J. Plant Production, Mansoura Univ., Vol. 5 (6): 937 - 951, 2014

REDUCING THERMO STRESS EFFECTS ON TOMATO CROP (*Lycopersicon esculentum*, Mill) BY USING PIGEON PEA AS SHADING PLANTS AND FOLIAR APPLICATION WITH SOME STIMULATIVE SUBSTANCES UNDER HIGH TEMPERATURE OF SUMMER SEASON.

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ABSTRACT

High temperature is a serious environmental factor which induce heat stress causing bad effect on growth, flowering and fruiting stages of tomato plants during summer season. For this purpose, the adverse effects of heat stress on tomato growing during summer season can be mitigated by some agro-techniques, i.e., shading plants and foliar application by specific stimulatory substances. Therefore, Two field experiments were carried out at EL-Baramon Research Station, Dakahlia Governorate, Egypt, to study the effect of shading by using pigeon pea plantation and foliar applications with calcium (2000 mg/L), boron (50 mg/L), vitamin E (150 mg/L) and selenium + vitamin E (50+150 mg/L) towards better thermal tolerances and higher productivity of tomato (*Lycopersicon esculentum*, Mill) cv Alisa Hybrid F1 during summer seasons of 2010 and 2011. The results revealed that both shading and aforementioned substances had ameliorative effects against the adverse condition on tomato plants, compared with control, which were reflected by enhancing vegetative growth characters (plant height, number of branches and leaves/plant and fresh and dry weight/plant), flowering aspects (number of flowers and clusters/plant, fruit set percent, number of fruits/plant and fruit weight), fruit quality (firmness, TSS, ascorbic acid BER and sunscald) and marketable fruit yield and yield attributes. However, the most effective treatments were foliar application by boron and calcium mixture and/or individual and shading 2 (growing pigeon pea plants on 100cm apart) in which attained the highest marketable fruit yield, by 44.95, 38.7, 34.21, 26.82, 25.75, 17.99, 15.13 and 14.39%, over the control, as for B and Ca mixture, B, shade 2, Se and VE mixture, Ca, shade 1, shade 3 and VE respectively, and best performance in the two studied seasons. By contrast, the adverse action of high temperature resulted in reducing growth and reproductive parameters of tomato plants, and increased fruit disorders, blossom end rot and sunscald injuries, (untreated control) in both seasons.

INTRODUCTION

Tomato (*Lycopersicon esculentum*, Mill) is a horticultural crop of great interest all over the world, due to its high nutritive value and various uses. In Egypt, it occupies the first rank among vegetable crops for local consumption and exportation. Camejo *et al.* (2005) reported that the optimum temperatures for tomato cultivation are between 25 and 30 ^{O}C during the photoperiod and 20 ^{O}C during the dark period. However, only 2-4 ^{O}C increase in optimal temperature adversely affected gamete development and inhibited the ability of pollinated flowers into seeded fruits and thus reduced tomato crops yields (Peet *et al.* 1997; Sato *et al.* 2001; Firon *et al.* 2006). Higher temperature stress either accelerates the formation of toxic reactive oxygen species (ROS), i.e., H_2O_2, OH, O^-_2 levels within plant tissues or impairs the normal defense mechanisms against ROS toxic effects. Such stress induces higher CO_2 photo-reduction through chloroplast, or electron transport disturbance, and donation of electron to CO_2 within mitochondrial, and finally led to generation of toxic ROS (Bowler *et al.,* 1992 and Elstner and Osswald 1994). ROS damaged chloroplast, reduced carbohydrate synthesis and`Q1 exportation and hasted oxygen senescence, attack cell membranes, led to their degradation and leakage of cell solutes, denaturation of proteins and enzymes, damage of nucleic acids, degradation of chlorophyll and suppression of all metabolic processes, and finally senescence and death of cells and tissues (Dicknson *et al.,* 1991).Moreover, high temperature is one of the most important abiotic factors affects growth and fruit set of tomato (Rivero *et al.,* 2004). Previous studies indicated that reproductive developments in tomato were more sensitive to high temperature than the vegetative ones **(**Soylu and Çömlekçioğlu, 2009). Several investigations had been carried out for protect plants against adverse effects of heat stress. Thereby, it can be mitigated by developing crops plants with improved thermotolerance effects by adopting many altitudes of agro-techniques, i.e., shading, antioxidant foliar application and nutritional programs. Tall, perennial pigeon peas are often used as fencing and windbreak for field crops. It is often grown as, a shade for many crops, a cover crop and its forage used as green manure crop, or occasionally as a windbreak hedge. In addition, pigeon pea plants serve as a host for some insects (Duke, 1981).

