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Impact of Exogenous Application of Plant Growth Regulators on Growth and Yield Contributing Attributes of Summer Tomato

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MEH, RA and MNHS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KUA and MTH managed the analyses of the study. Author RN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted with the intention of investigating the impact of different concentrations and combination of the plant growth regulators on growth and yield contributing attributes of summer tomato. The experiment was laid out in Completely Randomized Resign (CRD) with four replications. Different plant growth regulators viz. T_0= Control, T_1 = 20 ppm NAA, T_2 = 20 ppm GA3 and T_3 = 20 ppm NAA + 20 ppm GA3 were used in the study. The growth and yield contributing characters were significantly influenced by the application of plant growth regulators. At harvest, the longest plant (86.90cm), number of cluster plant^{-1}(9.95), bud cluster^{-1}(8.01) flower cluster^{-1}(5.94) and fruits plant^{-1}(16.48) and fruit yield plant^{-1} (309.04g) were found in BARI Hybrid Tomato-8. At harvest, the maximum plant height (88.30cm) was found in T_2 and the number of number of cluster plant^{-1}(10.12), bud cluster^{-1}(8.26)flower cluster^{-1}(5.99) and fruits plant^{-1}(17.65) and

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fruit yield plant^{-1} (328.99 g) were found with the application of 20 ppm NAA+20 ppm GA3, whereas the minimum for these characters were recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (90.79 cm) was found in V_4T_2 which was statistically similar to V_4T_3, and the number of number of cluster plant^{-1}(11.68), bud cluster^{-1}(8.80) flower cluster-^{1}(6.78) and fruits plant $^{-1}$(23.95) and fruit yield plant^{-1}(474.60 g) were found V_4T_3 whereas the minimum for all these characters were found in control plants. Therefore, it can be suggested that 20 ppm NAA along with 20ppm GA3 can be effective in enhancing growth and yield of summer tomato.

Keywords: Growth regulators; NAA; GA_3; growth; summer tomato; yield.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is one of the most popular and versatile vegetables in the world which is cultivated in almost all parts of Bangladesh under both field and protected conditions. It is one of the most popular and consumed vegetables in Bangladesh because of its excellent overall eating characteristics. Tomato fruits are consumed as raw, cooked and other dishes like as soups, juice, Jam, Jelly, ketchup, pickles, sauces, conserves, puree, paste, powder and other products. *From the nutritional point of view, tomato has higher caloric value and contains almost all the essential vitamins and minerals* [1]. In terms of human health, tomato is a major component in the daily diet and constitutes an important source of minerals, vitamins and antioxidants, like lycopene [2]. *Lycopene pigment is a vital anti-oxident that helps to fight against cancerous cell formation as well as other kind of health complications and diseases* [3]. Nevertheless, it plays a vital role in providing a substantial quantity of vitamin C and A in human diet [4]. Due to the excellent nutritional and health benefits of tomato, the demand of tomato remains higher throughout the year, but production is far below in relation to demand, especially in the summer season. With the increase of population, the demand of tomato is increasing day by day. Therefore, to meet up the growing demand for tomato priority should be given on summer tomato production. Although tomato is considered to be a day neutral plant but it is not productive under high temperature (>30°C) which is the main hindrance to summer tomato production in Bangladesh as the average summer temperature ranges 28-32°C in summer. High temperature was reported as limiting factor of fruit setting due to imbalance in the physiological process in the pistil resulting in flower and fruit abscission. To overcome this problem several plant growth regulators were tested to determine the effectiveness in fruit setting. Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development. Gemici *et al*. [5] reported that application of synthetic auxin and gibberellins (GAs) are effective in enhancing both yield and quality of tomato. GA3 is known to promote fruit development in pollinated ovaries that undergo dormancy due to high temperature [6].However; information regarding the commercial application of plant growth regulators in summer tomato production is not adequate. The present study was, therefore, undertaken to find out the best summer tomato varieties which could be suggestive for summer tomato production in Bangladesh. In addition, attempt was undertaken to determine the most suitable growth regulators along with dozes which can be effective for enhancing growth and yield of summer tomato.

