



Effect of chloromequat chloride and indole-3-butyric acid as chemical growth regulators on tomato productivity and its chemical composition

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Abstract

This study aimed to increase tomato productivity through improving fruit set and plant performance and its chemical contents using plant growth regulators. A specific experiment has been carried out to study the effect of plant growth regulators: Milagro (1% indole-3-butyric acid) and Atlet active substances (4% chloromequat chloride plus 0.01% indole-3-butyric acid) at different three applied doses: 0.6, 1.0 and 1.5 M/L and 1.0, 1.5 and 2.0 M/L, respectively on growth and chemical composition of tomato plants (Big bif F₁). Both growth regulators were foliar applied three times spraying on plants at 30, 60 and 90 days after transplanting (DAT). The obtained results showed that foliar application of Milagro at 1.0 M/L resulted in the highest significant number of leaves per plant and leaf area at 30, 60 and 90 DAT, as well as number of flower cluster per plant and increased fruit number per plant and fruit weight during the cultivated seasons. The foliar application of Atlet at 1.5 M/L increased plant height and stem diameter at 30, 60 and 90 DAT during the cultivated seasons. Chlorophyll contents in leaves was increased by foliar application of Atlet at 1.5 and 2.0 M/L during the first and second growing seasons, respectively. Milagro significantly improved tomato fruit quality by increasing total soluble solid (TSS), vitamin C and carotenoids contents in tomato fruits. While, Atlet at 1.5 M/L increased dry matter percent in tomato fruits.

Keywords: Tomato, indole-3-butyric acid, chloromequat chloride, plant growth regulators.

1. INTRODUCTION

Tomato (*Solanum lycopersicum*) belongs to the family Solanaceae. Tomato is the most important vegetable crop cultivated in both open field and greenhouses and other protected cultivation areas [1, 2, 3]. In view of the rapid increase in population growth and the increase in consumption of foodstuffs, including tomato crop, scientific studies have been carried on the available methods to increase plant production, including the study of the influence of growth regulators on plant growth and its productivity. The farmers often apply several chemical substances which have similar structure and activity with endogenous plant hormone as Plant Growth Regulators (PGRs). PGRs are cheap alternative to enhance plant growth and increase its productivity [4, 5]. Application of plant growth regulators have been found very effective in improving quantity and quality of many crops [4-6]. PGRs have wide category of compounds that can enhance, inhibit or change plant morphological or physiological processes at very low concentrations. Thus, the use of PGRs has become an important element of the agrotechnical procedures for most cultivated crops [4, 7]. The most studied of PGRs

include Abscisic acid, Indole acetic acid, Cytokinin, Gibberellic acid, Ethylene, Jasmonic acid and Salicylic acid [4, 8]. Nowadays, there are new plant growth regulators, but chemically unrelated compounds with a similar hormone such as Milagro (1% indole-3-butyric acid) and Atlet active substances (4% chloromequat chloride plus 0.01% indole-3-butyric acid). Most of such chemical or natural substances have not been studied for their effect on vegetables and fruits that enter directly into the human daily diet especially tomatoes, which occupies the fourth ranks in terms of worldwide production with approximately 5 million ha as a harvested area produced 170.75 million tones according to FAO statistics' database [9] and [10]. Tomato is an important condiment in most diets and a very cheap source of vitamins and nutrients that are very good for the human body and protect the body against diseases [11]. This is primarily due to its more contents from these vitamins and beta-carotene working as antioxidants to neutralize harmful free radicals in the human blood [12-13]. In that regard, our research aims to improve plant performance, fruit set and yield of tomatoes by studying the effect of plant growth regulators (synthetic and natural) on tomato plants

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(*Lycopersicon esculentum*), using different new types (Milagro and Atlet) as plant growth regulators on tomato Hybrid "Big bif F₁".

2. Materials and Methods:

This experiment aimed to study the effect of foliar application of Milagro (1% indol-3-butyric acid) and Atlet active substances (4% chloromequat chloride plus 0.01% indole-3-butyric acid) with different three applied doses on the vegetative growth, flowering and fruiting of tomato Hybrid "Big bif F₁". Different three doses: 0.6, 1.0 and 1.5 M/L of Milagro as well as different three doses: 1.0, 1.5 and 2.0 M/L of Atlet were foliar sprayed three times at 30, 60 and 90 DAT on tomato plants (Big bif F₁) during the two growing season of 2019 and 2020. All sprayed doses expressed in terms of active substances of both Milagro and Atlet were applied three times with three replications. The experimental design was a Complete Randomized Blocks Design with three replicates. Soaked seeds were planted on trays, then after 30 DAT, tomatoes seedling was transplanted on pots (20-inch diameter). Average day and night temperatures in greenhouses were 25°C and 18°C, this conforms within normal temperature ranges established for greenhouse [14].

