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Effects of Foliar Application of Indol Butyric Acid(IBA), Gibberellic Acid (GA_3) and Zinc (Zn) on Yield and Quality of Tomato

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Authors' contributions

This work was carried out in collaboration among all authors. Author MSI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAH, SAS, MJ and Kamrunnahar managed the analyses of the study. Authors SAR and MS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The yield and quality of tomato largely depend on soil and climatic conditions and also on variety. Plant growth regulators function as chemical messengers for intercellular communication. In tomato, different growth regulators and zinc play a pivotal role in germination, root development, branching, flower initiation, fruiting, lycopene development, synchronization and early maturation, parthenocarpic fruit development, ripening, TSS, acidity, seed production etcetera. The field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh

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during October 2017 to April, 2018 to evaluate the effect of foliar application of IBA, GA3 and Zn on yield and quality of tomato [1]. Single variety BARI Tomato-14 and foliar application of IBA 5 ml/L, GA3 5 ml/l and Zn were used to conduct this experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) having three factors and replicated three times. Data were collected on chlorophyll content of leaf, number of flowers cluster per pant, number of fruit per plant, yield per hectare, Vitamin-C content and TSS% content. A statistically significant variation was recorded in terms of the above characters about yield and quality of tomato. All the characters shows maximum result in treatment of T_7 (IBA+GA3+Zn).The treatment combination of T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) and T_4 (IBA 5 ml / L, GA3 5 ml / L) gave the maximum yield (100.00 t/ha) and the minimum yield (39.75 t/ha) was found from the treatment combination on T_0 (control). The highest Vitamin C content (113.10 mg/100 gm) and highest TSS (%) (7.000) were found from T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) than that of control under present experiment. So, it can be concluded that treatment combination of T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) is the best for yield and quality of tomato and can be tested further under different field conditions.

Keywords: Tomato; growth hormone; yield and quality.

1. INTRODUCTION

Tomato (*Solanum lycopersicum*) is a solanaceous self-pollinated vegetable crop. Its chromosome number 2n=24. It is one of the important, popular and nutritious vegetable grown in Bangladesh in both winter and summer season around all the parts of the country [2]. Tomato is one of the most popular [3], important and widely used vegetable crops ranked as second position vegetable of the world after potato [4] Olaniyi et al. 2010. Tomato is widely used as salad as well as for cooking purpose. Tomato is very rich in nutrients, especially potassium, folic acid, vitamin C and contains a mixture of different carotenoids, including vitamin A, effective β-carotene as well as lycopene [5,6].

The Average yield of tomato is 14.35 tons/ha in Bangladesh, while 41.81 t/ha in the world. So production in Bangladesh is very low in compare with that of other countries, namely India (15.67 t/ha), Japan (52.82 t/ha) and USA (63.66 t/ha). The yield of tomato in our country is not satisfactory enough in compare to requirement [7].

The growth promoting hormones (GPH) is used in commercial horticulture to improve plant growth and yield. Which can be used safely on fruits, vegetables and leafy crops. Products produce under hormonal treatment are safe to eat, like wise naturally organic product producer. Currently, a large number of growth regulators are available in the market but basically they are two types i.e. growth promoters and growth inhibitors or retardants. Indole 3-Butyric Acid is a plant bio- regulator belonging to the auxin group either natural or synthetic that modifies or controls one or more specific physiological processes within a plant. IBA that regulate growth and influence various developmental process, including stem elongation, early root formation, callus formation, enhance flowering, enzyme induction and leaf & fruits senescence [1]. They can accelerate or retard the growth and maturation rate [8]. Indole 3-Butyric Acid (IBA) is the leading plant hormone used to promote the formation of roots and to generate new roots in the cloning of tomato plants through cuttings [9].

GA3 is one of the most important growth stimulating substances used in agriculture since long. It may promote cell elongation, cell division and thus helps in growth and development of tomato plant. GA3 applications help in improvement in number of fruits per cluster, fruit set, and marketable fruit number per plant and extended maturity time and harvest [10,11].