However, the benefit of shade on tomato quality in the latter study was attributable to less blossom end rot and cracked skin. High light intensity can lead to several disorders in development and appearance of tomato fruit that affect quality (Dorais *et al.,* 2001). Sunscald injury and uneven ripening are two disorders brought on by direct effects of light on fruit. Sunscald injury of tomato fruit increased with irradiance and air temperature and their combined effects (Adegoroye and Jolliffe 1987). Field-grown fruit exposed to sunlight were more than twice as likely to develop cracks as shaded fruit (Whaley-Emmons and Scott, 1997).

Moreover, selenium plays an important regulatory role in improving the tolerance of plant to high temperature stress through increasing chlorophyll content and activating antioxidant enzymes (Shang QingMao *et al.,* 2005). Also, through its antioxidative function, Se may delay plant senescence and promote plant growth (Hartikainen, 2002). Regarding, vitamin E (α-tocopherol), it is appeared to play a major role in chloroplastic antioxidant network of plants. It is being finely regulated depending on the severity of the stress sensitivity. Therefore, it contributes to preservation of an adequate redox station in chloroplasts, and maintaining thylokoid membrane structure and function during plant development, and in plant responses to stress (Munne-Bosch and Alegra, 2002; Sattler *et al*., 2004 and Munne-Bosch, 2005). Interestingly, the more positive response of tocopherols to Se under high light conditions in summer suggested that Se contributed to defense ability of plants against increased production of oxygen radicals due to enhanced photosynthesis, however, without added Se, tocopherols started to diminish at vegetative phase, whereas plants supplied with Se maintained an increasing trend (Hartikainen, 2002).

Higher transpiration and temperature levels enhance water uptake, thereby increasing the transport of Ca to the leaves via the xylem (Taylor *et al*., 2004). However, under such 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, and squencely increasing the percentage of fruits with blossom end rot (Adams, 2002). Also, boron plays an important role in cell wall synthesis and structure, signification membranes, carbohydrate metabolism, sugar translocation, phenol or RNA metabolism, respiration, IAA and other phytohormone metabolism (Parr and Loughman, 1983), as well as, calcium metabolism in cell wall of tomato plants (Yamauchi *et al.,* 1986). Therefore, this work aimed to use some agro-techniques for attenuating the adverse effects of high temperature on tomato crop, growth and yielding, under local condition of summer season.

MATERIALS AND METHODS

Two field experiments were carried out at EL-Baramon Research Station, Dakahlia Governorate, Egypt, during summer seasons of 2010 and 2011 to study the effect of shading and foliar spray with calcium, boron, vitamin E and selenium + vitamin E on plant growth, flowering, fruit setting, fruit yield and its component and chemical composition of tomato (*Lycopersicon esculentum*, Mill) cv Alisa Hybrid F1.

The experimental layout was a randomized complete blocks design with three replicates included 9 treatments, were arranged as follows:

a.Growing pigeon pea as a shadow growth plants were arranged as follow:

1-Shading one (growing pigeon pea 50cm apart on one side of the plot).
2-Shading two (growing pigeon pea 100cm apart on one side of the plot).
3-Shading three (growing pigeon pea 150cm apart on one side of the plot).

b. Foliar applications:

4- Vitamin E at 150 mg/L.
5- Selenium (Se) + Vitamin E (se at concentration of 50 mg/L in form of sodium selinite + VE at concentration of 150 mg/L).
6- Ca at 2000 mg/L. in form of calcium chloride.
7- B at 50 mg/L in form of boric acid (16%).
8- Ca + B half concentration of each.
9- Control (tap water).

Seeds of long duration pigeon pea plants cv. ASHA (250 cm height) were sown 15^{th} days before tomato transplanting in both season. Tomato seedlings were transplanted on 18^{th} and 15^{th} of May in the first and the second seasons, respectively. Seedlings were transplanted at 30 cm apart on one side of ridge. Plot area was 15 m^2(3 lines × 5 m long × 1 m width). Tomato plants were sprayed three times, with aforementioned substances, the first at 15 days after transplanting and repeated each (15) days.

