investigate the effects of micronutrients on bulb growth, yield and quality of local and high yielding (HY) onion cultivars in Bangladesh. The experimental area is located at 26° 46'N latitude and 90° 24'E longitudes. The elevation of the area is approximately 18 m from average sea level. The experimental site was under sub-tropical climatic zone which is characterized by scanty rainfall, low humidity, low temperature and short day period during Rabi season (October to March) and heavy rainfall, high humidity, high temperature and relatively long day during Kharif season (April to September) and Edris *et al.* (1979) reported that this experimental location is under sub-tropical climate characterized by these distinct seasons of the monsoon or rainy season extending from May to October, the winter or dry season from November to February and pre-monsoon period or hot season from March to April. The winter (Rabi season) followed by early part of a hot season is favourable for onion cultivation. The experimental site was medium high land belonging to the Old Brahmaputra Floodplain under the Agro-Ecological Zone 9 having non-calcareous dark gray floodplain soil (UNDP and FAO, 1988). The soil of the experimental plot was silty loam in texture. Soil pH was 6.85, having low organic matter. It was well drained with good irrigation facilities.

Treatments

The experiment consisted of three cultivars *viz*., V_1= Taherpuri (local), V_2= BARI Piaz-1 (HY) and V_3= BARI Piaz-4 (HY), and five micronutrients *viz*., T_0 = Control (no micronutrient), T_1 = Boron (B) @ 0.2 g/plot, T_2 = Zinc (Zn) @ 0.5 g/plot, T_3 = Copper (Cu) @ 0.2 g/plot, T_4 = B+Zn+Cu @ (0.2+0.5+0.2 g/plot).

Planting materials

One local onion cultivar Taherpuri, and two Bangladesh Agriculture Research Institute (BARI) released variety BARI piaz 1 and BARI piaz 4 were selected and used for this experiment. Onion seeds were collected from the local markets of Mymensingh and Spice Research Centre (SRC) of BARI, Bagura.

Experimental design and layout

The two-factor experiment was laid out in randomized complete block design with three replications. The total area of this experiment was divided into three blocks and each block contained 15 plots. Thus, there were 45 (3×5×3) unit plots in total. The treatments were randomly placed to unit plot in each block. The size of each unit plot was 1m × 1m. The distance between the blocks was 50 cm and between the plots was 30 cm with the plant spacing of 25 cm × 10 cm to facilitate different intercultural operations.

Seedbed preparation

The land was first ploughed with power tiller and the clods were broken by ladder. Weeds and stubbles were removed from the land. Three seedbeds were prepared for three varieties of onion.

Each of the beds were used for each varieties i.e. Taherpuri in seedbed 1, BARI Piaz 1 in seedbed 2 and BARI Piaz 4 in seedbed 3. Seeds of the three varieties of onion were sown in seedbeds.

Land preparation and application of manures and fertilizers

The land was first ploughed with a power tiller before 20 days of seed sowing. Thereafter, it was ploughed and cross ploughed five times followed by laddering to break the clods and to level the soil. During land preparation, weeds and stubbles of previous crops were collected and removed from the plot. These operations were done to obtain a good tilth for planting of onion seedlings. Urea, TSP, MoP and sulphur fertilizers were applied to the experimental plots with N @ 100 kg/ha, P @ 35 kg/ha, K @ 96 kg/ha and S @ 15 kg/ha except micronutrients under investigation according to BARC (2010). Cowdung was applied to the land @ 12 t/ha before land preparation during the month of October. The doses of NPKS were same for all treatments but the micronutrients doses were different.

Transplanting of seedlings

Thirty five days old healthy, disease free and uniform seedlings were uprooted from the seedbeds and were transplanted to the main field after slight leaf trimming on 23 November 2017, maintaining the spacing of 25 cm × 10 cm accommodating 40 plants in each unit plot. The depth of planting was 2.5 cm from the surface of the soil. Seedbeds were watered in the morning before uprooting the seedlings. The seedlings were uprooted carefully from the seedbed to ensure minimum injury to the root system. Transplanting was done in the afternoon and lightly watered with watering can immediately after transplanting for better establishment. A number of seedlings were planted in the border of the experimental plot for gap filling.

