Effect of Some Antioxidants and Nutrients on Growth of Carnation Plants (Dianthus caryophyllus L.) Cv."Giant Pink" under High Temperature Stress

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ABSTRACT

An experiment was conducted to compare the ability of some antioxidants namely salicylic and ascorbic acids at 0.01-0.02g/l for each and nutrients namely boric, calcium, magnesium at 0.05-0.10g/l for each and potassium as a foliar spray at 0.7-1.4 g/l to decrease high temperature stress and to improve flower productivity of carnation plants. Calcium nitrate at 0.05 g/l was more effective than most of the other treatment for increasing plant height, leaf and flower numbers, fresh and dry weight of plants, pigments content of leaves and chemical composition. Calcium nitrate at 0.05 g/l as three foliar sprays at fifteen days intervals reduced the high temperature stress and improved number and quality of flowers of carnation plants.

Keywords: Carnation, antioxidants, nutrients and high temperature stress

INTRODUCTION

Carnation (Dianthus caryophyllus L.) is one of the most widely grown cut-flower crops due to long vase-life and a variety of flower forms and colors in protected cultivation in the Mediterranean areas. Carnation is a semi-hardy perennial but treated as an annual plant. It is a member of the Caryophyllaceae family and one of three hundred species of annual and perennial herbs in the genus Dianthus.

According to Mahajan and Tuteja, (2005) and Cançado, (2011), the main stresses consists of salt, drought, water abundance, (UV-B) radiation, cold, heat, pathogens, insects, chemicals and ozone.

The optimum temperature for growth of Carnation is between 55-65°F / 13-18°C. It has been stated that the whole earth average surface temperature has increased nearly by 0.6±2°C over the 20th century and is projected to increase by 1.4-5.8°C over this century (Houghton et al., 2001).

The stress of the heat is a very important abiotic factor defined as the ascent in temperature past a limit level for a specific timeframe enough to cause irreversible harm to plant growth development. Generally speaking, the transient elevation in temperature by 10–15 °C above ambient, is considered heat shock or heat stress. Mean, heat stress is a complex function as degree of temperature, rate of increase in temperature and duration. The specific climatic zones rely on the period of high degree of temperature and it occurs through the day or night.

Heat tolerance is described as the ability of the plant to develop, grow and produce economic yield under high temperature.Pee and Willits, (1998),Cramer et al.,(2011) and Bokszczanin et al., (2013) proved that the diurnal mean temperature is a superior indicator of plant reaction to high temperature with day temperature having a secondary role. There are some researches proved that night temperatures are major factors while, on other hand, some researchers reported that the day and night temperature don’t affect the plant in dependently. Very high temperatures, cause severe cellular injury and even cell death may occur within minutes, which could be attributed to a catastrophic collapse of cellular organization (SchÖffl et al., 1999).

There are two direct and indirect injuries. Direct injuries due to high temperatures contain protein denaturation and aggregation and increase fluidity of membrane lipids. While indirect heat injuries include inactivation of enzymes in chloroplast and mitochondria, inhibition of protein synthesis, protein degradation and loss of membrane integrity (Howarth, 2005).

The present study was carried out to evaluate the effect of foliar applications of some substances, i.e., B, Ca, Mg, K and ascorbic acid, salicylic acid as antioxidant substances on growth, flowering and chemical composition of carnation plants.

MATERIALS AND METHODS

The current research was conducted during the two successive seasons of 2014/2015 and 2015/2016 at the Experimental Station and Laboratory of the Vegetable and Ornamental Plants Dept., Faculty of Agriculture, Mansoura Univ., Egypt, to study the influence of some antioxidants (ascorbicacid, salicylicacid, boricacid, calcinnitrate, magnesiumsulphate and potassium sulphate) for protection from heat stress on growth, flowering and chemical constituents of carnation plants.