Collecting data:

Vegetative growth characters: Ten plants from each replicate (3 replicates) were selected to measure the following parameters: Plant height (cm), number of

leaves per plant, stem diameter (mm) and leaf area (m²/plant) were determined.

Yield: Number of cluster per plant, number of fruits per plant and fruit weight (g) was determined.

Chemical composition: Chlorophyll (SPAD) was determined in tomato leaves at 60 DAT, and biochemical parameters were evaluated in the fruit ripening stage at 90 DAT to determine different chemical properties: Dry matter (%), TSS (°Brix), Vitamin C (Ascorbic acid, mg/100g) and Carotenoids (mg/100g) according to [15,16].

The obtained results were statistically analyzed using one-way analysis of variance (ANOVA) using Co-Stat program. The mean values were compared using Duncan's multiple range test at P<5% as reported by [17].

3. RESULTS AND DISCUSSIONS:

3.1. Plant height:

Plant height produced by tomato plant was found to be significantly as affected by spraying treatments with Milagro and Atlet compared to untreated control (Fig. 1). The obtained results showed that foliar application of Atlet at 1.5 M/L ranked the first to increase highest values of plant height at 30, 60 and 90 days after transplanting (DAT), respectively during the growing seasons. (Fig. 1). Our results are agreed with [18-19].

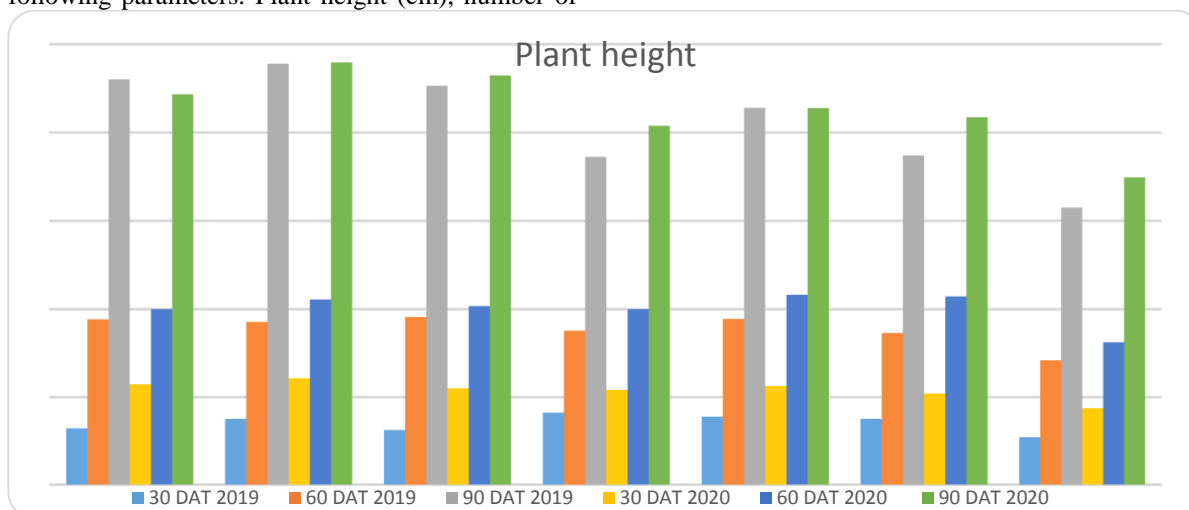


Fig. (1): Effect of different foliar application doses from Atlet and Milagro on plant height (cm) of Big bif tomato hybrid during the two growing seasons.

3.2. Number of leaves:

Number of leaves per plant produced by tomato plant was found to be significantly affected by spraying treatments with Milagro and Atlet compared to untreated control (Fig. 2). The obtained results showed that spraying with Milagro at 1.0 M/L

recorded the highest value of number of leaves per plant at 30 and 60 DAT during the growing seasons. On the other hand, untreated control recorded the lowest value of number of leaves per plant during the two growing seasons. Our results are consistent with those obtained from [20], the number of leaves in tomatoes increased with the use of chemical growth

regulators, and this may be attributed to the fact that plant growth regulators improved cellular nutrition and division with a significant elongation of the stem. The results also corroborate with the results of [21-22], who reported that tomato varieties affected the nature of the growth processes.