Adequate supply of micronutrients also plays an important role in tomato production. Among the micro elements, Zinc plays an important role in directly and indirectly improving the yield and quality of tomato in addition to checking various diseases and physiological disorders. It gives a rosette appearance and yellow color between the veins of new growing leaves occur in plant [12]. Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes [13]. Zinc deficiency is thought to restrict RNA synthesis, which in turn inhibits protein synthesis [14]. In the salt affected areas, zinc application could alleviate possible Na and Cl injury in plants [15]. Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development [16]. The use of Growth regulators and micro elements improved the production of tomato including other vegetables in respect of better growth and quality which ultimately lead general interest among scientist and farmers for commercial application of these substances. It is, therefore, highly desirable to explore possible ways and means to enhance the productivity of this important crop employing cost effective and easy to use techniques [1].

Although, tomato is the second major crop of the world after potato, but there is lack of research, particularly under field conditions, to show interactive effect of IBA, Gibberellic Acid (GA3) and Zinc on tomato. Keeping the above point of view, the present study was undertaken to evaluate the effect of IBA, Gibberellic Acid (GA3) and Zinc on yield and quality tomato.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October, 2017 to March, 2018. The location of the experimental site was at $23°74^{/N}$ latitude and $90°35^{/E}$ longitude with an elevation of 8.45 meter from the sea level [1]. The temperature of the field at that time was 15-20°C.

2.2 Varieties and Treatment of the Experiment

Tomato variety "BARI Tomato-14" was used. The experiment consisted of three factors as follows:- Factor A: IBA (Indol Butyric Acid), Doses of IBA 5 ml/L, Factor B: GA3 (Gibberellic Acid) Doses of GA3 5 ml/L, Factor C: Zinc level (1 kg/ha). Total 8 treatments were as follow with symbolically: T_0= control, T_1= IBA 5 ml/L, T_2= GA3 5 ml/L, T_3= Zn 1 kg/ha, T_4= IBA 5 ml/L and GA3 5 ml/L,T_5= IBA 5 ml/l and Zn 1 kg/ha,T_6= GA3 5 ml/L and Zn 1 kg/ha,T_7= IBA 5 ml/L ,GA3 5 ml/L and Zn 1 kg/ha.

2.3 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) having three factors with three replications. The treatment combinations were accommodated randomly in the unit plots. An area of 19.5 m x 8 m was divided into three equal blocks. Each block consisted of 8 plots where 8 treatments were allotted randomly. There were 24 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were 0.5 m and 0.5 m respectively.

2.4 Data Collection

Randomly five plants were selected and uprooted carefully at the time of collecting data and mean data on the following parameters were recorded :- Leaf Area index, Chlorophyll content, Number of cluster per plant, Number of fruit per plant, Fruit weight per plant, Fruit yield (t/ha),Total soluble solid percent (TSS%),Vitamin C content.

2.5 Statistical Analysis

Data were statistically analyzed by a computer program MSTAT-C software and Duncan's multiple range tests was used to analyze the growth, yield and quality contributing characters of tomato to find out the statistical significance. The significance of the difference was evaluated by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) for interpretation of the results at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Yield

3.1.1 Chlorophyll content of leaf

Chlorophyll content of leaf of tomato varied significantly due to the application of IBA which applied singly in treatment T_1 recorded (48.7%) that may compare to treatment T_0 (Fig. 1). Chlorophyll content of leaf of tomato varied significantly due to the application of GA3 which applied singly in treatment T_2 recorded (48.9%) that may compare treatment $T_{0.}$ Chlorophyll content of leaf of tomato varied significantly due to the application of Zn which applied singly in treatment T_3 recorded (48.7%) that may compare treatment T_0. Combination effect of IBA, GA3 and Zn showed statistically significant variation (at 5% level of significance) on chlorophyll content of leaf. The highest chlorophyll content of leaf (59.32%) was found in T_7 (IBA 5 ml / L, GA3

5 ml / L and Zn 1 kg/ha) while the lowest chlorophyll content of leaf (46.61%) was recorded from T_0 (control).