Plant material

Perennial carnation (Dianthus caryophyllus L.)cv. "Giant Pink" seeds were obtained from Barcelona (Spain). Seeds were sown an April 10th each season in seedling trays filled with a mixture of sand and clay at 1.2(v/v), the seeds were covered with soil, lightly sprayed with water over the soil surface to moisten them. The seeds germinated within 2 to 3 weeks then transplanted into 10 cm2 plastic pots full the previous culture mixture. The N, P and K (20:20:20) compound fertilizer was added as a basal dose (1g/l) weekly for all plants until 8-10 leaves (25em almost) appeared on each plant, then were trans planted in the open field in rows. 50 cm apart and between seedlings was about 30-40 cm.

Experimental design:

The experimental treatments were arranged in a randomized complete blocks design with three replicates, each replicate included three plants and experiment design included 14 treatments as follows:

1. Shade (sown under sunflower).
2. Control (water only).
3. Salicylic acid (0.01g/l).
4. Salicylic acid (0.02g/l).
5. Ascorbic acid (0.01g/l).
6. Ascorbic acid (0.02g/l).
7. Boric acid (0.05g/l).
8. Boric acid (0.10g/l).
9. Calcium nitrate (0.05g/l).
10. Boric acid (0.01g/l).
11. Boric acid (0.02g/l).
12. Calcium nitrate (0.01g/l).
13. Calcium nitrate (0.02g/l).
14. Calcium nitrate (0.05g/l).
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10. Calcium nitrate (0.10g/l).
11. Magnesium sulfate (0.05g/l).
12. Magnesium sulfate (0.10g/l).
13. Potassium sulfate (0.7g/l).
14. Potassium sulfate (1.4g/l).

N.B. Each treatment consisted of 3 foliar sprays at 15 days interval.

Samples of the experimental soil were mechanically and chemically analyzed. Data of the soil analysis are showed in Table (1).

Table 1. Physical and chemical analysis of the soil before the application of any treatments in the experiment.

<table>
<thead>
<tr>
<th>Mechanical analysis</th>
<th>Chemical analysis</th>
<th>Soluble cations and anions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand (%)</td>
<td>Available N (ppm)</td>
<td>1.96 Cations (meq/100 g soil)</td>
</tr>
<tr>
<td>Fine sand (%)</td>
<td>Available P (ppm)</td>
<td>29.33 Ca&lt;sup&gt;2+&lt;/sup&gt; 1.83</td>
</tr>
<tr>
<td>Silt</td>
<td>Available K (ppm)</td>
<td>37.03 Mg&lt;sup&gt;2+&lt;/sup&gt; 1.27</td>
</tr>
<tr>
<td>Clay</td>
<td>Organic matter (%)</td>
<td>31.68 Na&lt;sup&gt;+&lt;/sup&gt; 0.97</td>
</tr>
<tr>
<td>Texture</td>
<td>E.C.* %</td>
<td>3.16 Organic matter (%)</td>
</tr>
<tr>
<td></td>
<td>pH**</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td>CaCO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>8.14</td>
</tr>
<tr>
<td></td>
<td>Anions (meq/100 g soil)</td>
<td>1.95 CO&lt;sub&gt;3&lt;/sub&gt;&lt;sup&gt;-&lt;/sup&gt; 0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HCO&lt;sub&gt;3&lt;/sub&gt;&lt;sup&gt;-&lt;/sup&gt; 2.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;-&lt;/sup&gt; 0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cl&lt;sup&gt;-&lt;/sup&gt; 0.88</td>
</tr>
</tbody>
</table>

* 1:5 soil: water extraction
** 1:2.5 soil suspension

The monthly average maximum and minimum temperature during the two seasons at the experimental region is shown in Table (2).

Table 2. Monthly average maximum and minimum temperature during 2015 and 2016 seasons at the experimental region.

<table>
<thead>
<tr>
<th>Month</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>May</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>June</td>
<td>32</td>
<td>20</td>
</tr>
<tr>
<td>July</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>August</td>
<td>34</td>
<td>24</td>
</tr>
</tbody>
</table>

Data recorded:

The harvest was done on August 15th (after about 15 days from the last foliar spray) in both seasons.

1. Vegetative growth and flower parameters:
   - Plant height (cm).
   - Number of leaves/plant.
   - Number of flowers/plant.
   - Fresh and dry weights (g/plant).