3.3. Stem diameter:

The stem diameter of tomato plant was found to be significantly affected by spraying treatments with Milagro and Atlet compared to untreated control (Fig. 3). The obtained results showed that foliar application of Atlet at 1.5 M/L resulted in the highest values of stem diameter at 30, 60 and 90 DAT), respectively during the growing seasons. (Fig. 3).

Results showed that no significant differences were found between 1.0 and 1.5 M/L of Milagro on stem diameter values at 30 and 90 DAT during the two

growing seasons. On the other hand, untreated control recorded the lowest value of stem diameter during the two growing seasons. Similar results were obtained by [23, 24, 25 and 26].

3.4. Leaf Area:

Data in Fig. (4) explain changes in leaf area measurements as a response of the application of different growth regulators to tomato plants at various times. At 90 DAP, applying Milagro and Atlet increased leaf area comparing to untreated control. The foliar application of Milagro at 1.0 M/L was positively significant. The maximum leaf area was obtained from Milagro 1.0 M/L, while the minimum leaf area was related to untreated control during the two growing seasons. The obtained results are in agreement with those obtained by [23, 24, 25 and 26].

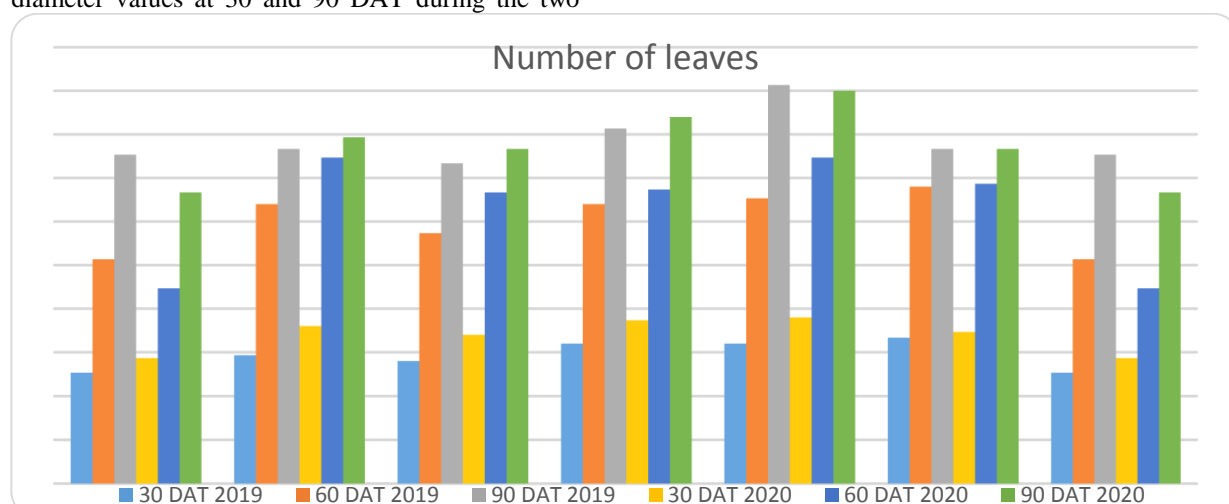


Fig. (2): Effect of different foliar application doses from Atlet and Milagro on number of leaves per plant of Big bif tomato hybrid during the two growing seasons.