Data collection

Data on various parameters such as plant height (cm), number of leaves per plant, Bulb length (cm), bulb diameter (cm), fresh weight of bulb (g), percent dry matter content, percent splitted bulb, percent rotten bulb, percent weight loss, gross yield per plot (kg) and hectare were recorded from the sample plants during experimentation. Ten plants were randomly selected for this purpose from each plot in such a way so that border effect could be avoided.

Statistical analysis

The recorded data on various parameters under study were statistically analyzed using MSTAT-C program. The means for all the treatments were calculated and analysis of variance for each parameter was performed by F-test (Gomez and Gomez, 1984). Comparison of the treatment means was done by Least Significance Difference (LSD) test at 5% level of probability.

RESULTS AND DISCUSSION

Effect of onion cultivars

Statistically significant variation was observed among the onion cultivars in terms of all the parameters under study (Table 1 and Figure 1). Results revealed that during the growth period, plant height and number of leaves per plant increased gradually and reached to peak at 85 days after storage (DAS). The maximum plant height (48.82 cm) and number of leaves per plant (11.40) were obtained from the BARI Piaz 4 and the minimum plant height (38.46 cm) and number of leaves per plant (8.82) were recorded from Taherpuri (Table 1). It was found that the variety (V_3) BARI Piaz 4 gave the maximum bulb length (5.06 cm), bulb diameter (4.06 cm) and fresh weight of bulb (45.60 g), while the minimum bulb length (3.18 cm), bulb diameter (2.22 cm) and fresh weight of bulb were recorded from Taherpuri (V_1), respectively (Table 1). The highest splitted bulb (23.11%) and rotten bulbs (14.23%) were recorded from V_3 (BARI Piaz 4) and the lowest splitted bulb (10.52%) and rotten bulb (6.37%) was recorded from V_1 (Taherpuri), respectively (Table 1).

Results showed that the maximum yield (17.14 t/ha) was recorded from BARI Piaz 4 (V_3) followed by 14.19 t/ha in BARI Piaz 1 (V_2) whereas Taherpuri (T_0) gave the minimum yield (9.00 t/ha) (Figure 1). The maximum weight loss of bulbs (23.74%) was recorded at 18 DAS and it was found from BARI Piaz 4 (V_3), followed by BARI Piaz 1 (23.08%) and Taherpuri (22.33%) (Table 1). The highest dry matter content of bulb (12.29%) was recorded from V_3 (BARI Piaz 4) and the lowest dry matter content (10.34%) was observed in V_1 (Taherpuri) (Table 1). This might be due to the fact that BARI Piaz 4 gave maximum vegetative growth as well as leaf number, which helped in maximum photosynthesis and accumulation of food material, which ultimately resulted in maximizing the percentage of dry matter content of onion bulbs. The result is supported by the findings of Naher *et al.* (2017) who reported that the maximum plant height, leaves plant-1, length of leaf, length of bulb, diameter of bulb, average bulb weight, number of bulb per m^2 and yield of bulbs were obtained by from the onion crop variety BARI Piaz 3 which was treated with 120 kg K ha^{-1} from the Sulphate of Potash (SOP) fertilizer.

Table 1. Main effect of local and high yielding cultivars on growth, yield and quality characters of onion.

Variety	Plant height at 85 DAS (cm)	No. of leaves/ plant at 85 DAS	Bulb length (cm)	Bulb diameter (cm)	Fresh weight of bulb (g)	Spitting of bulb (%)	% Rotten bulb	Weight loss (%)	% Dry matter content of bulb
V_1	38.46	8.82	3.18	2.22	19.93	10.52	6.37	22.33	10.34
V_2	45.70	10.74	4.18	3.02	37.99	18.77	8.17	23.08	11.73
V_3	48.82	11.40	5.06	4.06	45.60	23.11	14.23	23.74	12.29
$LSD_{0.05}$	0.57	0.25	0.05	0.05	0.61	0.73	0.33	0.11	0.21
Level of significance	*	*	*	*	*	*	*	*	*

*=5% level of probability, DAS= Days after sowing, V_1= Taherpuri (local), V_2= BARI Piaz 1 (HY) and V_3= BARI Piaz 4 (HY).

Table 2. Main effect of micronutrients on growth, yield and quality characters of onion.