The normal agronomical practices of tomato production were followed as the recommendation of the Ministry of Agriculture.

Data were recorded as follows:

Vegetative growth:

Five plants were randomly taken from each plot at 65 days after transplanting to determine vegetative growth parameters as expressed on plant height, number of branches and leaves per plant, as well as fresh and dry weight per plant.

Flowering parameters:

Five plants from each plot were labeled (all over the season was recorded) to determine number of clusters / plant, number of flowers / plant and Fruit setting percentage: (No. fruits/plant)/ (No.flowers/plant) ×100.

Fruit yield and its components:

All tomato fruits reached to the pink stage after nearly six weeks from transplanting were picked weekly through the harvesting period to calculate the following parameters:

1- Number of fruits per plant: the number of all harvested fruits per plot was divided by the number of plants per plot.

2- Average fruit weight (gm): the total yield per plot was divided by the number of plants per plot then the weight of fruits per plant divided by the number of fruits per plant.

3- Yield (gm) per plant: the weight of all harvested fruits per plot was divided by the number of plants per plot.

4- Total yield (ton) per feddan: it was calculated from all harvested fruits per plot and then converted to tons per feddan.

5- Marketable yield (ton) per feddan:

Total fruit yield (ton/fed) - Weights of (blossom end rot and sun scald fruits).

6- Unmarketable yield (kg) per feddan: it calculated from weights of (blossom end rotted and sun scald fruits).

7- Blossom end rot percentage (BER%): mean injured fruits by BER disorder.

8- Sun scald percentage (%): mean of damaged fruits by sun scald disorder.

Fruit qualities:

Fruit characters were recorded as follow:

1- Total soluble solids percentage: determined in the juice by refractometer.

2- Vitamin C content was determined by using 2, 6 dichlorophenol indophenols method as described by A.O.A.C. (1990).

3-Fruit firmness as Lb/In: was measured at two points of the equatorial region by using a pressure tester 8 mm plunger.

Statistical Analysis:

Collected data were statically analyzed by the analysis of variance (ANOVA) according to Sendecore and Cochran (1980). The Duncan multiple range test was used to separate means by using computer program of CoStat statistical software.

Half monthly average, maximum and minimum, temperature and humidity during 2010 and 2011 seasons at experimental region is shown in Table (1).

Table (1): Half monthly average maximum and minimum temperature during 2010 and 2011 seasons at experimental region.*

Month	Temperature C				Relative humidity %			
	2010		**2011**		2010		2011	
	Max.	**Min.**	Max.	Min.	Max.	Min.	Max.	Min.
May	30.1	16.9	27.11	16.2	82.9	38.5	84.9	42.3
	29.8	18.0	31.06	20.18	83.6	41.0	84.25	42.62
June	32.o	20.8	33.13	22.73	83.3	31.3	83.86	41.73
	35.4	23.3	32.4	21.86	83.3	37.5	83.73	42.26
Julie	32.7	22.9	34.86	22.73	84.3	38.9	84.13	44.73
	34.1	24.1	35.75	23.5	87.4	40.8	83.62	41.37
August	34.3	23.5	34.06	23.93	84.3	41.6	83.60	40.40
	34.8	24.9	33.93	24.12	84.9	42.5	83.62	41.50

*** Data from ministry of Agriculture (Agriculture Extension Services).**

RESULTS AND DISCUSSION

Vegetative growth:

Data given in (Table 2) showed that the growth characters as expressed on plant height, number of branches and leaves/plant and fresh and dry weight/plant were increased significantly with all treatments compared with untreated one. The tallest plants of 59.25 and 62.58cm, in the two years respectively, were recorded by planting pigeon pea, as a shadow plants, 50cm apart (shade 1), followed by growing pigeon pea 100cm apart (shade 2), and plants sprayed with mixture of calcium and boron in both seasons. Meanwhile, the maximum number of branches per plant was obtained by the interaction of foliar application with boron and calcium and planting pigeon pea as a shading plants on 100cm apart (shade 2), in the two seasons. Similarly, boron and calcium treatment and shading (2) treatment exhibited the highest number of leaves per plant in the two years of study.