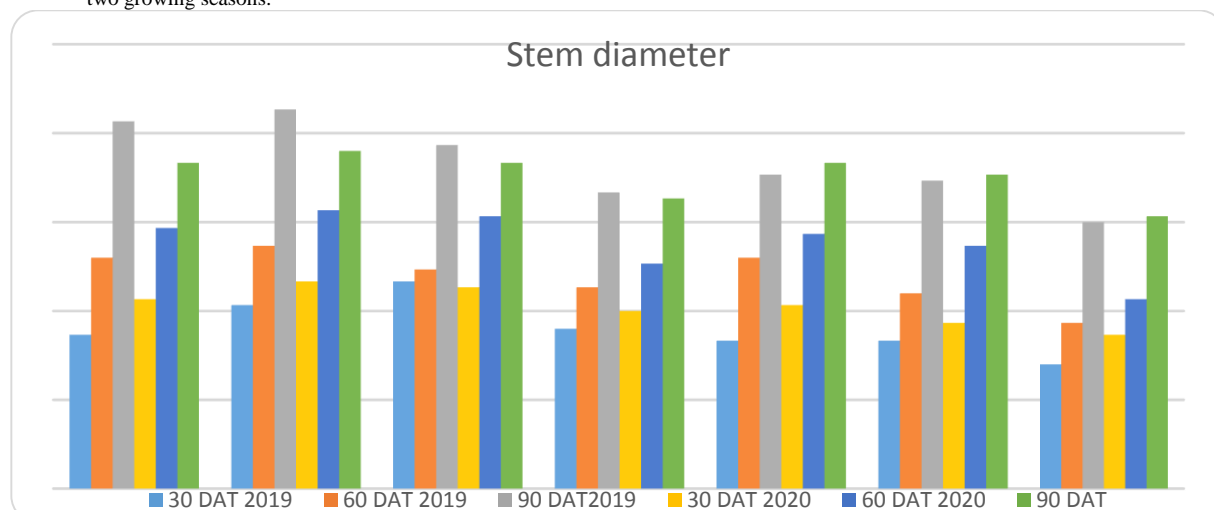


Fig. (3): Effect of different foliar application doses from Atlet and Milagro on stem diameter (cm) of Big bif tomato hybrid during the two growing seasons.

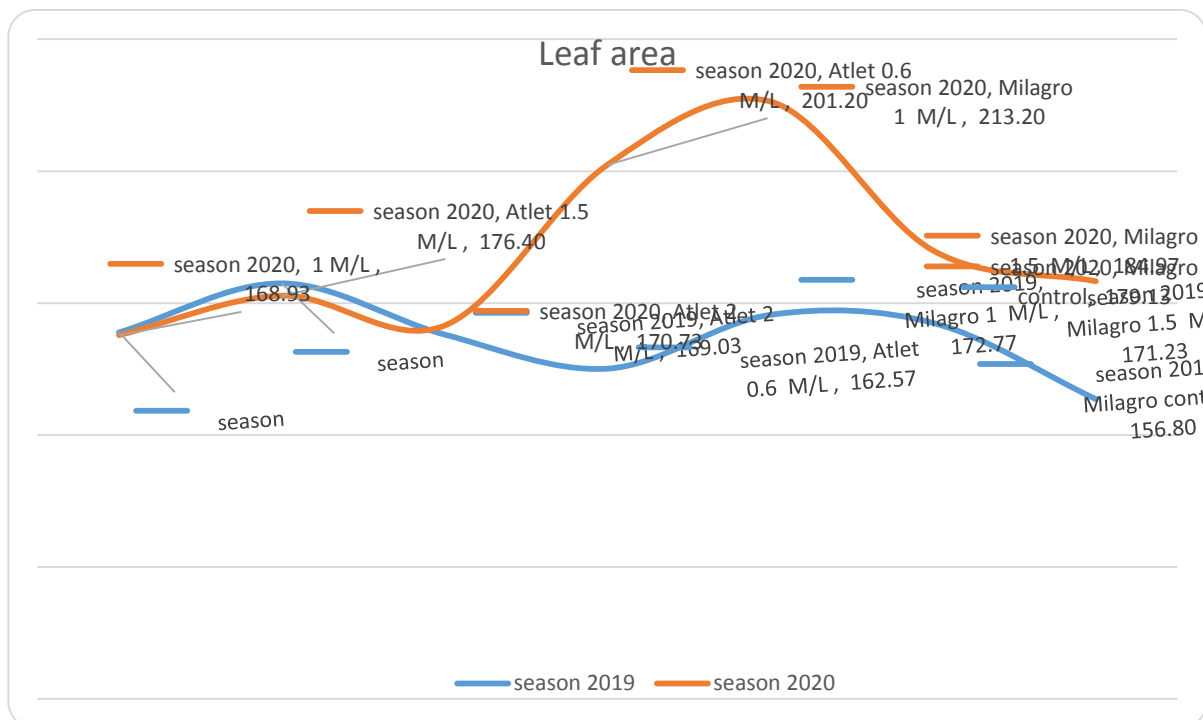


Fig. (4): Effect of different foliar application doses from Atlet and Milagro on leaf area (cm²) of Big bif tomato hybrid during the two growing seasons.