3.1.2 Number of flower clusters per plant

Number of flower clusters per plant of tomato varied significantly due to the application of IBA, GA3 and Zn at 60, 75 and 90 DAT which applied in treatment T_1, T_2, T_3 respectively that may compare to treatment T_0 (control) (Fig. 2). There was statistically significant difference among the treatment combinations in respect of number of flower clusters per plant. It was evident that the treatment combination of T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) gave the maximum number of flower clusters per plant at 60 and 75 DAT and the minimum number of flower cluster per plant was recorded in the treatment combination of T_0 (control) [2]. But at 90 DAT the maximum number of flower clusters per plant was recorded in case of both T_7 and T_4 and the minimum number of cluster was recorded from treatment T_0 (Fig. 2). Uddain et al. [17] observed that GA3 gives the highest number of flowers cluster plant-1 than other plant growth regulators. Sultana [18] concluded that application of GA3 50 ppm in tomato increases the number of flower clusters per plant.

3.1.3 Number of fruits per plant

Number of fruits per plant of tomato varied significantly due to the application of IBA, GA3 and Zn at 60, 75 and 90 DAT which applied in treatment T_1, T_2, T_3 respectively that may compare to treatment T_0 (control) (Fig. 3).Combined effect IBA, GA3 and Zn on number of of fruit per plant were found to be significant. The maximum number of fruit per plant was observed in the treatment combination of at T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) the count from 60, 75 and 90 DAT and the minimum was T_0 (control) (Fig. 3). El-Abd et al. [19] observed that plant growth regulator improve fruit set of tomato. Ejaz et al. [20] also reported that application of zinc provide better results in number of fruits plant-1 of tomato as compared to control. Naeem et al. [21] revealed GA3 spray on tomato plant reduces fruit drop and contributes better number of fruits plant-1. Application of GA3 at 50 ppm increases number of fruits in tomato [17].

3.1.4 Fruit yield per hectare

Fruits yield per hectare of tomato varied significantly due to the application of IBA that is 71.27 which applied in treatment T_1 that may compare to treatment T_0 (control) that is 39.75 (Fig. 4). Fruits yield per hectare of tomato varied significantly due to the application of GA3 that is 80.00 which applied in treatment T_2 that may compare to treatment T_0 (control) that is 39.75 (Fig. 4). Fruits yield per hectare of tomato varied significantly due to the application of Zn that is 61.63 which applied in treatment T_1 that may compare to treatment T_0 (control) that is 39.75 (Fig. 4). Due to combined effect of

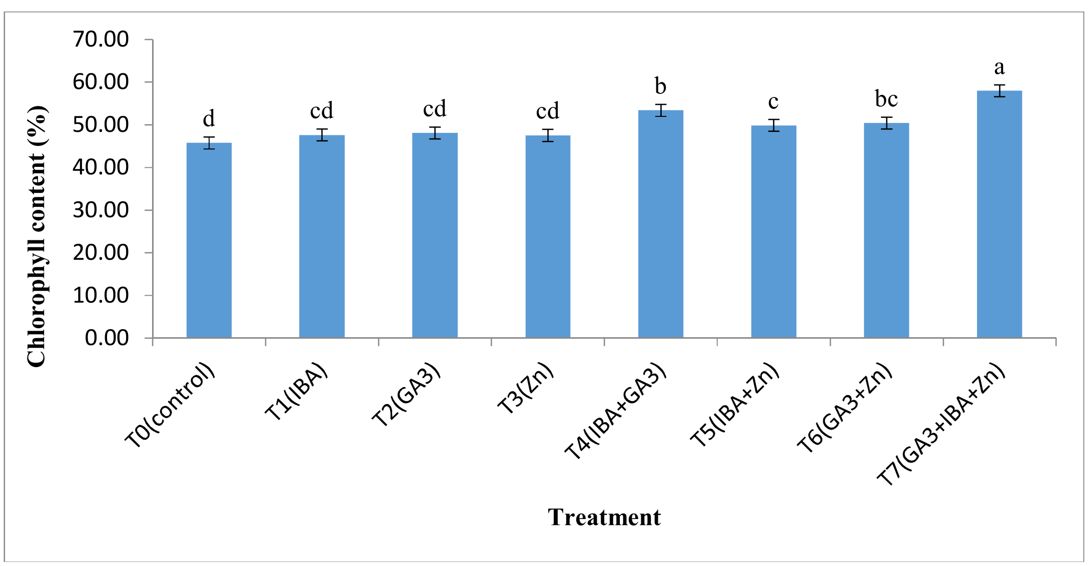

Fig. 1. Effect of different plant growth regulators and Zn on Chlorophyll content of tomato