Concerning plant fresh and dry weight, plants of tomato Alisa Hybrid F1 were treated with all aforementioned applications proved at par over control, but shading (2) treatment, as well as spraying with calcium and boron combination were the most stimulatory and potent effects for the two characters in both seasons. It is clear that vegetative growth parameters were affected by adverse condition of high temperature stress (table 1), thereby the lowest values of growth characters were obtained from untreated control (Tables 2). These results were in harmony with those reported by Adams, *et al.,* (2001), Hamsaveni *et al.* (2003), Oyinlola (2004), Glal *et al.* (2005), Patil *et al.* (2008) and Ragasekar *et al.* (2013) they observed that growth parameters of tomato crop were enhanced by such treatments.

High temperature cause an array of morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development, also may adversely affect photosynthesis, respiration, water relations, membrane stability (Wahid *et al.,* 2007). Moreover, high temperature condition strongly affected the vegetative and reproductive organs and tissues of tomato plants (Adil *et al*., 2003).

On the other hand, the enhancing effects of used treatments on tomato growth parameters may be due to, the role of shading in attenuated the adverse condition of high temperature. In this regard, Ragasekar *et al.* (2013) mentioned that Tomato registered better performance for growth and yield under shadenet house (33% shade). Lower temperature caused plant height, number of branches, internodal length, average fruit weight and yield per plant to be higher in the shadenet house than in the open field. Furthermore, calcium is a major constituent of cell walls where it helps in maintaining cell wall integrity and membrane permeability; it enhances pollen germination and growth; it activates a number of enzymes for cell metosis, division, and elongation and it affects fruit quality, (Jones, 1999). Also, Mohsen Kazemi (2013) mentioned that calcium foliar application increased tomato vegetative growth. Moreover, Pennanen *et al.* (2002) reported that in addition to Se increasing the growth of plants, it was also able to delay the death of plants subjected to severe UV-stress. In addition, Davis *et al.* (2003) reported that the delivery of B either through the nutrient solution or by foliar spraying of boron chelated with mannitol, to tomato, was associated with increased plant growth. El-Tohamy and El-Greadly, 2007 showed that foliar application of vitamin E treatment significantly improved vegetative growth and yield of bean plants compared to control plants.

Reproductive characteristics:

A- Flowering aspects:

Data given in Table (3) illustrate that all tested treatments enhanced number of, clusters, flowers and fruits per tomato plant, as well as fruit set percentage and fruit weight compared with untreated control during 2010 and 2011 growing seasons, with exception of No. clusters/plant in the first season in which there were slightly increments above control when tomato plants treated with shading, 1 and 3, and sprayed with V.E.. However, the highest number of clusters and flowers/plant were obtained from plants sprayed with mixture of boron and calcium and/or individual, followed by shading (2) treatment and sprayed with mixture of selenium and vitamin E, in both seasons.

Concerning, No. fruits/plant, fruit set% and fruit weight, it can be concluded that all treatments also affected the three characters by the same way did with number of clusters and flowers/plant comparing to control in the two seasons, however, the heaviest fruit weight (72.33&73.62 in 2010 and 2011 respectively) was obtained by shading (2) treatment, mixture of B & Ca and B (2010), and shading 2 (2011). Belong on, fruit set per cent was enhanced by boron as well as mixture of boron and calcium sprayers and shading 1 treatment. Interestingly, the promotable role of all used treatments above the control reflects the role of each treatment on specific physiological and biochemical operations through plant tissues. In this respect, Rylski and Spigelman, (1986), and Rajasekar *et al.* (2013), mentioned that Shading increases yield of tomato compared to open field production, i.e. normal plantation, by increasing the average single fruit weight. Moreover, Gent (2007) found that the weight per fruit picked from plants under 50% shade was less than that under the other shade treatments (15 or 30%), and this pattern was similar to the effect of shade on total yield. Similarly, Ilic´ *et al.* (2012) reported that the modification of light quality by the tested photo-selective shade nets promotes tomato fruit-set, fruit survival rate or decreases temperature.