Treatments	Plant height at 85 DAS (cm)	No. of leaves/ plant at 85 DAS	Bulb length (cm)	Bulb diameter (cm)	Fresh weight of bulb (g)	Spitting of bulb (%)	% Rotten bulb	Weight loss (%)	% Dry matter content of bulb
T_0	42.27	9.09	3.87	2.87	30.90	9.67	11.50	27.34	10.02
T_1	44.67	10.98	4.30	3.20	36.14	19.95	8.41	21.70	12.21
T_2	43.77	10.15	4.07	3.03	34.34	17.90	9.51	22.66	11.47
T_3	43.03	9.64	3.97	2.93	31.93	14.56	10.68	23.55	10.76
T_4	47.90	11.73	4.50	3.47	39.22	25.33	7.47	20.00	12.80
$LSD_{0.05}$	0.74	0.32	0.07	0.06	0.79	0.94	0.43	0.15	0.28
Level of significance	*	*	*	*	*	*	*	*	*

*=5% level of probability, DAS= Days after sowing, T_0 = Control (no micronutrient), T_1 = Boron (B) @ 0.2 g/plot, T_2 = Zinc (Zn) @ 0.5 g/plot, T_3 = Copper (Cu) @ 0.2 g/plot, T_4 = B+Zn+Cu @ (0.2+0.5+0.2 g/plot).

Table 3. Combined effects of local and high yielding cultivars on growth, yield and quality characters of onion.

Treatment combination	Plant height at 85 DAS (cm)	No. of leaves/ plant at 85 DAS	Bulb length (cm)	Bulb diameter (cm)	Fresh weight of bulb (g)	Spitting of bulb (%)	Rotten bulb (%)	Weight loss (%)	% Dry matter content of bulb
V_1T_0	37.10	7.97	2.80	2.03	17.37	5.30	8.00	26.83	9.23
V_1T_1	38.90	9.37	3.40	2.30	20.88	11.55	5.50	20.83	10.80
V_1T_2	38.10	8.57	3.10	2.10	19.60	10.77	6.66	21.74	10.46
V_1T_3	37.20	8.15	3.03	2.07	18.45	8.33	7.50	22.62	9.83
V_1T_4	41.00	10.05	3.60	2.60	23.37	16.66	4.20	19.61	11.40
V_2T_0	43.50	9.16	3.97	2.70	34.32	8.40	10.00	27.16	9.96
V_2T_1	46.20	11.50	4.30	3.20	39.55	22.49	7.44	21.62	12.85
V_2T_2	45.10	10.64	4.10	2.93	37.42	20.50	7.66	22.77	11.50
V_2T_3	44.60	10.28	4.04	2.87	35.35	16.66	8.88	23.90	10.98
V_2T_4	49.10	12.10	4.50	3.54	43.30	25.88	6.88	19.98	13.33
V_3T_0	46.20	10.14	4.80	3.80	40.93	15.30	16.50	28.04	10.86
V_3T_1	48.90	12.08	5.20	4.15	48.67	25.82	12.30	22.65	12.98
V_3T_2	48.10	11.23	5.05	4.05	46.33	22.44	14.22	23.47	12.46
V_3T_3	47.30	10.50	4.90	3.95	42.67	18.69	15.65	24.12	11.48
V_3T_4	53.60	13.05	5.40	4.30	51.33	33.45	11.33	20.41	13.67
$LSD_{0.05}$	1.27	0.56	0.12	0.11	1.37	1.63	0.74	0.25	0.48
Level of significance	*	NS	NS	*	*	*	*	*	*

*=5% level of probability, DAS= Days after sowing, NS= Not significant, V_1= Taherpuri (local), V_2= BARI Piaz 1 (HY) and V_3= BARI Piaz 4 (HY), T_0 = Control (no micronutrient), T_1 = Boron (B) @ 0.2 g/plot, T_2 = Zinc (Zn) @ 0.5 g/plot, T_3 = Copper (Cu) @ 0.2 g/plot, T_4 = B+Zn+Cu @ (0.2+0.5+0.2 g/plot).

Effect of micronutrients

Micronutrients showed significant variation in all the parameters under study (Table 2 and Figure 2). Plant height and number of leaves per plant increased gradually with the growth period in all micronutrients including control and peaked at 85 DAS. The treatment T_4(B+Zn+Cu) gave the maximum plant height (47.90 cm) followed by T_1(44.67 cm), T_2(43.77 cm) and T_3 (43. 03 cm), and number of leaves per plant (11.73) followed by T_1(10.98), while the minimum plant height (42.27 cm) and number of leaves per plant (9.09) were found from control treatment (T_0) (Table 2), respectively. This might be due to the fact that micronutrients supplied plant nutrients for proper growth of onion plants. It was reported that the application of zinc and boron significantly increased the plant height and number of leaves per plant of onion (BARI, 2008).