IBA, GA3 and Zn performed significant effect on yield per hectare. The treatment combination of T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) and T_4 (IBA 5 ml / L, GA3 5 ml / L) gave the maximum yield (100.00 t/ha) and the minimum yield (39.75 t/ha) was found from the treatment combination on T_0 (control). Graphical presentation about effect of IBA, GA3 and Zn combined on yield of tomato shown in Fig. 4. This result agree with the work of Kumari and Sharma [22] who conducted an experiment to determine the effects of boron, zinc, molybdenum, copper, iron and/or manganese, applied as foliar sprays, on the growth, fruit and seed yield of tomato. Ullah et al. [23] also showed that application of zinc gave higher yield ha-1 than untreated control in tomato. Sultana [18] concluded that application of GA3 50 ppm increases the yield of tomato. Hasanuzzaman et al. [10] revealed that application of GA3 @ 125 ppm showed an increased fruit yield ha-1. Verma et al. [24] revealed that GA3 plays role on increasing fruit yield and extending shelf life in tomato. Prasad et al. [25] reported that fruit yield ha-1 significantly increased with the application of GA3 compared to control [1].

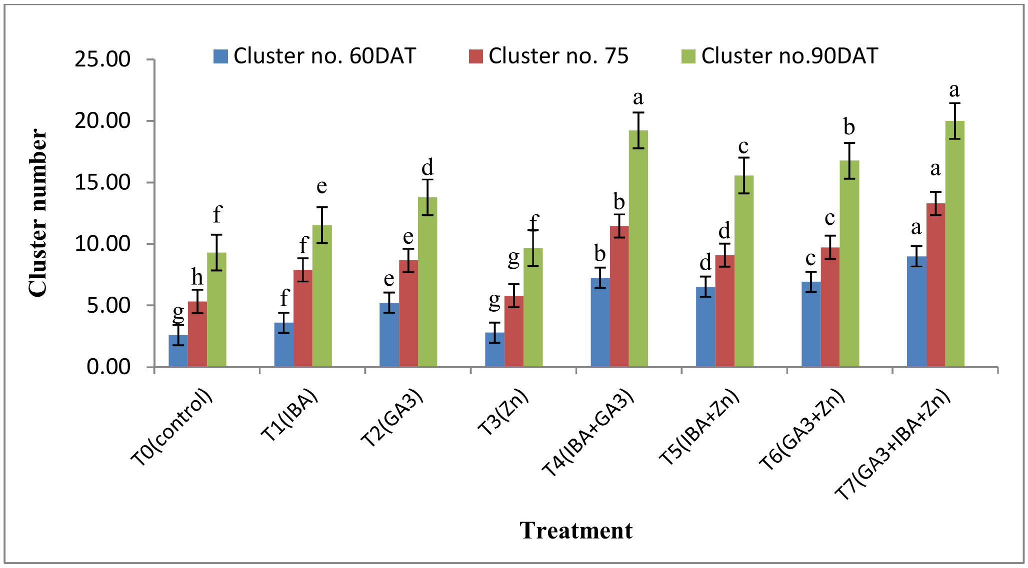

Fig. 2. Effect of different plant growth regulators and Zn on cluster number of tomato at different DAT (Days after Transplanting

