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# Role of Foliar Applications by some Safety Compounds and Shading in Alleviating the Harmful Impacts of High Temperature on Tomato

**Hoda I. Ahmed**
**Vegetable Res. Dept., Hort. Res. Institute, Agric. Res. Center, Giza, Egypt**

## ABSTRACT

In Egypt, a large number of tomato varieties are grown but most of them lost their potential mainly because of the biotic and abiotic factors. Among these factors, heat stress that is one of the most important determinants of the continuity of the production in the late summer period. The aim of the current study was to assay the role of some treatments in lessening the harmful impacts of high temperatures on production of two commercial hyrids "Alisa $F_1$" and "888 hybrid". The study was elaborated in the open field at El-Baramoun farm, Mansoura Horticulture Research Station, Dakahlia governorate during two successive late summer seasons of 2014 and 2015. The experimental design was in split plot included six treatments i.e., naphthaline acetic acid (NAA) at 2.5 ppm, Purshade ($CaCO_3$) 1%, Kaoline (Aluminum silicate) 2.5% as foliar spray and intercropping with maize through two levels of shading; shade 2 (intercropping with maize at two meters apart at the same side of ridge planted with tomato; shade 3 (intercropping at three meters apart at the same side of ridge planted with tomato). Significant differences were observed between "Alissa $F_1$" and "888 hybrid" tomato hybrids for the majority of studied traits. In general, the mean performance of "888 hybrid" grown under high temperature was better and more tolerant than "Alissa $F_1$". In regard to effect of the treatments, both treatments of shade 2 and NAA gave the highest plant height without significant differences between them. Furthermore, NAA at 2.5 ppm gave the great number of branches per plant over the two seasons. In addition, expressive increase in the leaf area was recorded for all treatments in the second season comparing with the first one, however, the shade 3 treatment gave the highest leaf area over the two seasons estimated by 730.87 cm and 772.8 cm, respectively. The treatment of NAA caused a high and significant increase in the total chlorophyll content over the control during the two seasons estimated by 1.15 and 1.72 mg/g, respectively followed by Kaoline treatment. In contrast, a great accumulation of dry weight was observed with the shade 3 treatment that gave 30.03 % and 30.22%, for the first and second season, respectively followed by NAA treatment. Kaoline caused a significant increase in TSS % compared with the control. High vitamin C content was recorded by the NAA treatment with significant differences comparing with the control. Concerning fruit firmness, shade 3 has a significant effect on firmness over the two seasons that estimated by 30.55 and 30.98 inch/$cm^2$, for the first and second season, respectively followed by Kaoline and $CaCO_3$ treatments. In addition, the foliar application by NAA increased significantly fruit set % that estimated by 13.10 % and 8.83 % for "888 hybrid" and "Alissa $F_1$", respectively over the control. Concerning the total fruit yield, the shade 3 treatment recorded an increase estimated by 10.45 and 10.68 ton/fed over the control for "888 hybrid" and "Alissa $F_1$", respectively as a mean performance of the two years followed by NAA treatment. According to the previous results, it can recommended under high temperature spraying tomato plants by NAA at 2.5 ppm combined with intercropping with maize at three meters apart at the same side of ridge planted with tomato which enhanced different vegetative growth parameters as well as the quantity and quality of fruit yield.

**Keywords**: NAA, heat stress, Kaoline , Purshade, fruit set, *Solanum lycopersicon*

## INTRODUCTION

Tomato (*Solanum lycopersicon* L.) belongs to the *Solanaceae* family, is one of the most important vegetable crops grown in Egypt and worldwide because of its wide adaptability, high yielding potential as well as suitability for variety of uses in fresh or processed and food industries. Tomatoes also produce large amounts of important primary and secondary metabolites which can serve as intermediates or substrates for producing valuable new compounds. As a model crop, tomato already has a broad range of tools and resources available for biotechnological applications, either increased nutrients for health-promoting biofortified foods or as a production system for high-value compounds (Li *et al.,* 2018).

Among the abiotic factors, temperature is the main environmental factor affecting the plant growth and development as well as physiological and biochemical characters (Fu *et al.* 2015a; Zhang *et al.* 2017). In Egypt, a large number of tomato varieties are grown, most of them lost their potential due to genetic deterioration, biotic and abiotic factors. Hence, heat stress is the most important determinants of the continuity of the tomato production in Egypt in the late summer period. The day/night temperatures during this period i.e., from June to August rise above the optimal temperature for tomato development, especially for flowering and fruit set. Consequently, the fresh market tomato prices arise about 400% to 500% during this period of the year with inferior fruit quality (Elsayed *et al.,* 2015).

The phytohormone auxin plays as prominent role in regulating acclimation to high temperature in plants and high temperature boosts the level of free auxin (Sun *et al.,* 2012; Wit *et al.,* 2014; Zheng *et al.*, 2016). The results of Franklin *et al.,* (2011) indicated that the high levels of auxin was required in an adaptive response to heat stress.

In this regard, the foliar spray application of NAA at variable concentrations significantly increased the fruit yield of tomato and the nutrient contents which increased also in the majority of cases (Alam and Khan, 2002). Also, foliar application of NAA significantly increased fruit yield, number of fruits and average fruit weight of bell pepper. Total chlorophyll, ascorbic acid and nitrate reductase activity were also increased (Sridhar *et al.*, 2009). Recent studies indicated that the bioregulators i.e., IAA, IBA and NAA enhanced tomato growth in the field at the concentration of 100 $mgL^{-1}$ (Olaiya and Adigun, 2010). The effects of these bioregulators on tomato fruit yield and quality have also been reported by (Olaiya, 2010a and Olaiya *et al.,* 2010).

On the other hand, anti transpirants are safety chemical compounds whose role is to harden plants against stress as a method of reducing the effect of stress (Abd Allah, 2017). There are different types of anti transpirant i.e., stomatic, which only affects the stomata, reflecting materials and film-forming which stops almost all transpiration (Nasraui 1993). Reducing transpiration is the useful role which played via anti transpirant by preventing the excessive loss of water to the atmosphere via stomata (Khalil, 2006). Kaoline, alumino-sillicate ($Al_4$ $Si_4$10

($(OH)_8$), is one of these substances. It is white non-porous, non swelling, low abrasive, fine grained and plate-shaped clay mineral that easily disperses in water and is chemically inert over a wide range of pH (Creamer *et al.*, 2005). Kaoline reduces leaf temperature by improving the vapor pressure tendency between leaf surface and bulk air, which is the driving force behind transpiration. This means that the water use efficiency and the ratio of carbon dioxide assimilation are enhanced, especially under conditions that induce water loss through transpiration, such as high temperature combined or not with high intensity solar radiation.

Calcium is well known by its vital role in regulating a number of physiological processes in plants at tissue cellular and moecular levels that influence both growth and responses to environmental stresses (Waraich *et al.,* 2011). Kolupaev *et al.,* (2005) reported that exogenous application of $Ca^{+2}$ promotes plants heat tolerance, decrease the malondialdehyde (MDA) content (lipid peroxidation product) and stimulate the activities of guaiacol peroxidase and catalase which could be the reasons for the induction of heat tolerance. Taylor *et al.,* (2004) illustrated that higher transpiration and temperature levels enhance water uptake, thereby increasing the transport of Ca to the leaves via the xylem. However, under same conditions, the transport of water to fruits is reduced due to competition with the leaves, and thus translocation of Ca to fruits is also restricted causing increasing of fruits infection with bloosm end rot (Adams, 2002).

Shading is another factor to overcome the harmful effect of high temperature on tomato plants. Dorais *et al.,* (2001) found that, the benefit of shading on tomato quality minimizing blossom end rot as well as cracked skin and high light intensity can lead to several disorders in development and appearance of tomato fruit that affect quality. Also Jones (1992) indicated that shading resulted in increasing water content in shaded plants through enhancement of leaves capacity for absorbing radiation and decreasing reflection.