3.5. Number of clusters:

Number of clusters produced by tomato plant was found to be significantly affected by foliar spraying with Milagro and Atlet treatments compared to untreated control (Fig. 5). The obtained results showed that plants sprayed by Milagro at 1.0 mg/L produced the highest values of number of cluster per plant at 60 and 90 DAT in the two seasons. On the other hand, untreated control recorded the lowest values of number of cluster during the two growing seasons. Our results have the same trend and agreement with the conclusion of [19].

3.6. Number of fruits:

Number of fruits produced by tomato plant was found to be significantly affected by Milagro and Atlet treatments compared to untreated control (Fig. 6). The maximum number of fruits per plant was recorded by foliar application of Milagro at 1.0 M/L, while the minimum number of fruits per plant was recorded with untreated control at 60 and 90 DAT in the two seasons during the growing seasons. Our results are consistent with the conclusion of [19, 27].

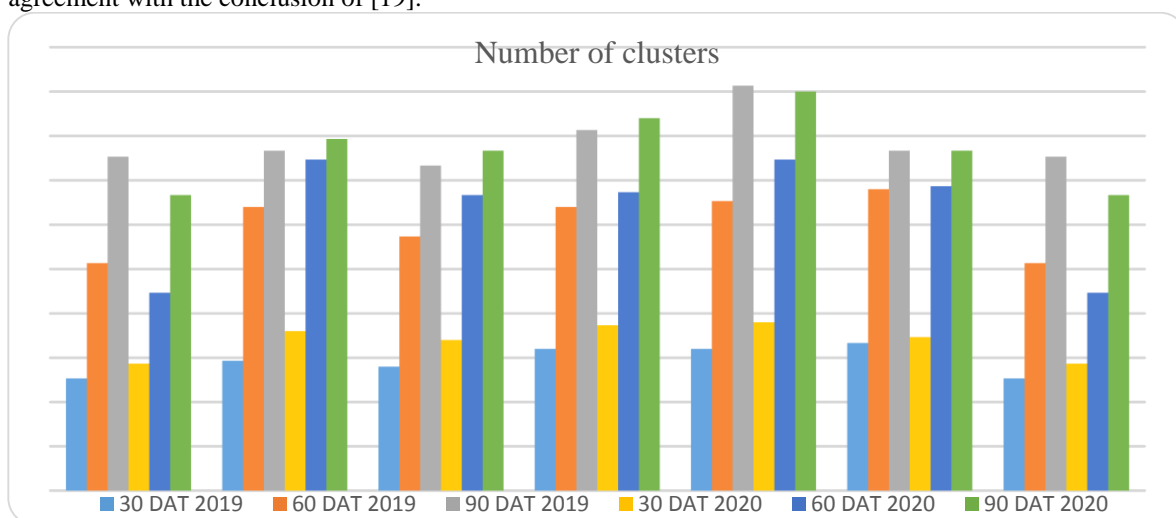


Fig. (5): Effect of different foliar application doses from Atlet and Milagro on number of clusters per plant of Big bif tomato hybrid during the two growing seasons.

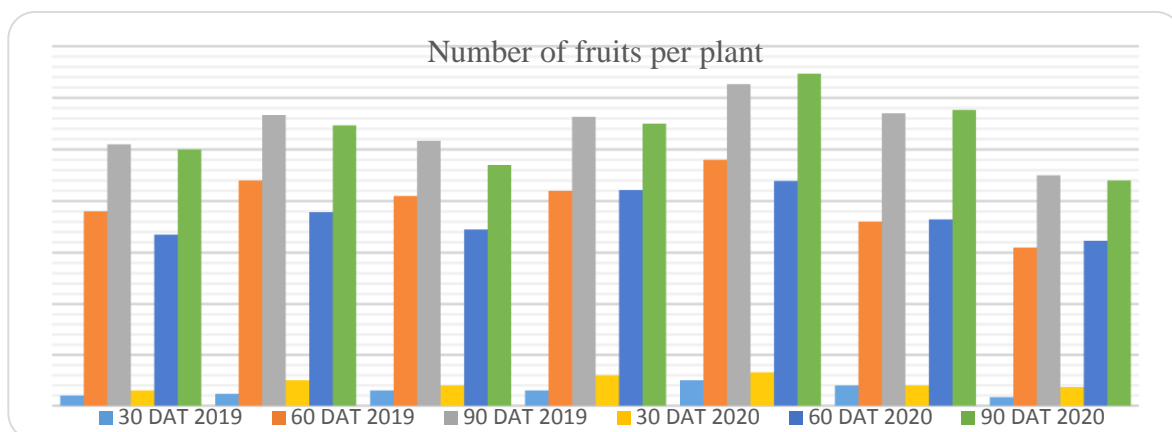


Fig. (6): Effect of different foliar application doses from Atlet and Milagro on number of fruits per plant of Big bif tomato hybrid during the two growing seasons.