The treatment T_4(B+Zn+Cu) also gave the maximum bulb length (4.50 cm) followed by T_1(4.30 cm), T_2(4.07 cm) and T_3(3.97 cm), bulb diameter (3.47 cm) followed by T_1(3.20 cm), T_2(3.03 cm) and T_3(2.93 cm) and fresh weight of bulb (39.20 g) followed by T_1(36.14 g), while the minimum bulb length (3.87 cm), bulb diameter (2.87 cm) and fresh weight of bulb (30.90 g) were found in T_0, respectively (Table 2). From the above results it was observed that treatment combination of B, Zn, Cu was found to be better for the production of bigger sized bulb. This might be due to the available soil nutrients supported proper vegetative growth by producing succulent bulb with more protoplasm in the cells in comparison to less available nutrients in onion. Similar result was reported by Goyal *et al.* (2017) who found that foliar application of combined micronutrients Zn+Mn+B+Cu gave the highest vegetative growth and bulb yield of onion. Fouda (2017) also found that the highest values of vegetative growth parameters including fresh, dry weight of bulb and total yield as well as N, P, K, Cu, Fe and Zn, beside nitrate reductase activity in onion bulb recorded with using 50% NPK as soil addition and foliar application of (Fe + Zn + Cu).

The treatment T_4(B+Zn+Cu) gave the maximum percentage of splitted (25.33%) and rotten bulbs (11.50%), while control treatment (T_0) gave the minimum splitted (9.67%) and rotten bulbs (7.47%), respectively (Table 2). It was observed that the highest yield (16.07 t/ha) was obtained from T_4(B+Zn+Cu), while the lowest yield (8.92 t/ha) was recorded from control treatment (T_0) (Figure 2). From the results of present study it was found that the combined effect of micronutrient (Boron+Zinc+Copper) provided better growing condition for onion plants by increasing soil fertility and nutrients availability in resulting maximum gross yield per hectare. The available soil nutrients supported proper vegetative growth by producing succulent bulb with more protoplasm in the cells in comparison to less available nutrients in onion. Sindhu and Tiwari (1993) observed the effect of micronutrients on yield and quality of onion and found the highest yield of bulb when (B+Zn+Cu) was applied in the field. Similar result was also found by Pramanik *et al.* (2018) who concluded that foliar application of micronutrient mixture @ 0.25% followed by borax @ 0.5% at 30 and 45 DAP not only increase the quality attributing parameters but also enhance the consumer preference.

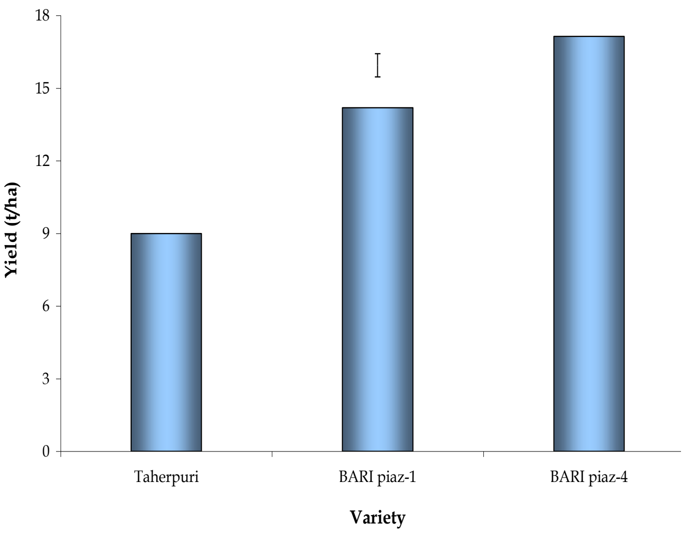

Figure 1. *Gross yield of onion bulb (t/ha) as influenced by variety. Vertical bar represents LSD at 5% level of significance. V_1 = Taherpuri, V_2 = BARI Piaz 1, V_3 = BARI Piaz 4.*