T2-3

Ca and B also affected marketable fruit weight per plant by increasing the fruit weight by almost 11% with a 12% higher marketable yield over the control, Heng Vuthy (1999). In the same line, Naresh-Babu (2002) indicated that boron enhanced number of flowers and number of fruit set per tomato plant. Moreover, Lee GuangJae *et al.* (2007) Found that Se treatment increased fruit weight and fruit number in tomato plants. Belong on, Patil *et al*., (2008) recorded that the effect of boron application was more pronounced by giving the maximum average fruit weight, yield per plant and yield per hectare of tomato. In addition, Mohsen Kazemi (2013) revealed that Ca had significant effect on number of flower branchs per plant, number of fruits per plant, mean fruit weight and yield of tomato.

In contrast, plants were exposed to high temperature condition without treatment (control) registered the lowest values of mentioned traits, in this regard Kinet and Peet, (1997) showed that the most noticeable effect of high temperature on reproductive processes in tomato is the production of an exerted style (i.e., stigma is elongated beyond the anther cone), which may prevent self-pollination. Also, at a daily mean temperature of 29 °C, the fruit number, percentage of fruit set and fruit weight per plant, decreased in comparison with that at 25 °C. This reduction in yield is mainly due to impaired pollen and anther development, as well as reduced pollen viability (Sato *et al.,* 2002 and Sato *et al.,* 2006). However, under high temperature, fruit set in tomato plants failed due to the disruption of sugar metabolism and proline transport during the narrow window of male reproductive development (Sato *et al.,* 2006). Furthermore, Soylu and Çömlekçioğlu, (2009) found that the elevated temperature caused reduction in percentage of fruit set in all studied genotypes. The genotypes means percentage of fruit set was 63.84%, 54.02% and 15.76% at optimum temperature (28/21°C day/night), moderate high temperature (32/22°C) and high temperature (37/27°C) respectively. Along this line, Sato *et al.* (2006) mentioned that moderately elevated temperature stress (METS) significantly reduced the number of fruit set. Furthermore, Adams *et al.,* (2001) mentioned that there was a tendency towards small parthenocarpic fruits at both high and low temperature regimes which, combined with low flower numbers and poor fruit set, resulted in low fruit yields.

B-Fruit qualities:

Fruit qualities of tomato Alisa Hybrid F1 as expressed on Blossom end rot (BER) and sunscald percent, firmness, TSS and vitamin C responded significantly to all used applications in both seasons (table 4). The highest percent of BER and sunscald physiological disorders were collected from untreated control, in this regard, Paraikovic *et al.* (2007) mentioned that in periods of high temperatures and low relative air humidity, Ca deficiency in fruits appears and affects BER occurrence. On the other hand, using shading and foliar applications with VE and Se+VE mixture as well as B, Ca and their combination had ameliorative impacts against the high temperature stress and enhanced fruit performance in both seasons. However, mixture of calcium and boron or alone were the most effective in decline BER percent, whereas shading treatments were the best in decreasing sunscald injuries, that’s was true in two studied seasons. These results are in accordance with those reported by Davis *et al.* (2003), Taylor and Locascio (2004), Cardona *et al.* (2005), El-Mansi *et al.* (2005), Glal *et al.* (2005), Gent (2007), Olle and Bender (2009) and Mohsen Kazemi (2013) .

Regarding, fruit firmness, TSS and vitamin C contents, it's obvious from the data in table (4) that the firm fruits with highest concentrations of TSS and vitamin C were obtained from plants sprayed with mixture of boron and calcium, and shading (3) treatment (TSS), in both seasons. In this respect, Cardona *et al*. (2005) studied the influence of Ca on (BER) in tomato and they found that no physiological disorder but an effect of Ca sprays was observed on the fruit texture (increased in firmness). Also, Wanas (2007) reported that vitamin C and total soluble solids in tomato fruits were increased when tomato plants cv. Castle Rock sprayed with boron foliar application. Furthermore, Guan ZhiHua and Cheng ZhiHui (2009) mentioned that foliar application of $CaCl_2$ at 2 g/l was identified as the best treatment in terms of improving yield, quality and increasing fruit firmness and pressure resistance in both processing tomato cvs. In the same line, Mohsen Kazemi (2013) recorded that Ca application increased TSS and ascorbic acid of tomato fruit, but decrease BER physiological disorder comparing to control (untreated).