3.7. Fruit weight:

Fruit weight produced by tomato plant was significantly affected by foliar application with Milagro and Atlet treatments compared to untreated control (Fig. 7). The foliar application of Milagro at

1.0 M/L ranked the first to increase fruit weight, while the minimum fruit weight was related to untreated control at 60 and 90 DAT during the growing seasons. The same trend was reported by [19, 27].

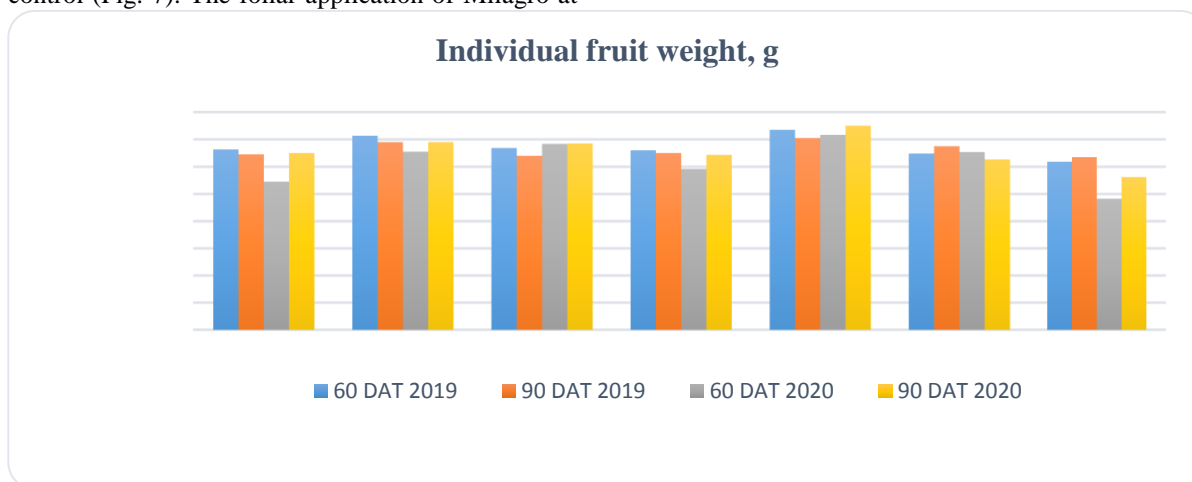


Fig. (7): Effect of different foliar application doses from Atlet and Milagro on fruit weight of Big bif tomato hybrid during the two growing seasons.

3.8. Chemical composition:

Chemical composition: Chlorophyll (SPAD) in tomato leaves at 60 DAT, Dry matter (%), TSS ($^{\circ}$ Brix), Vitamin C (Ascorbic acid, mg/100g) and Carotenoids (mg/100g) have been determined in tomato fruits in the ripening stage at 90 DAT during the two growing seasons. Results of the chemical composition of tomato plants and tomato fruits as affected by different doses of studied growth regulators are shown in Table (1) and (2). The highest value of Chlorophyll content (59.8) was observed in tomato plants when Atlet at 1.5 M/L was foliar sprayed in the first season, while the foliar sprayed plants by Atlet at 2.0 M/L gave the highest content of Chlorophyll (60.1) in tomato leaves in the second season. On the other hand, the lowest values of Chlorophyll contents (50.8 to 52.3) in tomato leaves were related to untreated control at during the growing seasons. The highest values of dry matter