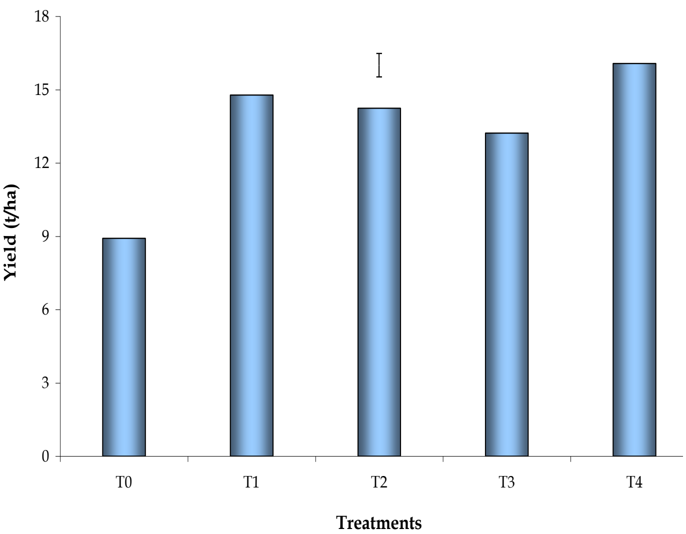

Figure 2. *Gross yield of onion bulb (t/ha) as influenced by micronutrients. Vertical bar represents LSD at 5% level of significance. T_0 = Control (no micronutrient), T_1 = Boron (B) @ 0.2 g/plot, T_2 = Zinc (Zn) @ 0.5 g/plot, T_3 = Copper (Cu) @ 0.2 g/plot, T_4 = B+Zn+Cu @ (0.2+0.5+0.2 g/plot).*

Control treatment (T_0) gave the maximum weight loss of bulbs (27.34%) and T_4 treatment gave the minimum weight loss of bulbs (20.10%) (Table 2). Applying T_4(B+Zn+Cu) gave the highest dry matter content of bulb (12.80%) followed by T_1 (12.21%), T_2(11.47%) and T_3(10.76%) and the lowest dry matter content of bulb (10.02%) was observed in control treatment (T_0) (Table 2). It can be noted that a reverse relationship was found in between percent dry matter and soil nutrients. The available soil nutrients supported proper vegetative growth by producing succulent bulb with more protoplasm in the cells in comparison to less available nutrients in onion. On the other hand when nutrients availability became reduced in the soil, decreased plant growth with thicken walls and less protoplasm containing cells resulting higher percent of dry matter in the onion bulb. This result is similar to the findings of Lu and Edwards (1994) who found that collard plants were severely damaged or killed within 7 days after transplanting when the application rate of PL exceeded 26 g kg^{-1} soil. Maximum dry matter yield of cabbage shifted from 26 to 106 g PL/kg soil during three successive crops. After four successive growth periods, 6% to 37% of N, 3% to 62% of Ca, 20% to 120% of K, 5% to 60% of Mg, and 3% to 25% of P added through PL was removed by plants. The decrease in water-extractable K accounted for the decrease in the soil salinity. Their results suggest that application rates of PL ≥ 53 g kg^{-1} soil can result in elevated levels of salts and NH_3 in soil, which can produce severe salt stress and seedling injury.

Combined effects of onion cultivars and micronutrients

Combined effects of variety and micronutrients had significant influence on all the parameters studied except number of leaves per plant and bulb length. At 85 DAP, results showed that the maximum plant height 53.60 cm followed by 49.10 cm, and number of leaves per plant 13.05 followed by 12.10 were recorded from V_3T_4 and V_2T_4, respectively, while the minimum plant height (37.10 cm) and number of leaves per plant (7.97) were observed from V_1T_0, respectively (Table 3). Similar result was found by Samad *et al.* (2011) who reported that growth parameters of onion plants were positively affected by application of micronutrients, specifically by application of zinc and / or iron. Similarly, increased average bulb weight in onion by application of zinc and boron was reported by Abedin *et al.* (2012). Use of micronutrients increased the chlorophyll content and thereby photosynthetic rate, which usually cause increased the yield of onion (Trivedi and Dhamal, 2013). Satbir *et al.* (1989) also found that i.e. plant height, fresh and dry weight of plants and number of leaves per plant were highest when plants receiving Zn, B and Cu.