2. MATERIALS AND METHODS

2.1 Experimental Site

The pot culture experiment was conducted at the research filed of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the summer (May to September) of 2016 under transparent polythene shade conditions. Geographically, the location of the experimental site was 23°74′N latitude and 90°35′E longitude and at an elevation of 8.2 m from sea level. The climate of experimental site was under the subtropical climate. The soil of the experimental area belongs to the Modhupur Tract (AEZ No 28). It had shallow red brown terrace soil. The soil texture was sandy loam and pH was 6.0-6.4.

2.2 Planting Material

Four tomato varieties were used as planting materials viz. (i) BINA tomato-6 and (ii) BINA tomato-7, (iii) BARI Hybrid Tomato 4, (iv) BARI Hybrid Tomato 8. The seeds were collected from

the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA).

2.3 Experimental Design and Treatments

The experiment was carried out in pot culture based. The two factor pot culture experiment was laid out in a Completely Randomized Resign (CRD) with four replications. Four concentrations of plant growth regulators viz., T_0= Control, T_1 = 20 ppm NAA, T_2 = 20 ppm GA3 and T_3 = 20 ppm NAA + 20 ppm GA3 were applied exogenously (foliar spray) in the morning at 30 days after transplanting. There were 16 treatment combinations such as V_1T_0, V_1T_1, V_1T_2, V_1T_3, , V_2T_0, V_2T_1, V_2T_2, V_2T_3, , V_3T_0, V_3T_1, V_3T_2, V_3T_3, , V_4T_0, V_4T_1, V_4T_2, V_4T_3. A total number 4*4*4=64 unit pots were maintained for this study.

2.4 Growth Condition and Management

Seeds were sown in May 01, 2016 and 30 day aged healthy seedlings were transplanted in well prepared 12 inch plastic pots containing culture medium composed of 30% organic manure incorporated with sandy loam soil and recommended doses of inorganic fertilizer was applied during final pot preparation as prescribed in FRG, 2012 [7] by Bangladesh Agriculture Research Council (BARC). Each pot was filled with 10 kg of soil thoroughly mixed with well decomposed cowdung. For proper growth and management, each pot was placed 45 cm apart from each other. Intercultural operations such as irrigation, weeding and stalking were conducted whenever necessary. For controlling insect Emitaf 20 SL was applied at a rate of 0.25 ml L^{-1} of water at 7 days interval for three weeks.

2.5 Data Collection and Analysis

Data of final plant height (cm), root dry weight $plant^{-1}$, shoot dry weight $plant^{-1}$ were recorded at final harvest. Days to first cluster initiation, cluster $plant^{-1}$, bud $cluster^{-1}$, flower $cluster^{-1}$, fruit $cluster^{-1}$ were recorded and updated throughout the period of reproductive growth. SPAD value of leaves was recorded from number 9, 12 and 15 fully expanded leaflets of leaves of main stem avoiding main ribs using a SPAD meter. Fruits were harvested at early ripening stage at 3 days interval when they developed slightly red color. Fruit yield obtained from each sample plant was also recorded and used to calculate fruit yield $plant^{-1}$ (kg).

The data obtained were analyzed using MSTAT-C Statistical software to observe the significant difference among the different treatments. The mean values of all the parameters were calculated and factorial analysis of variance was performed. The variance among the treatment means was estimated by the Least Significant Difference (LSD) test at 5% probability (p= .05) [8].