Contrary, the control treatment had the lowest values of these characters as a result of high temperature condition, in which, strongly affected the vegetative and reproductive organs and tissues of tomato plants. It was stated that 10% more of the fruit was marketable under 50% shade compared with no shade during summer condition, (Gent, 2007). Similary, shading reduced the appearance of tomato cracking and eliminated sunscalds on tomato fruits and accordingly, increased the marketable tomato production by about 35% compared to non-shading conditions (Ilic´ *et al.*, 2012). Adams (2002) mentioned that under high temperature 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 and sequencely increasing the percentage of fruits with blossom end rot.

C-Yield and yield attributes:

Fruit yield and yield attributes, i.e., yield/plant, marketable and unmarketable yield per feddan are shown in table (5). As evident from presented data in tables (3&5) total fruit yield of Alisa hybrid F1 was resultant from, fruit set%, No. fruits/plant, fruit weight and fruit yield/plant, fractions, and all these characters observed higher positive responses to all used treatments compared with untreated one (control) during the two growing seasons of 2010 and 2011. However, the highest fruit yield per plant (1.438kg, mean of two years) and consequently total fruit yield/feddan were obtained from mixture application of B and Ca, followed by B then shade 2 treatments. Clearly, using such techniques resulted in increasing yield, and these increments surpassed control in dimension order by 41.56, 35.78, 31.18, 24.48, 22.54, 15.2, 12.95 and 12.45 %as for B and Ca mixture, B, shade 2, V. E + Se, Ca, shade 1, shade 3 and VE (means of the two seasons) respectively.

T 4-5

Regarding, marketable and unmarketable yields as shown in Table (5) it can be noticed that the ameliorative effects of the aforementioned treatments reflected the best performance of fruits, marketable yield, and achieved the highest values of yield quality compared to control in both seasons. By contrast, the adverse condition (table, 1) led to increasing the disorder injuries of tomato fruits (unmarketable yield). Interestingly, these increments of yield attributes may be explained on the bases that all used treatments had favorable stimulatory effects, other than protective role against heat stress on vegetative growth characters (Table 2) and enhanced photosynthesis partitioning from vegetative growth sinks to reproductive sinks Tables (3,4 and 5) under high temperature stress Table (1).These results are in agreement with those registered by Heng Vuthy (1999), Adams (2002), Davis *et al.* (2003), Taylor and Locascio, (2004), Glal *et al.* (2005), Patil , *et al.* (2008), Olle and Bender, (2009), Mohsen Kazemi (2013) and Rajasekar (2013).

Finally, it can be concluded that the adverse effects of high temperature stress on summer crops as tomato can be alleviated by agro-techniques application, i.e., shading plants and some foliar simulative substances such as calcium, boron vitamin E and selenium.

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تخفيف أثر الإجهاد الحرارى على محصول الطماطم بزراعة بسلة الطيور كنباتات ظل والرش ببعض المحفزات تحت ظروف الحرارة المرتفعة صيفا.

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تعتبر درجة الحرارة المرتفعة من أخطر العوامل البيئية التى تؤثر على نباتات الطماطم حيث تحدث اجهادا حراريا يسبب تأثيرات سيئة على النمو والتزهير زالاثمار خلال الموسم الصيفى، لهذا السبب يمكن تخفيف التأثيرات العكسية للحرارة المرتفعة على نباتات الطماطم النامية خلال أشهر الصيف باستخدام بعض التقنيات الزراعية مثل زراعة نباتات تستخدم فى التظليل، وكذلك استخدام بعض المحفزات الخاصة لمثل هذه الظرف كمعاملات رش. من أجل ذلك تم إجراء تجربة حقلية خلال موسمى الزراعة الصيفيين ٢٠١٠ و٢٠١١ لدراسة تأثير نباتات بسلة الطيوربغرض التظليل وكذلك الرش ببعض المواد مثل البورون (٥٠ ملجم/لتر) ، الكالسيوم (٢٠٠٠ ملجم/لتر) ، خليط من البورون والكالسيوم (٢٥ + ١٠٠٠ ملجم/لتر) ، فيتامين هـ (١٥٠ ملجم/لتر) و خليط من فيتامين هـ + سلينيوم (١٥٠ + ٥٠ ملجم/لتر) والتى لها دور فى تحمل النباتات للإجهاد الحرارى.