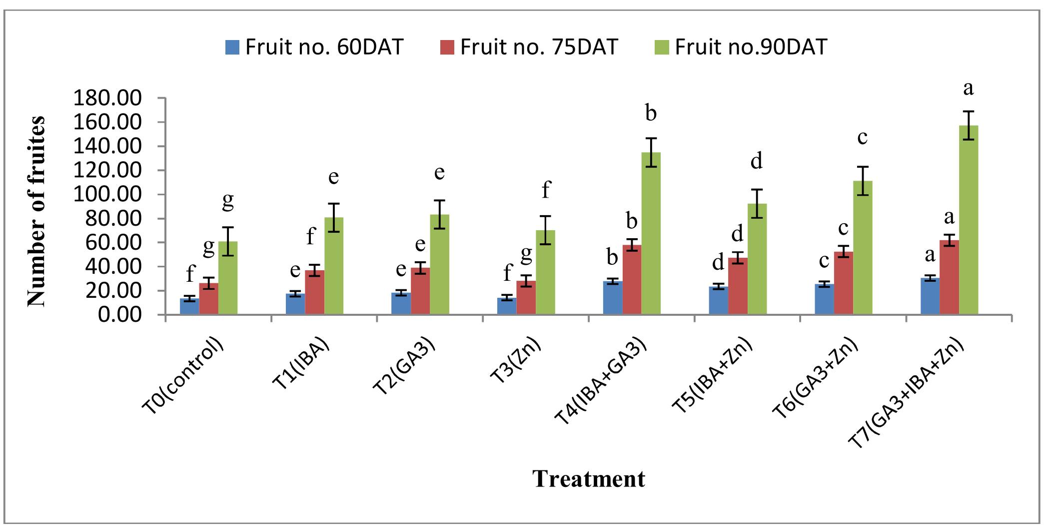

Fig. 3. Effect of different plant growth regulators and Zn on number of fruits of tomato at different DAT. (Days after transplanting)