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height of four summer tomato varieties showed statistically significant variation at harvest. BARI Hybrid Tomato-8 produced the tallest plants (86.90 cm) among the varieties (Table 1).Plant height at harvest was significantly affected by the application of different doses of plant growth regulators (Table 1).Result reveals that maximum plant height (88.30 cm) was produced by the application of GA_3 at the rate of 20 ppm which is statistically similar to the combined treatment T_3=20 ppm NAA+ 20 ppm GA_3.Meanwhile control treatment T_0 produced the shortest plant height of 77.92 cm. In case of combined effect significant variation was found plant height due to the application of plant growth regulators (Table 3). Highest plant height (90.79 cm) was found in V_4T_2 which was statistically similar to V_4T_3 & V_3T_2 whereas V_1T_0 produced the shortest plant height of (75.81cm). This might be due to the influence of plant growth regulators on the vegetative parts of the plant. GA3 promotes vegetative growth by active cell division and elongation especially in the apical portion of the plants. Taiz & Zeiger [9] reported that by promoting cell growth and division, the gibberellin stimulates elongation of internodes. The auxin and gibberellin control separate processes that, when combined, contribute to stem elongation and fruit set (including ovary growth), suggesting an additive effect, in which the auxin stimulates growth by cell expansion and cell division while gibberellin acts in the expansion as well as in the number of cells [10]. In fact, Gibberellins are the key regulators in shoot elongation in plants and this might be the reason to have tallest plant in V_4T_2.Similar kind of result was reported by Nibhavanti et al. [11] and our result is in agreement with their findings.

3.2 Root Dry Weight

Variety had a significant variation on the dry weight of root per plant. The highest dry weight

of root per plant (2.97 g) was recorded in V_3 and the lowest (2.38 g) in V_2 which was statistically similar with V_4 (Table 1). But there was significant variation in the dry weight of root per plant due to the application of plant hormone. The maximum dry weight of root per plant (2.96 g) was obtained from T_1 treatment and the minimum (2.47 g) from T_0 treatment (Table 1). Interaction effect of varieties and hormone had a significant effect on dry weight of root per plant. The highest dry weight of root per plant (3.46 g) was obtained from V_3T_1 treatment whereas the lowest (2.11) from V_2T_0 (Table 3).This might be due to the ameliorative effect of NAA in root growth and carbohydrate accumulation as NAA increases the ability of carbohydrates to transport to the root systems. Cato et al. [12] reported the increased root dry matter content of tomato due to the synergistic effect of Auxin and Gibberellins.

Chauhan et al. [13] reported the increased root dry weight of tomato due to the application of plant growth regulator and our finding is consistent with their findings.

3.3 Shoot Dry Weight

Varieties showed significant variation on the dry weight of shoot per plant. The highest dry weight of shoot per plant (13.52 g) was recorded in V_1, which was statistically similar with V_2 and V_3 and the lowest (12.55 g) in V_4 (Table 1).There was also a significant variation in the dry weight of shoot per plant due to the application of hormone. The maximum dry weight of shoot per plant (15.52 g) was obtained from T_3 treatment and the minimum (11.40 g) from T_0 treatment (Table 1).Interaction effect of different varieties and hormone showed significant variation on dry weight of shoot per plant. The highest dry weight of shoot per plant (15.90 g) was obtained from V_3T_3 treatment, while the lowest (10.51 g) from V_4T_0 (Table 3). It might be the results of their stimulatory effect of GA3 on plant growth due to cell elongation and rapid cell division in growing portion and there are number of reports showing that gibberellins and naphthalene acetic acid promote growth of intact plants. These results are in conformity with the findings of Arora et al. [14] and Chovatia et al. [15] Uddain et al. [16] reported the increased length of internode and number of branches due to the application of NAA and GA3.Therefore, increased internode, number of branches with increased vegetative growth might be the reason for higher shoot dry weight. Similar result was reported by Ali et al. [17], Patel et al. [18].