2. Chemical determinations:
   1-Pigments content (mg/g f.w.):
      Total chlorophyll (a + b) and total carotenoids were determined in leaf samples (mg/g fresh matter) according to Mackinney (1941).
   2-Nutrient elements determination:
      - Nitrogen determination:
         Nitrogen % was determined by modified micro kjeldahl method as described by Pregl (1945).
      - Phosphorus determination:
         Phosphorus % was determined according to Jackson (1967).
      - Potassium determination:
         Potassium % was determined according to Black (1965).
   3-Total carbohydrates (d.w.):
      Total carbohydrates in dried plant sample was determined according to Hedge and Hofreiter (1962).
   4-Total phenols (mcg/g dry weight):
      Total phenols estimation was carried out with the Folin-ciocalteau reagent according to Malick and Singh (1980).
   5-Proline (mg/g dry weight):
      Proline was determined by the modified ninhydrine methods of Troll and Lindsley (1955), omitting phosphoric acid to avoid interference with concentrated sugars (Mang and Larher, 1992).

Statistical analysis:

A randomized complete blocks design with three replicates was used according to Steel and Torrie (1980). Data were subjected to the statistical analysis according to SAS Institute (1994). The treatments mean were compared using the least significant difference (LSD) at 0.05 level, as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth and flowering parameters:

Data present in Tables (3, 4, 5, 6 and 7) illustrate the impact of certain components of shade, salicylic acid, ascorbic acid, boric acid, calcium nitrate, magnesium sulfate and potassium sulfate as a foliar spray controlling heat stress, its development and the resulting effect on carnation plants growth parameters under Egyptian conditions.

Plant height:

Data presented in Table (3) demonstrated that all of the tested materials were effective on protecting from heat stress and improving carnation plants growth. Treating plants with magnesium sulfate at 0.10g/l resulted in the highest significant increase in plant height in both seasons (56.33 and 55.33 cm., respectively). In the first season it was clearly indicated that plants treated with calcium nitrate at 0.05 g/l and potassium sulfate 1.4g/l, resulted in an increase in plant height values (54.33 and 53.67 cm., respectively), but without significant differences compared to than magnesium sulfate at (0.10g/l). Data in the second season, in the same Table clearly indicated a similar trend as observed in the first season.

The observed increase may be related to the several functions of this element concerning water relations, protein and fats synthesis and magnesium activation of many plant enzymes needed for vegetative growth.

These results are in the same line with those reported by Beata and Stanislaw (2012) on marigold.

Number of leaves/plant:

Data presented in Table (3) showed significant increase in number of leaves with calcium nitrate at 0.05 g/l (19.33) in the first season when compared with all the other studied treatments. In this respect, adding 0.05 g/l of calcium nitrate increased number of leaves about to 67.25% than treated plants with 0.10 g/l of the same material.
However in the second season calcium nitrate at 0.05 g/l resulted in the highest number of leaves than the other treatment (11.33) without significant differences in between.

Table 3. Effect of foliar applications of carnation plants under high temperature stress on plant height, leaf number and flower number/plant during the two seasons of 2014/2015 and 2015/2016.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Character</th>
<th>Vegetative growth parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant height(cm)</td>
<td>Leaf number</td>
</tr>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Shade</td>
<td>35.33 d</td>
<td>31.00c</td>
</tr>
<tr>
<td>Control</td>
<td>44.00 cd</td>
<td>43.33abc</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.01g/l)</td>
<td>46.67 bc</td>
<td>48.66ab</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.02g/l)</td>
<td>44.00 cd</td>
<td>43.33 ab</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.01g/l)</td>
<td>43.00 cd</td>
<td>41.33bc</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.02g/l)</td>
<td>52.33abc</td>
<td>53.66 ab</td>
</tr>
<tr>
<td>H₂BO₃ (0.05g/l)</td>
<td>45.00 bc</td>
<td>52.00 ab</td>
</tr>
<tr>
<td>H₂BO₃ (0.10g/l)</td>
<td>51.33abc</td>
<td>52.33 ab</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.05g/l)</td>
<td>54.33 ab</td>
<td>54.00a</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.10g/l)</td>
<td>51.33abc</td>
<td>53.00 bc</td>
</tr>
<tr>
<td>MgSO₄ (0.05g/l)</td>
<td>49.67 abc</td>
<td>50.00 ab</td>
</tr>
<tr>
<td>MgSO₄ (0.10g/l)</td>
<td>56.33 a</td>
<td>55.33a</td>
</tr>
<tr>
<td>K₂SO₄ (0.7g/l)</td>
<td>51.00 abc</td>
<td>52.66 ab</td>
</tr>
<tr>
<td>K₂SO₄ (1.4g/l)</td>
<td>53.67 ab</td>
<td>55.33a</td>
</tr>
</tbody>
</table>