Both genetic improvement and cultural practices such as planting time, plant density and soil irrigation managements must be employed simultaneously to reduce the negative impacts of abiotic stresses in general. Hence, the aim of the current study was to assay the role of Kaoline ,$CaCO_3$ and growth regulators (NAA) in addition to two levels of shading in lessening the harmful impacts of high temperatures on agricultural production of two commercial hybrids of tomato i.e., "Allissa" and "888".

## MATERIALS AND METHODS

Two field experiments were elaborated at El-Baramoun farm, Mansoura Research Station, Dakahlia Governorate, during two successive summer seasons of 2014 and 2015. Tomato seedlings of two commercial hybrids "Alisa hybrid $F_1$" and "888 hybrid" at 35 after seed sowing were transplanted on 18**th** and 15th of May in the first and second season, respectively. Seedlings were transplanted at 50 cm apart on one side of ridge. Plot area was 12 $m^2$ (3 lines × 4 m long ×1m width). The agricultural practices of tomato production were followed as the recommendation of the Ministry of Agriculture. The experimental design was in split plot since cultivars were in the main plot and the treatments were in the sub plot with three replicates each one contained six treatments arranged as follow:

1. Foliar spray with NAA (2.5ppm)
2. Foliar spray with Purshade ($CaCO_3$)1%
3. Foliar spray with Kaoline (Aluminum silicate) $Al_4 Si_410(OH)_8$ 2.5%,
4. Shade 2: intercropping with maize (*Zea mays* L.) hybrid "311"at two meters apart at the same side of ridge planted with tomato
5. Shade 3:intercropping with maize (*Zea mays* L.) hybrid "311" at three meters apart at the same side of ridge planted with tomato and
6. control treatment (Spraying with tap water)

Purshade is a plant protector against solar stress contains 62.5% calcium carbonate and 37.5 % inert ingredients by weight in organic forms. Seeds of maize plants were sown 15 days before tomato transplanting in both seasons. Foliar application was applied four times starting at 30 days after transplanting and repeated every 15 days intervals during growth season. Also air temperature during the two seasons of this work is presented in Table 1.

**Table 1. Monthly air temperature mean in El-Mansoura during seasons of 2014 and 2015.**

| Months | Air temperature °C | | | |
|---|---|---|---|---|
| | 2014 | | 2015 | |
| | Mini. | Max. | Mini | Max |
| May | 16 | 29.5 | 17.1 | 31.3 |
| June | 18.1 | 33.7 | 18.9 | 35.5 |
| July | 22.8 | 34.5 | 22.5 | 36.7 |
| August | 21.1 | 33.8 | 22.0 | 36.0 |
| September | 21.0 | 33.1 | 20.4 | 35.1 |

**Data recorded:**

**1- Vegetative growth traits and chlorophyll content in leaves:**

Five plants were randomly taken from each plot at 65 days after transplanting to determine vegetative growth traits as expressed on plant height (cm), number of leaves, number of branches per plant and leaf area ($cm^2$) as well as fresh weight (g/plant). Dry weight (%) of plant was calculated according the following formula:

$$\text{Dry wieght \%} = \frac{\text{dry wieght of plant (g)}}{\text{fresh wiegh of plant (g)}} x100$$

Chlorophyll content (mg/g) in leaves was estimated as the method described by Goodwin (1965).

**2- Fruit set and yield components**

Five plants selected randomly from each plot were labeled to determine fruit set % according to the formula:

$$\text{Fruit set\%} = \frac{\text{Number of setting fruits of the first five clusters}}{\text{Total number of flowers of the five clusters}} x100$$

Tomato fruits at the pink stage were picked weekly during the harvest season and the number of fruits per plant and total yield (ton/fed.) were recorded. Unmarketable yield% was calculated according the following formula:

$$\text{Unmarketable yield\%} = \frac{\text{sum of blossom end rot and sun scald fruits (ton/Fed)}}{\text{Total yield (ton/Fed)}} x100$$

**3- Fruit quality**

Ten ripe fruits per replicate were randomly selected to measure fruit length and diameter. Total soluble solids

% (TSS) was estimated using a hand refractometer. Vitamin C content was estimated according to Sadasivam and Balasubraminan (1987). Fruit firmness was measured by pleasure tester from the two sides of five fruits of three quarter pigmentation using stainless steel borer 10 mm diameter. The relative response over control for different vegetative growth parameters, yield components and fruit quality traits was calculated according to the following formula:

$$\text{Relative response (\%)} = \frac{t-c}{c}x100$$

**Where: $t_i$: the average performance of a trait the two seasons under the effect of $t_i$ treatment; c: is the mean value of corresponding control over the two seasons.**

**Statistical Analysis:**

After the collection of data from the different treatments, statistical analysis was accomplished to obtain the analysis of variance (ANOVA) according to Sendcore and Cochran (1980). The mean performance representing the effect of the tested treatments was compared by least significant value LSD method at 5%.

## RESULTS AND DISCUSSION

**a) Vegetative growth parameters and chlorophyll content:**

The mean performance of the following parameters i.e., plant height, number of branches per plant, leaf area, dry weight % and total chlorophyll was estimated under the effect of the individual treatments as well as their interaction and are presented in Table 2.

**1- Effect of the hybrids:**

Significant differences were observed between "Alissa $F_1$" and "888 hybrid" tomato hybrids for plant height at 5% of probability level. In addition, the "888 hybrid" gave the highest plant height estimated by 64.22 cm and 64.20 cm, in the first and second season, respectively. In general, the mean performance of "888 hybrid" grown under high temperature was better than "Alissa $F_1$" concerning number of branches per plant, leaf area, total chlorophyll and dry matter (Table 2).

**Table 2. Effect of some treatments on the mean performances of the vegetative growth parameters and total chlorophyll content of two tomato hybrids under high temperature conditions of 2014 and 2015 seasons.**