3.4 Chlorophyll Content (SPAD value)

SPAD meter reading of leaf was analyzed and presented in order to having an idea about relative leaf chlorophyll content per unit leaf area of the tomato varieties. SPAD Value of leaf was significantly influenced by variety (Table 1).The highest SPAD Value of leaf (48.72) was obtained from V_4 and the lowest SPAD value of leaf (47.95) was obtained from the V_1(Table 1). The different hormones had significant influenced on

Table 1. Main effects of variety and treatment on plant height, root dry weight, shoot dry weight and chlorophyll content of summer tomato

Treatments	Plant height(cm)	Root dry weight	Shoot dry weight	SPAD value
Variety				
V_1	82.55 c	2.66 bc	13.52 a	47.95 b
V_2	84.36 b	2.38 c	13.50 a	48.65 a
V_3	84.57 b	2.97 a	13.18 ab	48.57 a
V_4	86.90 a	2.92 a	12.55 b	48.72 a
Treatments				
T_0	77.92 c	2.47 b	11.40c	45.85c
T_1	84.24 b	2.96 a	12.86 b	49.74 a
T_2	88.30 a	2.90 a	12.96 b	48.32 b
T_3	87.93 a	2.58 b	15.52 a	49.98 a
$LSD_{(0.05)}$	0.59	0.14	0.33	0.35
CV %	1.98	14.66	7.22	2.06

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, T_0= Control, T_1= 20 ppm NAA, T_2= 20 ppm GA_3, T_3= 20 ppm NAA +20 ppm GA_3, V_1= BINA tomato 6, V_2= BINA tomato 7, V_3= BARI Hybrid Tomato 4, V_4= BARI Hybrid Tomato 8

Table 2. Effect of variety and treatment on days to cluster initiation, cluster per plant, bud per cluster, flower per cluster, fruit per cluster

Treatments	Cluster plant^{-1}	Bud cluster^{-1}	Flower cluster^{-1}	Fruit plant^{-1}	Fruit Yield plant^{-1}
Variety					
V_1	7.29 d	6.92 c	4.79 b	8.89 c	136.81 d
V_2	8.14 c	7.39 b	4.83 b	10.75 b	158.35 c
V_3	9.32 b	7.67 b	5.60 a	15.79 a	282.84 b
V_4	9.95 a	8.01 a	5.94 a	16.48 a	309.04 a
Treatment					
T_0	6.87c	6.55 c	4.08 c	7.79 d	116.77 c
T_1	9.03 b	7.64 b	5.43 b	13.82 b	216.81 b
T_2	8.68 b	7.55 b	5.66 ab	12.64 c	224.47 b
T_3	10.12 a	8.26 a	5.99 a	17.65 a	328.99 a
$LSD_{(0.05)}$	0.26	0.16	0.21	0.49	6.09
CV %	8.70	6.19	11.74	10.84	8.41

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, T_0= Control, T_1= 20 ppm NAA, T_2= 20 ppm GA_3, T3= 20 ppm NAA +20 ppm GA_3, V_1= BINA tomato 6, V_2= BINA tomato 7, V_3= BARI Hybrid Tomato 4, V_4= BARI Hybrid Tomato 8

the SPAD Value of leaf (Table 1). The maximum SPAD Value of leaf (49.98) was produced by hormones T_3 treatment. On the other hand, treatment T0 produced the minimum SPAD Value of leaf (45.85). The interaction between different variety and hormones put significant effect on the SPAD Value of leaf (Table 3). The maximum SPAD Value of leaf (50.70) was found in V_3T_3 treatment. The lowest SPAD Value of leaf (43.47) was found in V_1T_0 treatment. This might be due to the gibberellins and auxins stimulated cell division and cell elongation, therefore the combining foliar spray of these growth substances in the present study significantly increased the leaf length and width which might have facilitated higher chlorophyll content in leaves. Rai et al. [19] reported that maximum chlorophyll content and acidity were obtained with NAA at 75 ppm and our result is consistent with it.