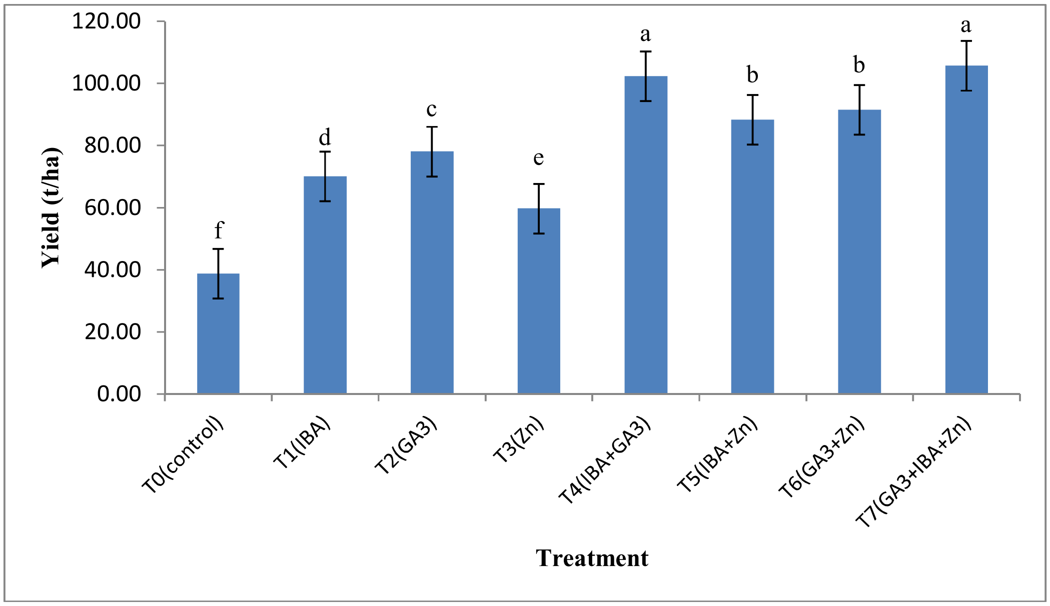

Fig. 4. Effect of different plant growth regulators and Zn on yield of tomato

3.2 Quality Attributes

3.2.1 Vitamin C content

Vitamin C content of tomato varied significantly due to the application of IBA which applied singly in treatment T_1 recorded (95.77 mg/100 gm) that may compare to treatment T_0 (Fig. 5). Vitamin C content of tomato varied significantly due to the application of GA3 which applied singly in treatment T_2 recorded (97.72 mg/100 gm) that may compare to treatment T_0 (Fig. 5). Vitamin C content of tomato varied significantly due to the application of Zn which applied singly in treatment T_3 recorded (90.03 mg/100 gm) that may compare to treatment T_0 (Fig. 5). Combination effect of IBA, GA3 and Zn showed statistically significant variation on Vitamin C content. The highest Vitamin C content (113.10 mg/100 gm) was found from T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) while the lowest (79.77 mg/100 gm) was recorded from T_0 (control) (Fig. 5). The result corroborated with the finding of Irshad [26] who carried out a study on the effect of organic manures and inorganic fertilizers on biochemical constituents of tomato. In this study tomato plants were treated with organic manures (F.Y.M, Sewage sludge) and inorganic fertilizers (N.P.K, Zn, S) were analyzed for biochemical composition. TSS, lycopene, carbohydrate, vitamin C, acidity and carotenoid content exhibited an increase at all the test concentrations and were found maximum in sewage sludge treated along with N.P.K, followed by @ FYM along with NPK. Singh and Tiwari [27] reported that maximum ascorbic acid were found with the application of boric acid + zinc sulphate + copper sulphate @ 250 ppm each. Dube et al. [28] recorded the highest ascorbic acid content with the soil application of zinc sulphate and borax @ 10 and 20 kg ha-1, respectively in tomato. Application of GA3 at 50 ppm increases ascorbic acid [28]. Kumar et al. [29] observed the highest ascorbic acid treated with GA3 at 50 ppm.

3.2.2 Total soluble solid (%) content

Total soluble solid (%) content of tomato varied significantly due to the application of IBA which applied singly in treatment T_1 recorded (6.5%) that may compare to treatment T_0 (Fig. 6). Total soluble solid (%) content of tomato varied significantly due to the application of GA3 which applied singly in treatment T_2 recorded (6.7%) that may compare to treatment T_0 (Fig. 6). Total soluble solid (%) content of leaf of tomato varied significantly due to the application of Zn which applied singly in treatment T_3 recorded (6.1%) that may compare to treatment T_0 (Fig. 6). Combination effect of IBA, GA3 and Zn showed statistically significant variation on total soluble solid (%). The highest TSS (%) (7.000) was found from T_7 (IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha) while the lowest TSS (%) (5.870) was recorded from T_0 (control) Fig. 6. The result

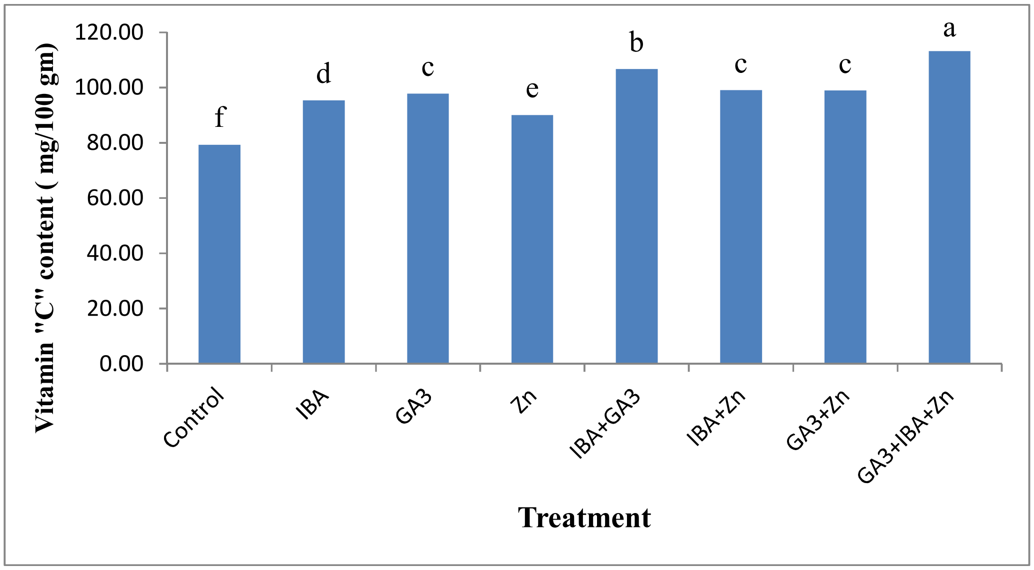

Fig. 5. Effect of different plant growth regulators and Zn on Vitamin C content of tomato