أوضحت النتائج أن كلا من معاملات التظليل ومعاملات الرش لها دور فى تخفيف التأثيرات العكسية للحرارة المرتفعة والتى تمثلت فى تحسين صفات النمو الخضرى (طول النبات ، عدد الأفرع والأوراق على النبات وكذا الوزن الطازج والجاف للنبات) وكذلك صفات الإزهار والإثمار (عدد الأفرع الثمرية ، عدد الأزهار ، نسبة العقد) كما أدت إلى زيادة المحصول الثمرى ومكوناته (عدد الثمار ، وزن الثمار ، محصول النبات ، المحصول الكلى) كذلك أدت إلى تحسين جودة الثمار (المحصول الصالح للتسويق ، فيتامين جـ ، المواد الصلبة الذائبة الكلية و صلابة الثمار) كما قللت نسبة العيوب الفسيولوجية بالثمار (عفن الطرف الزهرى و لطعة الشمس) وبالتالى تقليل نسبة الثمار التالفة. وكانت أفضل المعاملات الرش بمخلوط البورون والكالسيوم أو منفردا كلا على حده، ثم التظليل بنباتات بسلة الطيور المنزرعة على مسافة ١٠٠ سم (shading 2).

ومن ناحية أخرى أظهرت النباتات غير المعاملة تأثرا واضحا بالظروف الجوية المحيطة وتمثل ذلك فى نقص النمو الخضرى والمحصول ومكوناته وزيادة نسبة الثمار التالفة.

Table (2): Plant height, number of branches, number of leaves and fresh and dry weight of Alisa hybrid F1 tomato plants as affected by some agronomical treatments in 2010 and 2011 seasons.

Characters / Treatments	Plant height (cm)		No. branches/plant		No. leaves/plant		Plant fresh weight(g)		Plant dry weight(g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Shade 1	59.25 a	62.58 a	7.25 b	7.30 d	52.92 f	52.93 d	303.07 cd	305.27 f	54.09 f	54.74 e
Shade 2	58.08 b	61.40 ab	8.16 a	8.80 a	63.25 a	60.33 a	335.14 a	326.25 a	68.12 a	65.05 a
Shade 3	56.50 cd	58.16 de	7.58 b	8.20 b	57.08 c	55.57 c	303.43 cd	320.85 cd	59.25 e	63.98 b
V.E	56.75 c	60.73 bc	7.37 b	7.16 de	53.67 e	52.62 d	304.66 bcd	317.37 e	62.02 cd	60.56 d
V.E + Se	57.47 bc	56.97 ef	8.16 a	7.67 c	57.33 c	55.70 c	308.85 bc	318.88 de	62.88 bc	60.58 d
B	55.68 d	58.77 d	8.16 a	8.33 d	56.40 d	55.98 c	297.78 d	322.55 bc	60.79 d	61.24 c
Ca	56.80 c	59.42 cd	7.45 b	8.63 a	57.42 c	58.15 b	305.00 bcd	319.28 de	62.17 bcd	61.01 cd
B + Ca	57.83 b	62.00 ab	8.38 a	8.83 a	59.42 b	59.22 ab	311.39 b	324.71 ab	63.62 b	64.78 a
Control	54.16 e	55.77 f	6.75 c	7.00 e	51.25 g	49.97 e	286.56 e	295.33 g	52.11 g	53.04 f

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range Test at the 5% level.

Table (3): Number of cluster, number of flowers, number of fruits, fruit set percentage and fruit weight of Alisa hybrid F1 tomato plants as affected by some agronomical treatments in 2010 and 2011 seasons.

Characters / Treatments	No. clusters/plant		No. flowers/plant		No. fruits/plant		Fruit set (%)		Fruit weight(g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Shade 1	14.17 d	13.82 d	61.75 e	68.70 c	15.44 d	17.60 c	25.00 a	25.62 abc	71.23 b	70.43 cd
Shade 2	15.42 bc	17.53 ab	73.08 bc	76.30 ab	17.50 b	18.90 b	23.94 b	25.21 bc	72.73 a	73.62 a
Shade 3	14.58 d	15.60 c	67.00 d	68.23 cd	15.67 cd	16.67 d	23.38 bc	24.42 de	71.42 b	70.47 cd
V.E	14.17 d	14.18 d	71.35 c	65.27 d	15.60 cd	17.00 cd	21.86 d	24.78cde	69.65 cd	70.42 cd
V.E + Se	14.83 cd	15.37 c	74.08 b	73.65 b	16.43 c	18.43 b	23.08 c	25.03bcd	70.07 c	72.08 b
B	16.92 a	17.05 b	76.53 a	78.50 a	19.22 a	20.38 a	25.11 a	25.97 a	69.23 d	70.00 d
Ca	15.92 b	16.72 b	72.17 bc	76.43 ab	16.42 c	18.50 b	22.75 c	24.21 e	72.50 a	70.15 d
B + Ca	17.25 a	18.55 a	77.23 a	79.05 a	19.45 a	20.53 a	24.92 a	25.97 a	72.73 a	71.09 c
Control	14.05 d	12.40 e	61.53 e	66.05 cd	14.85 d	15.15 e	29.89 e	22.94 f	66.57 e	68.04 e