3.5 Cluster Plant^{-1}

There was a significant difference among the varieties in respect of number of flower cluster per plant (Table 2). The maximum number of flower cluster (9.95) was produced in V_4. The different hormones had significant effect on the number of flower cluster per plant (Table 2). The maximum number of flower cluster per plant (10.12) was produced from T_3 treatment and treatment T_0 produced the minimum number of flowers per cluster (6.87). Interaction of variety and hormones had significant influence on number of flowers cluster per plant (Table 4). The maximum number of flowers cluster per plant (11.68) was found in V_4T_3 which was statistically similar to V_3T_3 & V_4T_1; whereas the minimum number of flower cluster per plant (5.81) was found in V_1T_0. Our finding is in agreement with the finding of Uddain et al. [16] who reported that the increasing level of GA3 had promotive effect on the number of cluster per plant in case of tomato.

3.6 Bud Cluster^{-1}

Number of bud per cluster due to the influence of different varieties was significant (Table 2). The variety 'BARI Hybrid Tomato-8' had the highest number of flowers per cluster (8.01). The different hormones showed significant variation in the number of bud per cluster (Table 2). The maximum number of flowers per cluster (8.26) was produced by T_3 treatment and T_0 produced the minimum number of flowers per cluster (6.55). The number of flowers per cluster variation among the treatment combinations of variety and hormones was found significant (Table 4). The maximum number of flowers per cluster (8.80) was found in V_4T_3 treatment whereas the minimum number of flowers per cluster (5.86) was found in V_1T_0 treatment. Application of NAA increases the production of flower in tomato due to enhanced plant growth and faster rate of plant development by the action of NAA in cell elongation and there by increased cell enlargement, cell division and differentiation which in turn result into increase in number of flowers buds. Similar kind or result was reported by Kishan et al. [20].

Table 3. Combined effects of variety and treatment on plant height, root dry weight, shoot dry weight and chlorophyll content of summer tomato

Treatments	Plant height (cm)	Root dry weight	Shoot dry weight	SPAD value
V_1T_0	75.81 j	2.63 c-f	12.39 d-g	43.47 g
V_1T_1	82.30 h	2.75 c-e	13.32 cd	50.17 a
V_1T_2	86.30 d-f	3.02 a-c	12.75 d-f	48.45 cd
V_1T_3	85.75 e-g	2.26 d-f	15.61 ab	49.70 a-c
V_2T_0	77.97 ij	2.11 f	11.29 gh	45.37 f
V_2T_1	83.99 f-h	2.75 c-e	13.27 c-e	50.70 a
V_2T_2	87.14 c-d	2.47 c-f	13.40 cd	47.84 de
V_2T_3	88.35 b-d	2.20 ef	16.03 a	50.70 a
V_3T_0	78.07 ij	2.77 b-d	11.44 f-h	47.02 e
V_3T_1	83.75 gh	3.46 a	11.95 e-g	48.69 b-d
V_3T_2	88.97 a-c	2.79 b-d	13.44 cd	48.67 b-d
V_3T_3	87.50 c-e	2.85 bc	15.90 a	49.90 ab
V_4T_0	79.85 i	2.48 c-f	10.51 h	47.54 de
V_4T_1	86.85 c-d	2.88 bc	12.90 de	49.40 a-c
V_4T_2	90.79 a	3.32 ab	12.26 d-g	48.34 c-e
V_4T_3	90.12 ab	3.00 a-c	14.53 bc	49.62 a-c
$LSD_{(0.05)}$	1.18	0.28	0.67	0.71
CV %	1.98	14.66	7.22	2.06

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, T_0= Control, T_1= 20 ppm NAA, T_2= 20 ppm GA_3, T_3= 20 ppm NAA +20 ppm GA_3, V_1= BINA tomato 6, V_2= BINA tomato 7, V_3= BARI Hybrid Tomato 4, V_4= BARI Hybrid Tomato 8

3.7 Flower Cluster^{-1}

Number of flowers per cluster due to the influence of different varieties was significant (Table 2). The variety 'BARI Hybrid Tomato-8' had the highest number of flowers per cluster (5.94). However, the lowest number of flowers per cluster (4.79) was obtained from the variety 'BINA Tomato-6'. In case of hormonal treatment, the maximum number of flowers per cluster (5.99) was produced by T_3 treatment and T0 produced the minimum number of flowers per cluster (4.08). In case of combined effect of variety and treatment, the number of flower per cluster showed significant variation (Table 4). The maximum number of flowers per cluster (6.78) was found in V_4T_3 treatment. The minimum number of flowers per cluster (3.33) was found in V_1T_0 treatment. This might be caused because GA3 promotes flower primodia production in tomato plant which was confirmed by Uddain et al. [16]. Rahaman et al. [21] reported increased number of flower due to the application of plant growth regulators and our findings are similar with their findings.