| The hybrids (A) | | Plant Height (cm) | | No. of branches /plant | | Leaf area ($cm^2$) | | Dry weight (%) | | Total chl (mg/g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st s. | 2nd s. | 1st s. | 2nd s. | 1st s. | 2nd s. | 1st s. | 2nd s. | 1st s. | 2nd s. |
| Allissa $F_1$ | | 57.11 | 57.11 | 6.30 | 6.40 | 487.42 | 611.98 | 29.20 | 29.01 | 0.65 | 0.98 |
| 888 | | 64.22 | 64.20 | 8.97 | 9.50 | 756.49 | 742.96 | 29.06 | 29.65 | 1.55 | 1.57 |
| L.S.D 5% | | 11.27 | 1.04 | 0.15 | 0.24 | 17.58 | 15.43 | 0.37 | 0.24 | 0.012 | 0.020 |
| Treatments (B) | | | | | | | | | | | |
| Treatments (B) | NAA | 65.49 | 66.83 | 9.80 | 10.31 | 681.30 | 739.63 | 29.76 | 30.07 | 1.15 | 1.72 |
| | $CaCo_3$ | 58.20 | 59.00 | 6.85 | 7.08 | 554.30 | 647.56 | 28.39 | 28.64 | 0.78 | 1.18 |
| | Kaoline | 61.33 | 61.83 | 8.01 | 8.00 | 622.97 | 719.10 | 29.74 | 29.65 | 0.97 | 1.44 |
| | Shade2 | 66.50 | 65.83 | 6.30 | 6.30 | 556.58 | 585.30 | 27.94 | 28.38 | 0.69 | 1.04 |
| | Shade3 | 61.33 | 59.33 | 8.96 | 9.50 | 730.87 | 772.8 | 30.03 | 30.22 | 0.83 | 1.25 |
| | Control | 51.20 | 51.00 | 5.90 | 6.43 | 585.72 | 600.5 | 28.92 | 29.23 | 0.67 | 1.02 |
| L.S.D 5% | | 2.04 | 2.82 | 0.50 | 0.37 | 26.24 | 25.13 | 0.82 | 0.38 | 0.38 | 0.040 |
| Interaction effect (A*B) | | | | | | | | | | | |
| Alissa $F_1$ | NAA | 59.66 | 60.00 | 7.66 | 7.76 | 570.83 | 655.8 | 30.15 | 30.03 | 0.90 | 1.37 |
| | $CaCo_3$ | 54.66 | 56.66 | 5.66 | 5.86 | 416.30 | 579.8 | 28.85 | 29.00 | 0.59 | 0.91 |
| | Kaoline | 58.66 | 58.66 | 6.33 | 6.33 | 523.60 | 644.6 | 29.58 | 30.08 | 0.76 | 1.12 |
| | Shade2 | 62.33 | 59.33 | 5.40 | 5.60 | 424.73 | 540.3 | 27.98 | 28.97 | 0.48 | 0.74 |
| | Shade3 | 59.00 | 58.66 | 7.66 | 7.36 | 552.00 | 693.3 | 29.60 | 30.21 | 0.65 | 0.99 |
| | Control | 48.33 | 49.33 | 4.96 | 5.33 | 437.00 | 558.0 | 29.06 | 29.62 | 0.50 | 0.77 |
| 888 | NAA | 71.33 | 73.66 | 11.86 | 12.86 | 791.77 | 823.5 | 29.38 | 30.11 | 1.41 | 2.06 |
| | $CaCo_3$ | 61.66 | 61.33 | 8.03 | 8.3 | 692.30 | 715.3 | 27.94 | 28.28 | 0.97 | 1.46 |
| | Kaoline | 64.00 | 65.00 | 9.70 | 9.66 | 722.30 | 793.6 | 29.90 | 29.23 | 1.18 | 1.77 |
| | Shade2 | 70.66 | 72.33 | 7.20 | 7.00 | 688.43 | 630.2 | 27.89 | 27.80 | 0.89 | 1.35 |
| | Shade3 | 63.66 | 60.00 | 10.26 | 11.60 | 909.70 | 852.3 | 30.47 | 30.24 | 1.02 | 1.52 |
| | Control | 54.00 | 52.66 | 6.80 | 7.53 | 734.43 | 642.9 | 28.79 | 28.85 | 0.84 | 1.28 |
| L.S.D 5% | | 3.12 | 2.55 | 0.36 | 0.61 | 43.06 | 37.79 | 0.91 | 0.69 | 0.30 | 0.049 |

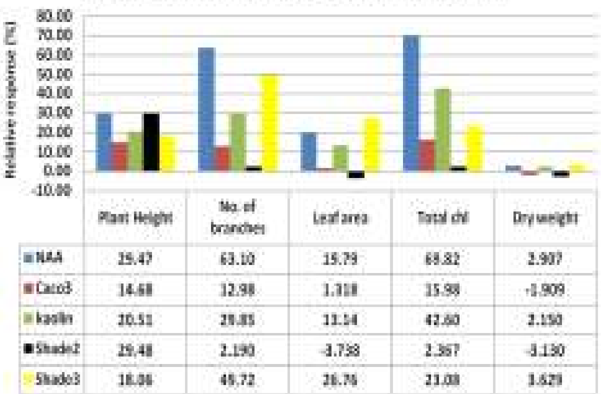
**2- Effect of the treatments:**

The majority of vegetative growth parameters showed an increase comparing with the untreated control regardless the effect of the hybrids, except dry weight and total chlorophyll. Hence, shade 2 treatment gave the highest plant height in the first season (66.50 cm) while, the same trait gave the highest value by the NAA treatment in the second season (66.83 cm). Similar findings were reported by Shokar (2014) when applied two level of shading on tomato and found that the highest plants of tomato were recorded by planting pigeon pea, as a shadow plants, 50 cm apart (shad1), followed by growing pigeon pea 100 cm apart (shade 2). Concerning number of branches per plant, NAA gave the highest number of branches estimate by 9.80 and 10.31 in the first and second season, respectively. For leaf area, it could be observed that, expressive increase in leaf area was recorded for all the treatments in the second season comparing with the first one however, the shade 3 treatment gave the highest leaf area over the two seasons estimated by 730.87 cm and 772.8 cm, respectively. The treatment of NAA caused a high and significant increase in the total chlorophyll content over the control during the two seasons estimated by 1.15 and 1.72 mg/g, respectively followed by Kaoline treatment. In contrast, a great accumulation of dry weight was observed by the shade 3 that gave 30.03 % and

30.22%, for the first and second season, respectively followed by NAA treatment.

The relative response over control for vegetative growth parameters and chlorophyll content based on the average performance of the two seasons were calculated and presented in Fig. 1. It could observe that, both NAA and shade 2 gave equal effect on plant height as recorded 29.47% increasing over control treatment. While Kaoline treatment gave 20.51 % over control in plant height followed by shade 3 and $Caco_3$. On the other hand NAA treatment recorded the highest increase over control in number of branches, leave area and total chlorophyll. While best response for dry weight increase over control is induced by shade 3 that increased by 3.629% over control (Fig. 1).

Fig. 1. Relative response over control for vegetative growth parameters and chlorophyll content based on the average performance of two seasons.




**3- Effect of the interaction:**

The interaction between the tomato hybrids and the studied treatments was significant for the vegetative growth parameters. Estimation of the relative increase or decrease over control for each hybrid could give an overview. In general, "888 hybrid" demonstrated superior values in plant height comparing with "Alissa $F_1$" across the all treatments. On the other hand, NAA treatment was the best one over the two tomato hybrids that gave the highest plant height in both seasons. Concerning number of branches per plant, "888 hybrid" continued superior over "Alissa $F_1$" for the most tested treatments. Also, the treatment of NAA gave the highest number of branches per plant over the two tomato hybrids.

For leaf area, there was a high interaction between the hybrids and treatments during both seasons. Where "888 hybrid" demonstrated its superiority over "Alissa $F_1$" in regard to the most investigated treatments. On the other hand, the effect of shade 3 gave the highest leaf area over the two seasons for "888 hybrid"that recorded 909.70 $cm^2$ and 852.3 $cm^2$, for the first and second season, respectively.

As for dry weight, the obtained data showed that highly interaction between the treatments and tomato hybrids. In this context, NAA treatment gave the highest dry weight for "Alissa $F_1$" whereas, shade 3 treatment recorded the highest dry weight in "888 hybrid". For the total chlorophyll content, there was a significant increase of the investigated treatments where the performance of "888 hybrid" which was superior over "Alissa $F_1$" across all the treatments. Moreover, NAA treatment has the best effect among the investigated treatments concerning total chlorophyll content. Similar findings were reported by El-Tohamy *et al.*, (2008) on egg-plant and Sridhar *et al.,*(2009) on bell pepper they mentioned that (NAA increased plant height, number of branches, and dry weight. These results may be due to that growth promoter (NAA) increased nitrate reductase activity (NRA), a key enzyme in control of nitrogen assimilation, is target of several regulatory processes.

The increase in chlorophyll content was obtained through current study may be due to a decrease in chlorophyll degradation (Whapham *et al.,* 1993). Furthermore, under high temperatures, degradation of chlorophyll a and b is more pronounced in young leaves compared with developing leaves (Karim*et al.,* 1997 and 1999). Such effects on chlorophyll pigments content or photosynthetic apparatus were suggested to be associated with the production of reactive oxygen species (ROS) (Camejo *et al.*, 2006 and Guo *et al*., 2006). Also, heat stress induces in respiration and photosynthesis and thus leads to shortened life cycle and diminished plant productivity (Barnabas *et al.,* 2008).