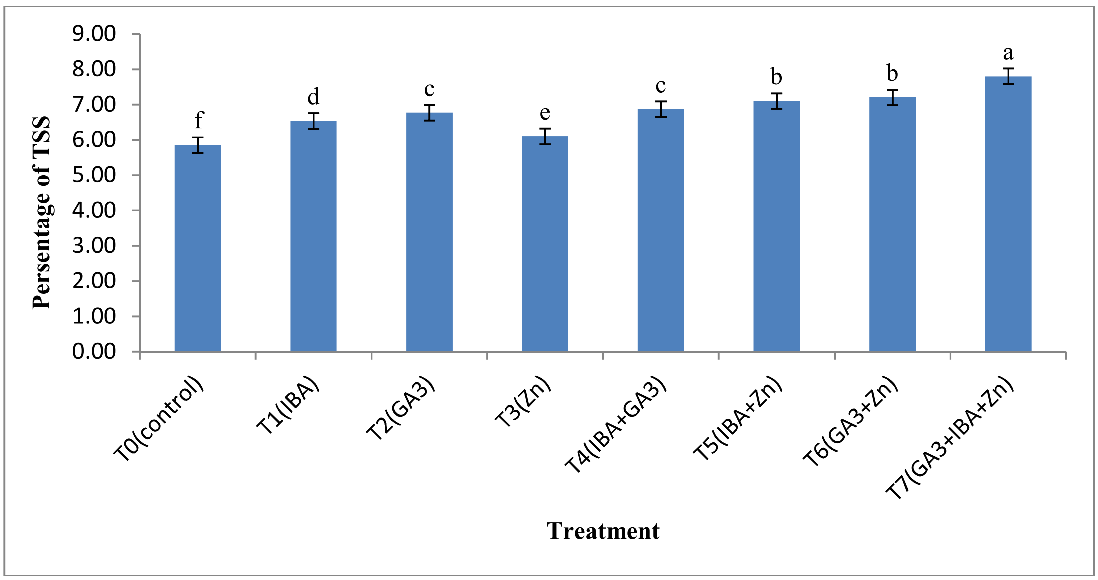

Fig. 6. Effect of different plant growth regulators and Zn on TSS percentage of tomato

corroborated with the finding of Dongre et al. [30] observed the highest total soluble solid (TSS 3.12%) treated with foliar application of 50 mg/L Zn + 100 mg/L Fe and the lowest was achieved in control. Singh and Tiwari [27] reported that maximum T.S.S. was found with the application of boric acid + zinc sulphate + copper sulphate @ 250 ppm each. Varied levels of boron and zinc had profound influence on TSS (%) content of fruit. It ranged from 4.02 to 4.47 [31]. Application of GA3 at 50 ppm increases TSS in tomato [9]. Kumar et al. [28] observed the highest total soluble solid (TSS) treated with GA3 at 50 ppm.

4. CONCLUSION

On the basis of the present research, it can be concluded that BARI Tomato-14 with combination of IBA (5 ml/L), GA3 (5 ml/L) and Zn 1 kg/ha showed the best performance to all studied parameter than that of control under present experiment. The maximum fruit weight per plant was obtained from the treatment combination of T_7 at 1st and 2nd harvest but at 2nd harvest the maximum fruit weight per plant was recorded in case of the treatment T_7 and T_4. The lowest fruit weight in this respect was found from the treatment combination T_0. T_7 and T_4 gave the maximum yield (100.00 t/ha) and the minimum yield (39.75 t/ha) was found from the treatment combination on T_0. The highest Vitamin C content (113.10 mg/100 gm) and TSS (%) (7.000) were recorded from the treatment combination of T_7 than that of control under present experiment. The conclusion from the above results, the treatment T_7 that conducted IBA 5 ml / L, GA3 5 ml / L and Zn 1 kg/ha is suitable combination for the tomato production. The findings obtained from the present investigation should be confirmed by conducting similar type of experiment in different agro-ecological zones (AEZ) of Bangladesh.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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