3.8 Fruit Plant^{-1}

There was a significant difference among the varieties in the number of fruit per plant (Table 2). The maximum number of fruits per plant (16.48) was produced by 'BARI Hybrid Tomato-8' (V_4). The minimum number of fruit per plant (8.89) was produced in V_1. The different hormones treatment showed significant variation in the number of fruits per plant (Table 2). The maximum number of fruit per plant (17.65) was produced from T_3 treatment while treatment T_0 produced the minimum number of fruits per plant (4.08). A significant variation was observed among the treatment combinations in number of fruits per plant (Table 4). The maximum number of fruits per plant (23.95) was found in V_4T_3 whereas the minimum number of fruits per plant (5.56) was found in V_1T_0. The significant improvement in fruit formation due to the foliar spray of GA3 and NAA in the present study might be because of the fact that they increases the metabolic activity in plant, which resulted in enhancement of reproductive phase in tomato. Chovatia et al. [15] reported that application of NAA at the time of flowering prevents pre-harvest flower abscission by increasing the available plant hormone (auxin) concentration at this critical phase of reproductive development in tomato plants which ultimately increases the number of fruits. The results are in conformity with the finding of Nibhavanti et al. [11], Rai et al. [19], Choudhury et al. [22], Alam and Khan [23].

Table 4. Combined effect of variety and treatment on yield and yield contributing characters of summer tomato

Treatments	Cluster plant^{-1}	Bud cluster^{-1}	Flower cluster^{-1}	Fruit plant^{-1}	Fruit yield plant^{-1}
V_1T_0	5.81 k	5.86 i	3.33 g	5.56 j	87.56 i
V_1T_1	7.81 g-i	7.12 f-h	4.87 d-f	9.81 f-h	133.41 h
V_1T_2	7.12 ij	6.96 gh	5.37 c-f	8.37 hi	129.05 h
V_1T_3	8.43 e-h	7.76 b-f	5.61 b-e	11.81 ef	197.22 f
V_2T_0	6.43 jk	6.06 i	3.62 g	7.12 ij	101.06 i
V_2T_1	8.00 f-i	7.59 d-g	4.96 d-f	11.25 fg	145.68 gh
V_2T_2	8.75 d-g	7.67 c-f	5.14 c-f	10.93 fg	162.77 g
V_2T_3	9.37 c-e	8.26 a-c	5.58 b-e	13.68 de	223.89 e
V_3T_0	7.81 g-i	7.43 e-h	4.79 ef	8.87 hi	137.70 h
V_3T_1	9.56 cd	7.50 e-h	5.88 bc	17.50 c	289.75 d
V_3T_2	8.93 c-f	7.53 e-g	5.73 b-d	15.62 cd	283.65 d
V_3T_3	11.00 ab	8.24 a-d	6.02 a-c	21.18 b	420.26 b
V_4T_0	7.43 h-	6.86 h	4.57 f	9.62 gh	140.76 gh
V_4T_1	10.75 ab	8.35 ab	6.01 a-c	16.75 c	298.39 cd
V_4T_2	9.93 bc	8.05 b-e	6.39 ab	15.62 cd	322.43 c
V_4T_3	11.68 a	8.80 a	6.78 a	23.95 a	474.60 a
$LSD_{(0.05)}$	0.53	0.33	0.44	0.99	12.194
CV %	8.70	6.19	11.74	10.84	8.41