**b) Fruit set and yield components**

**1- Effect of the hybrids:**

The mean performances of the following traits; fruit set percentage, number of fruits per plant, total yield (ton/feddan), non marketable yield percentage in both seasons were estimated and are presented in Table 3. Significant differences were obtained for the studied traits between the two tested tomato hybrids through field evaluation experiments over the two seasons under heat stress. In general, "888 hybrid" demonstrated significant increasing in fruit set % comparing to "Alissa $F_1$" estimated by 64.15% and 44.67%, respectively as the average mean of the two seasons. Also, the mean performance of "888 hybrid" was higher than "Alissa $F_1$" for both number of fruits per plant and total yield ton/fed (Table 3).

**2- Effect of the treatments:**

The relative response over control for fruit set and yield components based on the average performance of the two seasons was calculated and presented in Fig. 2. The application of growth regulators, anti transpirants and shading treatments significantly increased fruit set %, no. of fruits per plant, total yield, and decreased the non marketable yield percentage during both seasons (Fig. 2). According to the results, tomato plants grown under sahde 3 and NAA recorded the highest values of fruit set and other yield components traits, respectively. In addition, shade 3 and NAA, caused the highest increase in fruit set over the control estimated by 31.32 % and 22.96 %, respectively. Similar conclusion was detected for no. of fruits and total yield regarding the effect of shade 3 and NAA. While the treatment of $Caco_3$ caused a significant decreasing in non marketable yield estimated by -36.24 % over the control (Fig 2).

**Table 3. The mean performances of fruit set % and yield components for two tomato hybrids grown under high temperature treated by growth regulators, antitranspirants, $Caco_3$ and two levels of shade.**

| The hybrids (A) | | Fruit set (%) 1st s. | Fruit set (%) 2nd s. | No. of fruits per plant 1st s. | No. of fruits per plant 2nd s. | Total yield (ton/fed.) 1st s. | Total yield (ton/fed.) 2nd s. | Non marketable yield (%) 1st s. | Non marketable yield (%) 2nd s. |
|---|---|---|---|---|---|---|---|---|---|
| Allissa $F_1$ | | 46.05 | 43.3 | 26.52 | 24.71 | 16.49 | 15.21 | 10.51 | 10.16 |
| 888 $F_1$ | | 63.41 | 64.9 | 51.44 | 51.73 | 30.73 | 31.06 | 12.46 | 12.42 |
| L.S.D 5% | | 1.11 | 1.52 | 2.94 | 1.02 | 0.106 | 0.533 | 0.168 | 0.687 |
| Treatment effect (B) | | | | | | | | | |
| Treatments (B) | NAA | 59.03 | 58.31 | 45.53 | 41.26 | 27.39 | 26.81 | 11.73 | 10.31 |
| | $Caco_3$ | 51.53 | 48.93 | 37.23 | 36.38 | 21.18 | 21.13 | 8.58 | 8.80 |
| | Kaoline | 53.85 | 52.22 | 39.66 | 38.65 | 24.93 | 23.44 | 11.64 | 12.32 |
| | Shade2 | 54.03 | 54.62 | 34.15 | 35.53 | 20.65 | 20.80 | 12.78 | 11.68 |
| | Shade3 | 62.60 | 62.72 | 46.16 | 46.05 | 29.18 | 28.48 | 10.62 | 10.68 |
| | Control | 47.33 | 48.1 | 31.15 | 31.46 | 18.33 | 18.19 | 13.31 | 13.96 |
| L.S.D 5% | | 1.41 | 2.56 | 4.94 | 1.39 | 1.39 | 0.092 | 0.335 | 1.537 |
| Interaction effect (A*B) | | | | | | | | | |
| Alissa $F_1$ | NAA | 49.13 | 45.40 | 28.96 | 26.63 | 19.26 | 17.83 | 12.91 | 11.05 |
| | $Caco_3$ | 41.93 | 35.00 | 24.16 | 19.83 | 14.55 | 12.97 | 9.84 | 9.42 |
| | Kaoline | 45.10 | 42.20 | 27.1 | 25.26 | 17.06 | 14.74 | 12.71 | 14.59 |
| | Shade2 | 47.03 | 45.10 | 24.93 | 23.76 | 14.67 | 13.98 | 13.74 | 12.57 |
| | Shade3 | 55.10 | 53.60 | 35.23 | 33.40 | 22.40 | 20.88 | 11.69 | 11.75 |
| | Control | 38.00 | 38.87 | 18.73 | 19.36 | 11.02 | 10.89 | 13.89 | 15.12 |
| 888 | NAA | 68.93 | 71.27 | 26.1 | 55.90 | 35.52 | 35.80 | 10.54 | 9.57 |
| | $Caco_3$ | 61.13 | 62.87 | 50.3 | 52.93 | 27.82 | 29.28 | 7.87 | 8.18 |
| | Kaoline | 62.60 | 62.27 | 52.23 | 52.03 | 32.79 | 32.14 | 10.57 | 10.06 |
| | Shade2 | 61.03 | 64.14 | 43.36 | 47.30 | 26.62 | 27.61 | 11.81 | 10.79 |
| | Shade3 | 70.01 | 71.87 | 57.1 | 58.70 | 35.97 | 36.07 | 9.55 | 9.60 |
| | Control | 56.66 | 57.33 | 43.56 | 43.56 | 25.66 | 25.48 | 12.73 | 12.79 |
| L.S.D 5% | | 2.72 | 3.78 | 7.20 | 2.50 | 0.260 | 0.130 | 0.412 | 1.683 |

Fig. 2. Relative response over control for fruit set and yield compoents based on the avrage performance of the two seasons


### 3. Effect of the Interaction:

The interactions between all the applied treatments including foliar application as well as shading within the two cultivars were estimated and are presented in Table 3. Regarding fruit set %, the shade 3 treatment gave the highest fruit set % for both "888 hybrid" and "Alissa $F_1$" estimated. In addition, the foliar application by NAA increased significantly fruit set % comparing with untreated plants that estimated by 49.13% and 68.39 % for "Alissa $F_1$" and "888 hybrid", respectively for the first season. Similar finding was observed for number of fruits per plant except in the first season the foliar application with NAA on"888 hybrid" plants resulted in inferior number of fruits estimated by 26.1 fruits/plant.

Concerning the total yield per feddan, the shade 3 treatment caused an increasing estimated by 10.31 and 10.23 ton/fed over the control, in the first and second season, respectively for "888 hybrid" followed by NAA treatment. On the other hand, $Caco_3$ gave the less amount of increasing in the total yield with "Alissa $F_1$" which estimated by 3.53 and 2.08 ton/fed over the untreated plants. The behavior of the nun marketable yield as percentage of the total yield did not differ much since the same treatments that caused yield increasing consequently increased the non marketable yield. The high yielding which obtained by shading treatment (Shade 3), may be attributed to the increasing water content in shaded plants which increased the ability of leaves in absorbing radiation and decreasing reflection. In the same line, Nangare *et al.* (2015) found that 35% shade net brought improvement in quality and yield of tomato grown in semi-arid region.