Results showed that the highest bulb length (5.40 cm) followed by 5.20 cm, bulb diameter (4.30 cm) followed by 4.15 cm and fresh weight of bulb (51.33 g) followed by 48.67 g were found from V_3T_4 and V_3T_1, respectively, while the minimum bulb length (2.80 cm), bulb diameter (2.03 cm) and fresh weight of bulb (17.37 g) were observed from V_1T_0, respectively (Table 3).

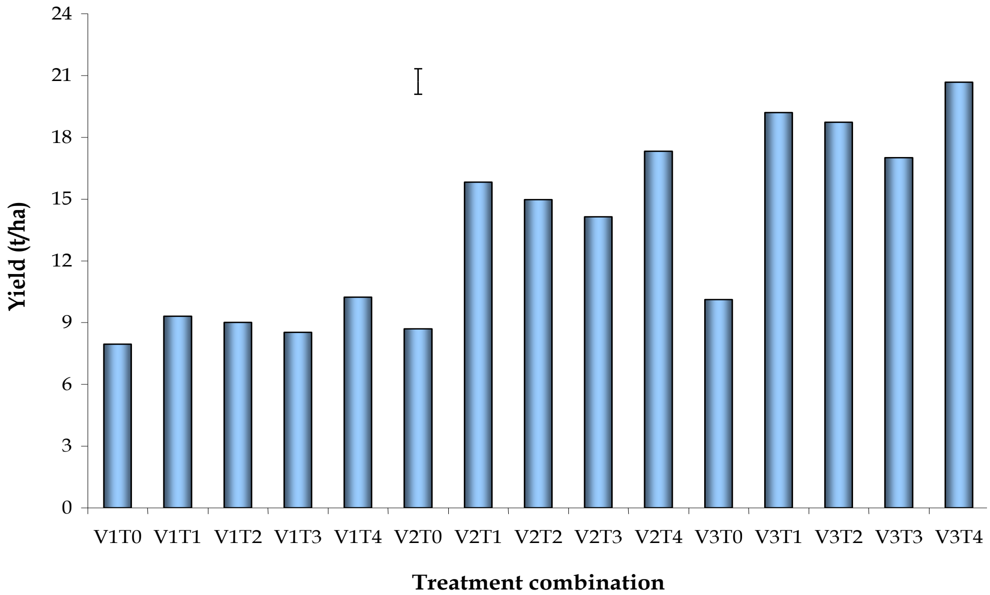

Figure 3. *Gross yield of onion bulb (t/ha) as influenced by variety and micronutrients. Vertical bar represents LSD at 5% level of significance. V_1= Taherpuri (local), V_2= BARI Piaz 1 (HY) and V_3= BARI Piaz 4 (HY), T_0 = Control (no micronutrient), T_1 = Boron (B) @ 0.2 g/plot, T_2 = Zinc (Zn) @ 0.5 g/plot, T_3 = Copper (Cu) @ 0.2 g/plot, T_4 = B+Zn+Cu @ (0.2+0.5+0.2 g/plot).*

Similar result was found in case of bulb length and diameter by Gautam *et al.* (2006). The highest percentage of splitted bulb (33.33%) was observed in V_3T_4 followed by V_2T_4 (25.88%) and the lowest percentage of splitted bulb (5.30%) was observed in V_1T_0 followed by V_1T_3 (8.33%) (Table 3). Similar result was supported by Abedin *et al.* (2012). The highest percentage of rotten bulb (16.50%) was observed in V_3T_0 followed by V_3T_3 (15.65%) and the lowest percentage of rotten bulb (4.20%) in V_1T_4 (Table 3). From the above result it was observed that combination of B, Zn, Cu with recommended rate gives the least number of rotten blubs and the controlled treatments gave the most number of rotten bulbs in percentage. The similar findings were supported by Acharya *et al.* (2015) and Tohamy *et al.* (2009).

The highest yield of onion bulbs per hectare (20.67 t/ha) was observed in V_3T_4 followed by V_3T_1 (19.20 t/ha) and the lowest yield of onion bulbs per hectare (7.95 t/ha) was observed in V_1T_0 (Figure 3). The highest weight loss of bulbs (28.04%) was observed in V_3T_0 followed by V_2T_0 (27.16%) and the lowest weight loss of bulbs (19.61%) was observed in V_1T_4 (Table 3). Results revealed that the highest dry matter content of bulb (13.67%) was observed in V_3T_4 followed by V_2T_4 (13.33%) and the lowest dry matter content of bulb (9.23%) was observed in V_1T_0 (Table 3). This result is also similar to the findings of Alam *et al.* (2010) who reported that combined application of Zn+B along with onion cv Taherpuri gave the increased vegetative growth, bulb yield and better quality in calcareous soil.