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, T_0= Control, T_1= 20 ppm NAA, T_2= 20 ppm GA_3, T_3= 20 ppm NAA +20 ppm GA_3, V_1= BINA tomato 6, V_2= BINA tomato 7, V_3= BARI Hybrid Tomato 4, V_4= BARI Hybrid Tomato 8

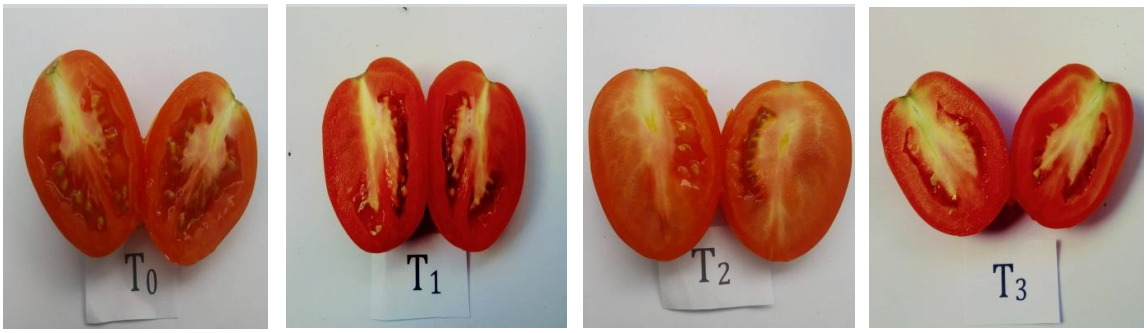

Fig. 1. Photographic view of BARI hybrid tomato 8 with four treatments of plant growth regulators, viz. T_0= Control, T_1= 20 ppm NAA, T_2= 20 ppm GA_3, T_3= 20 ppm NAA +20 ppm GA_3

3.9 Fruit Yield Plant^{-1}

The different varieties of tomato significantly influenced on the yield of fruits per plant (Table 2). The maximum yield of fruits per plant was obtained from BARI Hybrid Tomato-8 (309.04 g) followed by BARI Hybrid Tomato-4 (282.84 g) and the minimum yield of fruits per plant was obtained from BINA Tomato-6 (136.81 g).The different hormones had significant effect on the yield of fruits per plant (Table 2). The maximum yield of fruits per plant (328.99 g) was produced by T_3 (20 ppm NAA + 20 ppm GA3) treatment and T_0 (control) treatment produced the minimum yield of fruits per plant (116.77 g).The combined effect of variety and hormones put significant difference on yield of fruit per plant (Table 4). The highest yield of fruits per plant (474.60 g) was obtained from 'BARI Hybrid Tomato-8' with 20 ppm NAA + 20 ppm GA3 (V_4T_3). The lowest yield of fruits per plant (87.56 g) was obtained from BINA Tomato-6 with Control (V_1T_0).This might be due to the combined application of NAA and GA3 by which the plant remained physiologically more active to build up sufficient food stocks for developing flowers, fruit and resulted in increased fruit set, which ultimately lead to higher yields. This result is in agreement

with the findings of Baliyan et al. [24] where reported that tomato fruit set and yield was increased by the application of 4-CPA as compared to the fruit set where no hormone was applied. Patel et al. [18] revealed that the application of NAA increases the fruit diameter and yield in tomato.

4. CONCLUSION

In this experiment two different plant growth regulators and their combination were used which resulted in significant variation in growth and yield contributing characters of summer tomato varieties. BARI Hybrid Tomato-8 showed better performance in terms of all the yield contributing characters studied. Among the different treatments of plant growth regulators-plants treated with the combined application of 20 ppm NAA and 20 ppm GA_3 showed an increased flower per cluster, number of fruits and yield as compared to the plants treated with NAA and GA_3 alone. Therefore it may be suggested that 20 ppm NAA along with 20ppm GA_3 can be effective in enhancing growth and yield of summer tomato.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

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