Cantore *et al.*, (2008) found that inner fruit temperature of the plants treated by Kaoline was 4.4°C lower than the control. Moreover, marketable yield of Kaoline -treated plants were 21% higher than those measured in the control plants. The same authors also found that Kaoline treatment did not affect on the total soluble solids contents, fruit dry matter, juice PH, or tomato fruit firmness. They concluded that the use of Kaoline -based particle film technology would be an effective tool to alleviate heat stress and to reduce water stress in tomato production under arid and semi-arid conditions. Both shading and anti transpirants had positive effects comparing with the high NAA which was more efficient followed by Kaoline treatment, then Caco3 and the shade 3 treatment, compared with control. These results have great interest because the previous mentioned treatments are slightly considered direct reason for the dry matter production and distribution in shoots of tomato plants as affected by different treatments. It was clearly that the performance of untreated plants was inferior this might be due to either trivial synthetic capacity or due to degeneration of chlorophyll as a result of heat /oxidative stress effects (Munns and Tester, 2008; Grewal 2010). Many authors reported that under heat stress, degeneration of chlorophyll a and b was more remarkable in developing leaves (Guo *et al*., 2006). Such effect on chlorophyll or photosynthetic apparatus was as evidence to be related to the production of reactive oxygen species (Larkindale and Knight, 2002; Camejo *et al*., 2005).

Applying Kaoline as foliar application enhanced rose plant acclimation to high temperatures levels under greenhouse conditions in tropical regions (Yuly *et al*., 2011). In addition, Moftah and Al-humaid, (2002) demonstrated that the positive effect of Kaoline which might be contributed to its mechanism in reducing leaf temperature, transpiration rate, improvement of plant water status and maintaining biomass production and to the superiority of Kaoline particle film in regulating plant performance and chemistry, reducing water loss by plants and reduced leaf temperature by 2.5˚C approximately at midday compared to plants non-sprayed with Kaoline.

The results obtained here, support the findings of Abd El-Aal-Faten *et al*., (2008) and Saif El-Deen and Abd El-Hameed (2010). Furthermore, the positive effect of NAA on increasing vitamin C benefits that it reduces hydrogen peroxide, which preserves cells against reactive oxygen species (Zbynek *et al*., 2008) and plays a vital role in resistance to oxidative stresses such as heavy metals and salts (Taqi *et al*., 2011) and this reflected rather on the plant growth and yield.

Heat stress affects a wide series of both biochemical and physiological responses within the plant cells (Warren *et al*., 2011; Hochberg *et al*., 2013). A water deficit in plant tissues could be happen which in turn lead to injury of cell membranes and reduction in transpiration rates, protein synthesis and ion uptake. Plant growth regulators are a common horticultural practice that used to improve yields (Latimer *et al*., 1992). Plant growth regulators can affect rooting, flowering, fruiting and fruit growth, leaf or fruit abscission senescence, regulation of some metabolic processes and plant resistance to temperature or water stresses (Rakesh *et al*., 2018). These bioregulators serve as inhibitor for the genetic and environmental barriers, manipulate source sink relationship and stimulate the translocation of photo assimilates thereby helping in better retention of flowers and fruits (Dulizhao *et al*., 2000; Arora *et al*.,2014; Kannan *et al*., 2009).

In current study, flower set, productivity and other related parameters has been increased as a result of foliar application with different substances including plant growth regulator, NAA anti transpirant and shading treatments. These findings could be applied for tomato grown under heat stress conditions in the late summer season period in order to relieve the harmful effects of high temperature in this time. Furthermore, this effect could be enhanced through planting the recommended hybrids and varieties of tomato that possess genetic ability to grow under such stresses. On the other hand, to improve tomato production during this critical period, it is very much essential to generate local varieties well-adapted to grow under heat stress conditions during this period. Recently, various global and regional seed companies have developed a few high yielding and disease, insect resistant varieties but the majority does not show stability performance under the local environmental conditions. In this regards, combining both exogenous applications mentioned here and the adapted varieties could be a provident approach for continuity of tomato production under the target environment of Egypt.

**c) Fruit quality:**

**1- Effect of the hybids:**

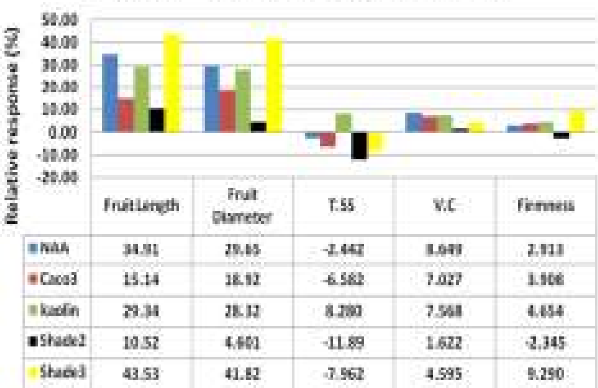
The following fruit traits; fruit length, fruit diameter, TSS, vitamin C and fruit firmness were estimated for both tomato hybrids "Alissa $F_1$" and "888 hybrid". The mean performances of these traits were calculated and are presented in Table 4. Generally, it appears from the Table, that significant differences between the two hybrids "Alissa $F_1$" and "888 hybrid" were observed regarding fruit length and fruit diameter. Regarding TSS and vitamin C, close values were obtained in both tomato hybrids. On the other hand, significant differences were obtained regarding fruit firmness between "Alissa $F_1$" and "888 hybrid" where the last one have fruits more firm than "Alissa $F_1$" estimated by 31.10 inch/cm$^2$.

**2- Effect of the treatments:**

On the other hand, regardless the effect of the used hybrids, diverse effect was obtained from the tested treatments on the behavior of the fruit quality traits. In this respect, shade 3 caused high and significant differences in fruit length comparing to the control in both seasons followed by NAA treatment. Furthermore, the same treatments caused the same effect for fruit diameter 7.02 and 6.85 cm, over the first and second season, respectively.

While, a limited variation was observed in TSS values that obtained from the application of the different treatments. In general, Kaoline treatment caused significant increase in TSS compared to the control. High vitamin C content was recorded by adding NAA treatment with significant differences comparing to the control. Similar effect caused by $Caco_3$ and Kaoline without significant differences between the both treatments during the first season on vitamin C content. Regarding fruit firmness, shade 3 treatment has a significant effect on firmness over the two seasons that estimated by 30.55 and 30.98 inch/cm$^2$, for the first and second season, respectively followed by Kaoline and $Caco_3$ treatments (Fig. 3). Moreover, the combination of high temperature as well as long time of exposure could inactivate the pectinesterase and polygalacturonase enzymes; thereby reducing the fruit firmness (Duoduo *et al*., 2018).

Fig. 3. Relative response over control for quality traits estimated based on the average performance of the two seasons



**3. Effect of the Interaction:**

The interaction between all treatments including foliar application of growth regulators, anti transpirants, shading and the two hybrids significantly affected on fruit quality as compared with the untreated plants (Table 4). Regarding fruit length, the response of "888 hybrid" was higher than "Alissa $F_1$" comparing to corresponding control for all treatments during the first season. This situation differed in the second season where "Alissa $F_1$" exhibited high performance over "888 hybrid" for all tested treatments. However, the NAA treatment maintained its effect over the two seasons for "888 hybrid". The same fact was detected for "Alissa $F_1$" since the same NAA treatment recoded the best one over the two seasons. Regarding fruit diameter, similar response was observed for both tomato hybrids "888 hybrid"and "Alissa $F_1$" which were affected by shade 3 treatment that gave the great fruit diameter comparing to corresponding control as well as the other treatments. For total soluble solids, foliar spraying of Kaoline at the concentration of 2.5% was the only treatment that caused positive increase in TSS content in both tomato hybrids however this increase was significant over the two seasons except "888 hybrid" in the first season.