Means having the same letter (s) in a column are not significant at 5% level

Actually, the increase in number of leaves means achieving a preferable and superior quality.

Calcium is one of the most important mineral elements that it is effective on flower quality and shelf life. This element exists in structure of cells’ middle lamella in a compound that called calcium pectate and until its amount is enough prevents pectin wall demolition (Marshner, 1995; Khalilhabbin and Islam Zade, 2001)

Calcium is already related in plant tolerance to heat stress by regulating antioxidant metabolism or water relations (Jiang and Huang 2001).

Number of flower/plant:

Data presented in Table (3) and illustrated in Fig. (1) showed that pronounced increase in number of flowers was achieved with calcium nitrate at 0.05 g/l in both seasons (21.33 and 12.00 flowers, respectively) but in the second season plants treated with salicylic acid at 0.02 g/l and boracic acid at 0.10 gave 10.66 without significant differences in between.

Under heat stress conditions, Ca²⁺ requirement for growth is high to mitigate adverse effects of the stress Kleinhenz and Palta, (2002).

Hansch and Mendel,(2009) reported that boron has a main role in many processes specially transport of sugars and carbohydrates metabolism in plants.

Fresh and dry weight (g/plant):

From data recorded in Table (4) showed that treating plants with calcium nitrate at 0.05 g/l significantly increased fresh weight values in the first season followed by boracic acid at 0.10g/l 64.00 and 45.00g, respectively), compared with other used treatments in this study. In the second season using 0.10g/l boracic acid gave significant increase in fresh weight followed by calcium nitrate at 0.05 g/l and other concentrations of boracic acid and without significant difference between them(50.33,46.33 and 46.33g) respectively. Most other treatments, showed no significant difference between them; actually this result may be due to the differences in environmental conditions prevailing.

Table 4. Effect of antioxidant responses of carnation plants under high temperature stress on fresh and dry weights during the two seasons of 2014/2015 and 2015/2016.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Character</th>
<th>Fresh weight g/plant</th>
<th>Dry weight g/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
</tr>
<tr>
<td>Shade</td>
<td>11.66c</td>
<td>11.66c</td>
<td>5.76c</td>
</tr>
<tr>
<td>Control</td>
<td>40.67bc</td>
<td>28.33bc</td>
<td>10.75bc</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.01g/l)</td>
<td>33.00bcd</td>
<td>29.33bc</td>
<td>9.26bc</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.02g/l)</td>
<td>26.67bcd</td>
<td>44.33 ab</td>
<td>8.33bc</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.01g/l)</td>
<td>22.00ede</td>
<td>29.33bc</td>
<td>6.07c</td>
</tr>
<tr>
<td>C₆H₁₂O₆ (0.02g/l)</td>
<td>34.67bcd</td>
<td>40.33g</td>
<td>11.67d</td>
</tr>
<tr>
<td>H₂BO₃ (0.05g/l)</td>
<td>26.67bcd</td>
<td>46.33 ab</td>
<td>7.93bc</td>
</tr>
<tr>
<td>H₂BO₃ (0.10g/l)</td>
<td>45.00ab</td>
<td>50.33a</td>
<td>12.85ab</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.05g/l)</td>
<td>64.00a</td>
<td>46.33 a</td>
<td>17.42a</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.10g/l)</td>
<td>38.33bcd</td>
<td>39.33 ab</td>
<td>11.73b</td>
</tr>
<tr>
<td>MgSO₄ (0.05g/l)</td>
<td>35.00bed</td>
<td>36.33 ab</td>
<td>10.62bc</td>
</tr>
<tr>
<td>MgSO₄ (0.10g/l)</td>
<td>34.67bcd</td>
<td>43.00c</td>
<td>11.15bc</td>
</tr>
<tr>
<td>K₂SO₄ (0.7g/l)</td>
<td>50.00de</td>
<td>36.33 ad</td>
<td>7.82c</td>
</tr>
<tr>
<td>K₂SO₄ (1.4g/l)</td>
<td>50.00bcd</td>
<td>41.66 c</td>
<td>11.14bc</td>
</tr>
</tbody>
</table>