Conclusion

The results of the experiment showed that the variety and micronutrients had significant influence on most of the parameters studied. BARI Piaz-4 produced the highest bulb, with increased plant height, number of leaves, fresh weight of bulb, percent dry matter content of bulbs compared to BARI Piaz-1, Taherpuri variety. The treatment T_4 (B+ Zn+Cu @ 0.2+0.5+0.2 g/plot) showed the best results on all the parameters studied such as increased plant height, number of leaves, fresh weight of bulb, bulb length, bulb diameter, percent dry matter content of bulbs and bulb yield compared to control treatment (T_0) except percentage of splitted bulb. The highest bulb yield (16.07 t/ha) was recorded in T_4 and the lowest bulb yield (8.92 t/ha) was found in T_0. The effect of micronutrients on yield were in order of $T_4 > T_1 > T_2 > T_3 > T_0$. Among the treatment combinations V_3T_4 gave the highest plant heights (53.60 cm), number of leaves (13.05), fresh weight of bulb (51.33 g), percent dry matter content (13.67%), whereas the lowest plant height (37.10 cm), number of leaves (7.93), fresh weight of bulb (17.37 g), percent dry matter content (9.23%) were obtained from V_1T_0. V_3T_4 showed highest (28.04%) of weight loss and V_1T_4 showed the lowest weight loss (19.61%). The highest gross yield of onion (20.67 t/ha) was recorded in V_3T_4. Based on the findings of the experiment, it may be concluded that combined application of B+ Zn+Cu @ 0.2+0.5+0.2 g/plot along with BARI Piaz 4 was found to be better for higher yield of onion, hence may be recommended at farmers level for profitable crop production without affecting the soil health.

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REFERENCES

Abedin, Md. J., Alam, Md. N., Hossain, Md. J., Ara, N.A. and Faisal, Md. H.K. (2012). Effect of micronutrients on growth and yield of onion under calcareous soil environment. *International Journal of Biosciences*, 2(8): 95-101.

Acharya, U., Venkatesan, K., Saraswathi, T. and Subramanian, K.S. (2015). Effect of zinc and boron application on growth and yield parameters of multiplier onion (*Allium cepa* L. var aggregatum Don.) var. CO-5. *International Journal of Research*, 2(1): 757-765.

Alam, M.N., Abedin, M.J. and Azad, M.A.K. (2010). Effect of micronutrients on growth and yield of onion under calcareous soil environment. *International Research Journal of Plant Science*, 1(3): 056-061, http://www.interesjournals.org/IRJPS

BARC. (2010). Fertilizer Recommendation Guide- 2010. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

BARI. Bangladesh Agriculture Research Institute. (2008). Effect of NPKS and Zn, B on garlic. Annual Report (2007-08).

BBS. (2017). Yearbook of Agricultural Statistics- 2017. Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning. Govt. of the Peoples's Republic of Bangladesh. Dhaka. pp. 377.

Brewster, J.L. (1994). Onions and other vegetable Alliums. CAB International, UK, pp. 236

Edris, K.M., Islam, A.T.M.T., Chowdhury, M.S. and Haq, A.K.M.M. (1979). Detailed Soil Survey, Bangladesh Agricultural University Farm, Mymensingh. Department Of Soil Survey, Govt. of the People's Republic of Bangladesh. pp. 118.

El-Samad, E.H.A., Khalifa, R.K.M., Lashine, Z.A. and Shafeek, M.R. (2011). Influence of urea fertilization and foliar application of some micronutrients on growth, yield and bulb quality of onion. *Australian Journal of Basic and Applied Sciences*, 5(5): 96-103.

FAOSTAT. (2016a). Food and Agriculture Organization of the United Nations-Agricultural Data. [online]. Retrieved June 12, 2016, from http://faostat3.fao.org/browse/rankings/countries_by_commodity/E

Fouda, K.F. (2017). Response of onion yield and its chemical content to NPK fertilization and foliar application of some micronutrients. *Egyptian Journal of Soil Science*, 1-12, https://doi.org/10.21608/ejss.2017.1083

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd Ed). John Wiley & Sons, New York. pp. 28-192.