Concerning vitamin C in tomato fruits, it was observed that the high effect of the different treatments comparing to corresponding control over the two seasons in "Alissa $F_1$" was more than "888 hybrid". This increase in vitamin C concentration reached its maximum level by NAA treatment followed by Kaoline in "888 hybrid". However this increase was less comparing to its corresponding control in "888 hybrid ". This result agree with Sridhar *et al*., (2009) who studied the effect of foliar spray of naphthalene acetic acid (NAA) on Bell pepper and found that NAA significantly increased total leaf chlorophyll, ascorbic acid and nitrate reductase activity. Finally, fruit firmness trait represent one of the most important fruit quality that affected directly by heat stress. In this context, positive response was observed for the majority of applied the treatments with "888 hybrid". Since both shade 3 and Kaoline treatments increased significantly fruit firmness when applied to "888 hybrid" (Table 4).

**Table 4. The mean performances of some fruit traits and its quality for two tomato hybrids grown under high temperature treated by growth regulators, antitranspirants, $Caco_3$ and two levels of shade.**

| The hybrids (A) | | Fruit Length (cm) 1st s. | Fruit Length (cm) 2nd s. | Fruit Diameter (cm) 1st s. | Fruit Diameter (cm) 2nd s. | T.SS (%) 1st s. | T.SS (%) 2nd s. | V.C (mg/100gm) 1st s. | V.C (mg/100gm) 2nd s. | Firmness (inch/cm²) 1st s. | Firmness (inch/cm²) 2nd s. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Allissa $F_1$ | | 5.36 | 6.08 | 4.78 | 5.58 | 4.58 | 4.45 | 19.2 | 19.1 | 26.77 | 27.17 |
| 888 | | 6.31 | 5.50 | 6.91 | 5.97 | 4.58 | 4.56 | 19.8 | 19.6 | 31.22 | 31.10 |
| L.S.D 5% | | 0.22 | 0.15 | 0.22 | 0.17 | 0.13 | 0.07 | 0.072 | 0.092 | 0.38 | 0.39 |
| Treatment effect (B) | | | | | | | | | | | |
| Treatments (B) | NAA | 6.33 | 6.50 | 6.33 | 6.35 | 4.66 | 4.53 | 20.2 | 20.0 | 28.48 | 29.46 |
| | $Caco_3$ | 5.55 | 5.40 | 5.33 | 6.30 | 4.42 | 4.38 | 19.9 | 19.7 | 29.30 | 29.20 |
| | Kaoline | 6.40 | 5.90 | 6.50 | 6.05 | 5.20 | 5.00 | 19.9 | 19.9 | 29.72 | 29.20 |
| | Shade2 | 5.30 | 5.21 | 5.08 | 5.15 | 4.08 | 4.22 | 18.9 | 18.7 | 27.72 | 27.26 |
| | Shade3 | 6.80 | 6.85 | 7.02 | 6.85 | 4.35 | 4.32 | 19.5 | 19.2 | 30.55 | 30.98 |
| | Control | 4.66 | 4.85 | 4.82 | 4.96 | 4.82 | 4.60 | 18.5 | 18.5 | 28.23 | 28.07 |
| L.S.D 5% | | 0.28 | 0.28 | 0.39 | 0.49 | 0.18 | 0.15 | 0.159 | 0.160 | 0.99 | 1.06 |
| Interaction effect (A*B) | | | | | | | | | | | |
| Alissa $F_1$ | NAA | 7.13 | 6.43 | 5.70 | 5.80 | 4.73 | 4.40 | 20.0 | 19.7 | 25.56 | 27.33 |
| | $Caco_3$ | 6.90 | 5.76 | 3.96 | 5.03 | 4.16 | 4.16 | 19.6 | 19.6 | 26.53 | 27.16 |
| | Kaoline | 6.63 | 6.73 | 5.00 | 6.26 | 5.33 | 4.90 | 19.8 | 19.8 | 27.30 | 26.16 |
| | Shade2 | 6.46 | 5.60 | 4.10 | 5.06 | 4.16 | 4.30 | 18.5 | 18.4 | 25.90 | 25.80 |
| | Shade3 | 6.23 | 7.16 | 6.03 | 6.83 | 4.36 | 4.23 | 19.1 | 18.8 | 28.50 | 28.90 |
| | Control | 6.03 | 4.80 | 3.90 | 4.46 | 4.76 | 4.70 | 18.1 | 18 | 26.83 | 27.70 |
| 888 | NAA | 5.90 | 6.56 | 6.96 | 6.90 | 4.60 | 4.66 | 20.4 | 20.3 | 31.40 | 31.60 |
| | $Caco_3$ | 5.80 | 4.96 | 6.70 | 5.50 | 4.66 | 4.60 | 20.2 | 19.9 | 32.06 | 31.23 |
| | Kaoline | 5.20 | 5.06 | 8.00 | 5.83 | 5.06 | 5.10 | 20.1 | 20.0 | 32.13 | 32.30 |
| | Shade2 | 4.86 | 4.83 | 6.06 | 5.23 | 4.00 | 4.13 | 19.3 | 19.0 | 29.53 | 28.73 |
| | Shade3 | 4.80 | 6.53 | 8.00 | 6.86 | 4.33 | 4.40 | 19.9 | 19.6 | 32.60 | 33.06 |
| | Control | 4.13 | 4.9 | 5.73 | 5.46 | 4.86 | 4.50 | 19.1 | 18.9 | 29.63 | 29.70 |
| L.S.D 5% | | 0.55 | 0.37 | 0.54 | 0.43 | 0.32 | 0.19 | 0.181 | 0.227 | 0.94 | 0.96 |

## CONCLUSION

According to the obtained results, it can be concluded that in order to alleviating the harmful impacts of high temperature on tomato it can be recommended that applying NAA and suitable shading model. According to current finding, NAA caused significant increase in chlorophyll content, fruit set % and vitamin C while a great accumulation of dry weight was observed with the shade3 (intercropping maize at three meters apart at the same side of ridge planted with tomato) that gave 30.03 % and 30.22%, for the first and second season, respectively followed by NAA treatment. On the other hand kaoline caused a significant increase in TSS%. Concerning fruit firmness, shade 3 has a significant effect on firmness followed by Kaoline and $CaCO_3$ treatments. The amount of fruit yield increased by the shade 3 estimated by 10.45 and 10.68 ton/fed over the control for "888 hybrid" and "Alissa $F_1$", respectively as a mean performance of the two years followed by NAA treatment.

## REFERENCES

AbdAllah, A. Impacts of Kaoline and Pinoline foliar application on growth, yield and water use efficiency of tomato (*Solanum lycopersicum* L.) grown under water deficit: A comparative study. Journal of the Saudi Society of Agricultural Sciences (2017), http :// dx. Doi .org / 10.1016 / j.jssas.2017.08.001

Abd El-Aal-Faten, S.; M. Mona- Abdel Mouty and H. Aisha-Ali (2008). Combined Effect of Irrigation Intervals and Foliar Application of Some Antitranspirants on Eggplant Growth, Fruits Yield and its Physical and Chemical Properties. Res. J. Agric. & Biol. Sci., 4(5): 416-423.

Adams, P. (2002). Nutritional control in hydroponics. In. Savvas D, Passam HC(Eds) Hydroponic of Vegetables and Ornamentals, Embryo Publications, Athens, Greece, pp: 211-261.

Alam S. M. and M. A. Khan (2002) Fruit Yield of Tomato as Affected by NAA Spray. Asian Journal of Plant Sciences, 1: 24-24.

Arora, Indu, Singh, J.P.and Singh, R.K. (2014).Effect of concentrations and methods of application of 2,4,-D and NAA on plant growth, yield and quality in summer seaonchilli (*Capsicum annuum* L.) cv. PLANT C-1. Adv. Res. J. Crop Improve.5(2): 176-180.

Barnabas, B.; Jager, K. and Feher, A. (2008). The effect of drought and heat stress on reproductive processes in cereals. Plant cell Environ. 31: 11-38.