percent ranges between 7.53 to 7.71 % during the two growing seasons due to foliar application of Atlet at 1.5 M/L. While, the lowest values of dry matter percent in tomato fruits was related to untreated control at during the growing seasons. The plants sprayed with Milagro at 1.0 M/L recorded the highest TSS (5.83 to 5.91 $^{\circ}$ Brix) in tomato fruits in the two growing seasons. While, the lowest values of TSS in tomato fruits was related to untreated control at during the growing seasons. The maximum contents of Vitamin C (19.44 to 19.91 mg Ascorbic acid/100g) in tomato fruits were related to foliar application of Milagro at 1.0 M/L during the growing seasons. On the other hand, the minimum contents of Vitamin C (18.28 to 18.35 mg Ascorbic acid/100g) in tomato fruits were related to untreated control during the growing seasons. Milagro at 1.0 M/L gave the highest contents of Carotenoids (4.90 mg/100g) in tomato fruits in the first season. In the second season, Milagro

at 1.5 gave the highest contents of Carotenoids (4.85 mg/100g) in tomato. While, the untreated control plants contained the lowest values of Carotenoids (3.86 to 3.95 mg/100g) in tomato fruits during the two growing seasons. Our results are agreed with [19, 27], who reported that chemical growth regulators enhanced mineral nutrients absorption by plants and increased the permeability of membranes of root cells to tomato plants. Also, as a result of increasing vegetative growth characters due to application of

growth regulators in tomato plants [23]. The obtained results are in agreement with those obtained by [19, 27] observed that the values commonly obtained for soluble solids of different cultivars of tomato fruit range from 4 to 6 °Brix. They found that TSS significantly increased by spraying of growth regulators as compared with control fruits. Moreover, noticed that the main soluble sugars in tomato fruit were glucose and fructose which made up 47% of the fruit dry matter.

Table (1): Effect of different foliar application doses from Atlet and Milagro on chemical composition of Big bif tomato hybrid during the growing season of 2019.

Treatments	Chlorophyll (SPAD)	Dry matter, (%)	TSS (°Brix)	Vitamin C (mg/100g)	Carotenoids (mg/100g)
Atlet 1.0 M/L	56.9 c	7.26 b	5.40 bc	18.87 b	4.78 ab
Atlet 1.5 M/L	59.8 a	7.53 a	5.67 b	19.39 a	4.87 a
Atlet 2.0 M/L	58.4 b	7.29 b	5.27 c	18.98 b	4.59 b
Milagro 0.6 M/L	54.9 d	6.63 c	5.70 b	19.05 b	4.50 bc
Milagro 1.0 M/L	58.4 b	7.33 ab	5.91 a	19.44 a	4.90 a
Milagro 1.5 M/L	57.1 c	7.00 b	5.64 b	19.13 b	4.68 ab
Control	52.3 d	6.10 c	4.83 e	18.35 c	3.95 c
Means within the same column that do not share a letter(s) are significantly different at $P \leq 0.05$.					

Table (2): Effect of different foliar application doses from Atlet and Milagro on chemical characters of Big bif tomato hybrid during the growing season of 2020.

Treatments	Chlorophyll (SPAD)	Dry matter, (%)	TSS (°Brix)	Vitamin C (mg/100g)	Carotenoids (mg/100g)
Atlet 1.0 M/L	56.1 c	7.32 b	5.21 c	19.22 c	4.67 b
Atlet 1.5 M/L	59.7 c	7.71 a	5.46 bc	19.54 b	4.70 ab
Atlet 2.0 M/L	60.1 a	7.46 b	5.52 b	19.77 a	4.62 b
Milagro 0.6 M/L	55.3 c	6.18 d	5.49 bc	19.39 c	4.50 c
Milagro 1.0 M/L	58.1 a	6.96 c	5.83 a	19.91 a	4.79 a
Milagro 1.5 M/L	57.4 b	7.14 b	5.30 bc	19.86 a	4.85 a
Control	50.8 d	6.13 d	4.90 d	18.28 d	3.86 d
Means within the same column that do not share a letter(s) are significantly different at $P \leq 0.05$.					

4. Conclusions

The foliar application of Milagro at 1.0 M/L increased number of leaves per plant, leaf area, number of flower cluster per plant, fruit number per plant and fruit weight. The foliar application of Atlet at 1.5 M/L increased plant height, stem diameter. Chlorophyll contents in leaves was increased by foliar application of Atlet at 1.5 - 2.0 M/L. Milagro significantly improved tomato fruit quality by increasing total soluble solid, vitamin C and carotenoids contents in tomato fruits. Atlet at 1.5 M/L increased dry matter percent in tomato fruits.

5. Conflicts of interest

There are no conflicts to declare.

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