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range Test at the 5% level.

Table (4): Blossom end rot, sun scald, firmness, total soluble solids and vitamin C of Alisa hybrid F1 tomato plants as affected by some agronomical treatments in 2010 and 2011 seasons.

Characters / Treatments	Blossom end rot (%)		Sun scald (%)		Firmness (Lb)		TSS		Vitamin C (mg/100 g f.W.)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Shade 1	2.61 c	2.16 c	1.30 g	0.57 h	7.77 b	7.53abc	5.20 cd	5.17 d	25.30 c	26.21 b
Shade 2	2.29 d	2.01 d	1.54 f	0.79 g	7.57 cd	7.51 bc	5.43 b	5.37 d	24.63 e	25.85 d
Shade 3	2.49 c	2.37 b	1.75 d	0.90 f	7.37 e	7.50 c	5.70 a	5.57 a	23.70 f	24.93 h
V.E	2.47 c	2.35 b	1.92 b	1.18 b	7.47 d	7.51 bc	5.27 bcd	5.38 d	24.57 e	25.67 f
V.E + Se	2.44 c	2.18 c	1.92 b	1.06 c	7.57 cd	7.51 bc	5.43 b	5.39 cd	25.40 c	25.77 e
B	2.14 e	2.17 c	1.82 c	0.98 d	7.67 c	7.55abc	5.40 b	5.43 b	25.17 d	25.49 g
Ca	1.83 g	1.62 f	1.82 c	0.95 de	7.83 b	7.56 ab	5.37 bc	5.42 bc	25.73 b	26.02 c
B + Ca	2.06 f	1.95 e	1.70 e	0.93 ef	8.07 a	7.57 a	5.77 a	5.60 a	25.87 a	26.31 a
Control	3.37 a	3.15 a	3.03 a	1.62 a	7.27 f	7.08 d	5.13 d	5.17 e	22.17 g	23.87 i

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range Test at the 5% level.

Table (5): Fruit yield/plant, total fruit yield, marketable yield and unmarketable yield of Alisa hybrid F1 tomato plants as affected by some agronomical treatments in 2010 and 2011 seasons.

Characters / Treatments	Yield/plant (Kg)		Total yield (ton/fed.)		Marketable yield (ton/fed.)		Unmarketable yield (Kg/fed.)	
	2010	2011	2010	2011	2010	2011	2010	2011
Shade 1	1.099 ef	1.240 f	15.391 ef	17.355 f	14.790 ef	16.883 f	600.72 f	472.63 g
Shade 2	1.272 c	1.391 c	17.813 c	19.474 c	17.101 c	18.927 c	712.17 d	546.54 e
Shade 3	1.119 e	1.175 h	15.661 e	16.445 h	14.997 e	15.908 h	664.60 e	537.21 f
V.E	1.087 f	1.197 g	15.213 f	16.753 g	14.545 f	16.161 g	668.37 e	591.95 d
V.E + Se	1.198 d	1.329 d	16.777 d	18.606 d	16.045 d	17.999 d	731.48 c	607.17 c
B	1.330 b	1.427 b	18.625 b	19.973 b	17.887 b	19.345 b	737.53 bc	628.49 b
Ca	1.190 d	1.298 e	16.665 d	18.167 e	16.056 d	17.701 e	608.78 f	466.89 g
B + Ca	1.415 a	1.460 a	19.805 a	20.435 a	19.061 a	19.848 a	744.66 b	587.17 d
Control	0.988 g	1.042 i	13.837 g	14.588 i	12.952 g	13.892 i	885.07 a	695.85 a

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range Test at the 5% level.