Camejo, D., A. Jim_enez, J. J. Alarcon, W. Torres, J. M. G_omez, and F. Sevilla. (2006). Changes in photosynthetic parameters and antioxidant activities following heat-shock treatment in tomato plants. Funct. Plant Biol. 33: 177–187.

Camejo, D., P. Rodr_ıguez, M. A. Morales, J. M. Dell'Amico, A. Torrecillas, and J. J. Alarcon (2005). High temperature effects on photosynthetic activity of two tomato cultivars with different heat susceptibility. J. Plant Physiol. 162: 281–289.

Cantore, V., Pave, B., and Albrizio, R. (2008). Kaoline-based particle film technology affects tomato physiology, yield and quality. Environmental and Experimental Botany, 66:279-288.

Creamer, R., S. Sanogo; O.A. El-Sebai; J. Carpenter; and R. Sanderson (2005): Kaolin-based foliar reflectant affects physiology and incidence of beet curly top virus but not yield of Chile pepper. Hortic. Sci., 40: 574–576.

Dorais, M., Papadopoulos, A.P., Gosselin, A., (2001). Greenhouse tomato fruit quality. Hortic. Rev. (Am. Soc. Hortic. Sci.) 26, 239–319.

Dulizhao and M.O. Derrick. (2000). Dixplux and Mepiquat chloride effects on physiology, growth and yield of field-grown cotton. J. Pl. Growth Reg.19:415-422.

Duoduo Wang ; Trevor H.Yeats; Selman Uluisik ; Jocelyn K.C.Rose and Graham B. Seymour (2018) Fruit Softening: Revisiting the Role of Pectin. Volume 23, Issue 4, P: 302-310

Elsayed, A. Y.A.M., E.M.Elsaid and Rehab M. Habiba. Selection for heat tolerance in tomato Ex situ germplasm. Journal of Agricultural Chemistry and Biotechnology 6 (12): 657- 674, 2015.

Eltohamy,W.A., H.M. El-Abagy and N.H.M. El-Greadly (2008). Studies on the effect of putrescine, yeast and vitamin C on growth, yield and physiologic responeses of eggplant (*Salanum melongena* L.) under sandy soil conditions. Australian Jornal of basic and applied. Science, 2(2):296-300.

Franklin KA, Sang HL, Patel D, Kumar SV, Spartz AK, Gu C, Ye S, Yu P, Breen G, Cohen JD, Wigge PA, Gray WM (2011) Phytochrome-interacting factor 4 (pif4) regulates auxin biosynthesis at high temperature. Pro Natl Acad Sci 108(50):20231–20235

Fu G, Zhang C, Yang X, Yang Y, Chen T, Zhao X, Fu W, Feng B, Zhang X, Tao L, Jin Q (2015a) Action mechanism by which SA alleviates high temperatureginduced inhibition to spikelet ifferentiation. Chin J Rice Sci 29(6):637–647

Goodwin, T.W. (1965) Chemistry and Biochemistry of plant pigments. Academic Press, New York. Gross J, 1987. Chlorophylls. In: Pigments in fruits. Academic Press Inc. London, UK: 1-55.

Grewal, H.S. (2010). Response of wheat to subsoil salinity and temporary waterb stress at different stages of the reproductive phase. Plant soil. 330: 103-113.

Guo, Y.P.; Zhou, H.F. and Zhang, L.C. (2006). Photosynthetic characteristics and protective mechanisms against photo oxidation during high temperature stress in two citrus species. Sci. Hort. 108: 260-267.

Hochberg, U., Degu, A., Toubiana, D., Gendler, T., Nikoloski, Z., Rachmilevitch, S., *et al*. (2013). Metabolite profiling and network analysis reveal coordinated changes in grapevine water stress response. *BMC Plant Biol.* 13:184. doi: 10.1186/1471-2229-13-184.

Jones H.G.(1992) plants and Microclimate Cambridge Univ Press 2nd edition.

Kannan, K., Jawaharlal, M. and Prabhu, M (2009). Effect of plant growth regulators on growth and yield parameters of paprika cv. KTPL-19Agri.Sci.Digest, 29(3):157-162.

Karim, M.A.; Fracheboud, Y. and Stamp, P (1999). Photosynthetic activity of developing leave mays is less affected by heat stress than that of developed leaves. Physiol. Plant. 105: 685-693.

Karim, M.A.; Fracheboud, Y. and Stamp, P. (1997). Heat tolerance of maize with reference of some physiological characteristics. Ann. Bangladesh Agri. 7: 27-33.

Khalil SE (2006) Phsiological study on sesame plants grown under saline water irrigation condition-PhD thesis, Cairo University,229pp.

Kolupaev, Yu.Ye., Akinina, G.Ye. and Mokrousov, A.V. (2005). Induction of heat tolerance in wheat coleoptiles by calcium ions and its relation to oxidative stress. *Russ. J. Plant Physiol.*, **52**, 199-204.

Larkindale, J. and Knight, M.R. (2002). Protection Against Heat Stress-induced Oxidative Damage in Arabidopsis Involves Calcium, Abscisic Acid, Ethylene, and Salicylic Acid. Plant Physiology, Vol. 128, pp. 682-695, ISSN 0032-0889.

Latimer, L. G. (1992) Drought, paclobutrazol, abscisic acid and giberellic acid as alternatives to daiminozide in tomato transplant production. J. Amer. Soc. Hort. Sci. 117:243-247.

Li, Y., Wang, H., Zhang, Y. *et al*. (2018) Can the world's favorite fruit, tomato, provide an effective biosynthetic chassis for high-value metabolites? Plant Cell Rep. https://doi.org/10.1007/s00299-018-2283-8.

Moftah, A.E., and Al-humaid, A.I. (2002). Response of vegetative and reproductive parameters of water stressed tuberose plants to vapor guard and kaolin antitranspirants. Agric. Sci., 18 (2): 127-139.

Munns, R. and Tester, M. (2008).Mechanisms of salinity tolerance. Annu. Rev. Plant Biol. 59: 651-681.

Nangare D.D., Jitendra Singh, V.S. Meena, Bharat Bhushan and P.P. Bhatnagar (2015): Effect of green shade nets on yield and quality of Tomato(*Lycopersicon esculentum* Mill) in semi-arid region of Punjab, Vol -1:No-1: 1-8

Nasraui B. (1993) Role of anti transpirant films in protecting plants against fungal disease. Annalsde Institute National de La Recherche Agronomiquede Tunisie 66,125-135.

Olaiya, C.O. and A.A. Adigun, 2010. Chemical manipulation of tomato growth and associated biochemical implications on flavonoid, lycopene and mineral contents. African Journal of Plant Science, 4(6): 167-171.

Olaiya, C.O., 2010a. Influence of auxinbioregulators on physiological changes and shelf-life of tomatoes. Vegetable Crops Research Bulletin, 72: 129-136.

Rakesh K., Reena, S Saravanan, Parshant B., Anil K., Manpreet S. and Vijay K. (2018) Influence of plant growth regulators on strawberry: A review International Journal of Chemical Studies, 2018;6(1):1236-1239

SaifEldeen, U. M. and A. M. Abd El-Hameed (2010). Effect of farmyard manure, irrigation water quantity and some antitranspirants on glope artichoke in sandy soils. J. Agric, Sci., Mans. Univ., 1 (2): 185-209.

Sadasivam, S. and Balasubramanian, T. (1987) Practical Manual in Biochemistry. Tamil Nadu Agricultural University, Coimbatore, India, 14.

Shokar, M. M. B. (2014) Reducing thermo stress effects on tomato crop (*Lycopersicon esculentum*, Mill) by using pigeon pea as stimulative substances under high temperature of summer season. J. Plant production, Mansoura Univ.,Vol.5 (6):937 -951, 2014

Snedecor, G.W. and W.G. Cochran (1980).Statistical Methods 7th Ed. The Iowa State Univ. Press Ames. Iowa, USA.