Goyal, R., Uike, V. and Verma, H. (2017). Effect of foliar application of micronutrients on growth and yield of onion (*Allium cepa* L.) c.v. Agri found dark red. *Agricultural Science Digest*, 37(2): 160-162, https://doi.org/10.18805/asd.v37i2.7995

Hossain, A.K.M.A. and Islam, J. (2006). Status of Allium Production in Bangladesh. *Acta Horticulturae*, 358: 33-36.

Kokobe, W., Derbew, B. and Adugna, D. (2013). Effect of farmyard manure and nitrogen fertilizer rates on growth, yield and components of onion (*Allium cepa* L). at Jimma, South West Ethiopia. *Asian Journal of Plant Science*, pp.1-6.

Lu, N. and Edwards, J.H. (1994). Poultry litter quantity influences collard growth in pots and affect cabbage growth and nutrient uptake. *Journal of Horticultural Science*, 29(10): 1143-1148, https://doi.org/10.21273/HORTSCI.29.10.1143

Mishra, H.P., Sarkar, C., Viswajith, K.P., Dhekale, B.S. and Sahu, P.K. (2013). Instability and forecasting using ARIMA model in aua, Production and productivity of onion in India. *Journal of Crop and Weed*, 9: 96-101.

Mondal, M.F. and Pramanik, M.H.R. (1992). Major factors affecting the storage life of onion- A Review, *Journal of Tropical Agriculture*, 10(2): 140-146.

Mondal, M.F., Brewster, J.L., Morris, G.E.L. and Butter, H.A. (1986). Bulb development in onion (*Allium cepa* L.) effects of plant density and sowing date in field conditions. *Annals of Botany*, 58(2): 187-195, 24-29.

Naher, M.S., Brahma, S., Islam, M.A., Sarkar, M.B., Hasan, M.M. and Fahim, A.H.F. (2017). Productivity of summer onion to different sources and levels of potash. *Bangladesh Agronomy Journal*, 20 (1): 37-43, https://doi.org/10.3329/baj.v20i1.34881

Pramanik, K., Tripathy, P., Mandal, P., Pradhan, M. and Biswal, M. (2018). Effect of micronutrients on quality of onion (*Allium cepa* L.). *International Journal of Chemical Studies*, 6(6): 1324-1327, http://www.chemijournal.com/archives/2018/vol6issue6/PartW/6-6-164-382.pdf

Purseglove, J.W. (1972). Tropical crops: Monocotyledons 1 and 2. Longman Group Limited, London. pp. 32-50.

Rashid, M.H.A, Massiah, A.J. and Thomas, B. (2016). Genetic regulation of day length adaptation and bulb formation in onion (*Allium cepa* L.). *Acta Horticulturae*, 1143: 7-14, http://dx.doi.org/10.17660/ActaHortic.2016.1143.2

Rashid, M.H.A. (2010). Effect of sulphur and GA_3 on the growth and yield of onion, *Progressive Agriculture*, 21(1& 2): 57-63, http://dx.doi.org/10.3329/pa.v21i1-2.16749

Satbir, S., Tiwari, R.S. and Sindhu, S.S. (1989). Effect of micronutrients on the growth characters of onion (*Allium cepa* L.) cv. Pusa red, *Haryana Journal of Horticultural Science*, 18(1-2): 146-149.

Sindhu, S.S. and Tiwari, R.S. (1993). Effect of micronutrients on yield and quality of onion (*Allium cepa* L.) cv. Pusa Red. *Progressive Horticulture*, 25(3-4): 176-180.

Tisdale, L.S., Nelson, L.W., Beaton, D.J. and Havlin, L.J. (1984). Soil Fertility and Fertilizers. Prentice Hall of India. 5th edn. 1997: 319-346.

Tohamy, W.A., Khalid, A.K., Abagy, H.M. and Hussein, H.D. (2009). 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*, 3(1): 201-205.

Trivedi, A.P. and Dhamal, K.N. (2013). Effect of soil and foliar application of zinc and iron on the yield and quality of onion (*Allium cepa* L.). *Bangladesh Journal of Agriculture Research*, 38(1): 41-48, https://doi.org/10.3329/bjar.v38i1.15188

UNDP and FAO. (1988). Land Resources Appraised of Bangladesh for Agricultural Development. Agro-Ecological Regions of Bangladesh, Report 2, Food and