Sridhar, G; R.V.Koti, M.B. Chett and S.M. Hiremath (2009). Effect of naphthalene acetic acid and mepiquat chloride on physiological components of yield in Bell pepper (*Capsicum annum* L.).J.Agric. Res., 47(1):53-62.

Sun J, Qi L, Li Y, Chu J, Li C (2012) PIF4–mediated activation of YUCCA8, expression integrates temperature into the auxin pathway in regulating Arabidopsis hypocotyl growth. PLoS Genet 8(3):e1002594

Taqi, A. K., M. Mohd and M. Firoz (2011). A review of ascorbic acid potentialities against oxidative stress induced in plants. J. Agrobiol., 28: 97-111.

Waraich. E. A., Ahmad, R.,Ashraf, M. Y. Saifullah, Ahmed, M. (2011). Improving agricultural water use efficiency by nutrient management in crop plants. Acta Agriculturae Scandinavica, Section B-Plant Soil Sci.,61(4):291-304 .

Warren, C. R., Aranda, I., and Cano, F. J. (2011). Responses to water stress of gas exchange and metabolites in *Eucalyptus* and *Acacia* spp. *Plant Cell Environ.* 34, 1609–1629. doi: 10.1111/j.1365-3040.2011.02357.x

Whapham, C.A; Blunden, G.; Jenkins, T. and Wankins, S.D. (1993). Significance of betaines in the increased chlorophyll content of plants treated with seaweed extract Appl. Phycology. 5: 231-234.

Wit MD, Lorrain S, Fankhauser C (2014) Auxin-mediated plant architectural changes in response to shade and high temperature. Physiol Plantarum 151:13–24

Yuly, M. S. C., Hermann, R. D., Alexandra, G. C., Augusto, R. G., Victor, J. F. R. (2011). Effect of kaolin film particle application (Surround WP) and water deficit on physiological characteristics in rose cut plants. American J. Plant Sci., 2: 354-358.

Zbynek, G., Z. Ondrej, P. Jitka, A. Vojtech, Z. Josef, H. Ales, R. Vojtech, B. Miroslava and K. Rene (2008). Determination of vitamin c (ascorbic acid) using high performance liquid chromatography coupled with electrochemical Detection. J. Sensors, 8: 7097-7112.

Zhang CX, Feng BH, Chen TT, Zhang XF, Tao LX, Fu GF (2017) Sugars, antioxidant enzymes and IAA mediate salicylic acid to prevent rice spikelet degeneration caused by heat stress. Plant Growth Regul 83:313–323

Zheng Z, Guo Y, Novák O, Chen W, Ljung K, Noel JP, Chory J (2016) Local auxin metabolism regulates environment-induced hypocotyl elongation. Nat Plants 2:16025

## دور إضافة الرش الورقى ببعض المركبات الآمنة و نظم التظليل فى الحد من الاثار الضارة للطماطم النامية تحت ظروف الاجهاد الحرارى

**هدى إبراهيم أحمد**

**قسم بحوث الخضر - معهد بحوث البساتين- مركز البحوث الزراعية**

على الرغم من استخدام العديد من الاصناف والهجن فى الانتاج المحلى للطماطم ذات التباين العالى فى صفاتها وخصائصها ، الا ان معظم هذه التراكيب الوراثية تفقد قدرتها الانتاجية نظراً للعديد من العوامل الحيوية والغير حيوية. حيث تمثل الحرارة المرتفعة احد هذه العوامل التى تؤثر على استمرارية الانتاج فى الموسم الصيفى. لذا كان الهدف من هذه الدراسة هو إختبار بعض المعاملات الفسيولوجية ونظم التظليل بهدف الاقلال من الاثار الضارة للحرارة المرتفعة على محصول الطماطم و جودة الثمار خلال العروة الصيفية المتأخرة. تمت الدراسة خلال موسمين حقليين ٢٠١٤ و ٢٠١٥ فى المرزعة البحثية بالبرامون ، معهد بحوث البساتين، محافظة الدقهلية. تم إتباع نظام القطاعات المنشقة فى تصميم التجربة حيث تضمنت ستة معاملات : نفثالين اسيتك اسد (NAA) ، كربونات الكالسيوم، كاولين، مع استخدام نبات الذرة فى اختبار نظامين من التحميل على محصول الطماطم بالأضافة الى معاملة الكنترول. أوضحت النتائج وجود إختلافات معنوية بين الهجينين المختبرين اليسا و ٨٨٨ لمعظم الصفات المدروسة. بشكل عام ، أظهر الهجين ٨٨٨ تفوقه على الهجين اليسا تحت ظروف الاجهاد الحرارى. و فيما يخص تأثير المعاملات، نتج عن استخدام التظليل (النموزج الثانى) و NAA اعلى قيمة فى طول النبات بدون اختلافات معنوية بين هاتين المعاملتين. كما اعطت المعاملة بـ NAA اكبر عدد افرع للبنات على مدار الموسمين. كما ادت جميع المعاملات الى زيادة فى المساحة الورقية خلال الموسم الثانى مقارنة بالموسم الاول. بينما اعطى نظام التظليل الثلاثى اعلى مساحة ورقية خلال الموسمين قدرت بـ ٧٣٠.٨٧ سم مربع و ٧٧٢.٨ سم مربع على التوالى. بينما أعطت المعاملة بـ NAA زيادة معنوية فى محتوى الاوراق من الكلورفيل الكلى مقارنة بمعاملة الكنترول خلال الموسمين قدرت بـ ١.١٥ و ١.٧٢ ملجم/جم على التوالى تبعها المعاملة بالكاولين. فى حين اعلى قيم للمادة الجافة نتج عن المعاملة بنظام التظليل الثلاثى متبوعاً بـ المعاملة NAA فى صورة رش ورقى .بينما تسبب الكاولين فى زيادة نسبة المواد الصلبة الذائبة الكلية TSS مقارنة بمعاملة الكنترول. ايضاً لوحظ ارتفاع معنوى لقيمة حمض الاسكوربيك فى الثمارعن طريق استخدام NAA. بينما ادى تطبيق النظام الثلاثى فى التظليل تحسين ملحوظ فى صلابة الثمار خلال الموسمين قدرت بنحو ٣٠.٥٥ و ٣٠.٩٨ انش/سم٢ للموسم الاول والثانى على التوالى متبوعة بمعاملة الكاولين و كربونات المكالسيوم. كما ادى الرش الورقى ب NAA الى زيادة معنوية فى نسبة العقد للثمار بنسبة ١٣.١٠% و ٨.٨٣% لـ ٨٨٨ و اليسا على التوالى مقارنة بمعاملة الكنترول. علاوة على ذلك، أعطت معاملة نظام التظليل الثلاثى بنباتات الذرة اعلى زيادة فى المحصول قدرت ب ١٠.٤٥ و ١٠.٦٨ طن/للفدان مقارنة بمعاملة الكنترول لكل من ٨٨٨ و اليسا على التوالى كمتوسط الموسمين متبوعة بالمعاملة NAA. وطبقاً للنتائج السبقة و المتحصل عليها يمكن التوصية تحت ظروف زراعة الطماطم تحت ظروف الحرارة المرتفعة رش نباتات الطماطم بمركب النفثالين اسيتك اسد بتركيز ٢.٥ جزء فى المليون تحت ظروف استخدام التظليل بناتات الذرة بنظام التظليل الثلاثى خط ذرة لكل ثلاث خطوط من الطماطم حيث ادى ذلك لى الحصول على قيم معنوية مرتفعة فى النمو الخضرى و أعلى محصول ثمار بمواصفات جيدة.