Means having the same letter (s) in a column are not significant at 5% level

The superiority of boron may be due to the important and essential role for the growth- carbohydrate metabolism, cell wall, protein synthesis and sugars translocation of higher plants. The primary function of boron element is to provide structural integrity to the cell wall, in plants. Other functions likely include the maintenance of the plasma membrane and other metabolic pathways. The results agree with those obtained by Singh and Sant Ram (1983), Babu et al. (1984) and Khan et al. (1993), Abd El-Mageed and Abd El-Fattah (2007), Fawzia et al. (2008) and Abd El-Messih et al. (2010). They found that calcium spray improved the
formation of cellulose and lignin. An increased cell wall thickening by reinforcement of the secondary wall with hemicellulose and lignin deposition can be protecting from heat stress (Gall et al., 2015).

Minerals (N, P and K%):

The function of N is important in protein and chlorophyll manufacture, phosphorous as one of the factors influence the rate of photosynthesis (carbohydrates, proteins, fats, vitamins and enzymes) beside the other factors involved in photosynthesis process such as light, carbon dioxide, water, temperature and apparently potassium is necessary for the synthesis of carbohydrates and proteins. It seems to be involved entirely as a regulator of processes or as catalyst.

In this concern data presented in Table (5) showed that plants treated with calcium nitrate at 0.05g/l gave the highest nitrogen, phosphorous and potassium % in both seasons, but there was significant difference as compared with each other. In opposite, carnation plants which were sprayed water (control) produced the lowest N, P and K % in both seasons.

From the previous results it is clear that the high concentration of nitrogen, potassium and phosphorus resulted when used calcium nitrate at 0.05 g/l may be due to their use for building up of the plant's body and increase number of flowers as evidenced in the previous tables in this study.

**Table 5. Effect of antioxidant responses of carnation plants under high temperature stress on mineral N, P and K% during the two seasons of 2014/2015 and 2015/2016.**

<table>
<thead>
<tr>
<th>Character</th>
<th>N%</th>
<th>P%</th>
<th>K%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade</td>
<td>1.29</td>
<td>1.40m</td>
<td>0.12</td>
</tr>
<tr>
<td>Control</td>
<td>1.17m</td>
<td>1.28</td>
<td>0.11</td>
</tr>
<tr>
<td>C-H2O3</td>
<td>0.01g/l</td>
<td>1.98c</td>
<td>2.17e</td>
</tr>
<tr>
<td>C-H2O4</td>
<td>0.02g/l</td>
<td>2.25b</td>
<td>2.46f</td>
</tr>
<tr>
<td>C-H2O5</td>
<td>0.05g/l</td>
<td>1.80f</td>
<td>1.97c</td>
</tr>
<tr>
<td>H2O</td>
<td>0.05g/l</td>
<td>1.71</td>
<td>1.87b</td>
</tr>
<tr>
<td>H2O</td>
<td>0.10g/l</td>
<td>2.07d</td>
<td>2.25d</td>
</tr>
<tr>
<td>Ca(NO3)2</td>
<td>0.03g/l</td>
<td>2.34c</td>
<td>2.55f</td>
</tr>
<tr>
<td>Ca(NO3)2</td>
<td>0.10g/l</td>
<td>1.91</td>
<td>2.07f</td>
</tr>
<tr>
<td>MgSO4</td>
<td>0.05g/l</td>
<td>1.44</td>
<td>1.59e</td>
</tr>
<tr>
<td>MgSO4</td>
<td>0.10g/l</td>
<td>1.64</td>
<td>1.80c</td>
</tr>
<tr>
<td>K2SO4</td>
<td>0.7g/l</td>
<td>1.36c</td>
<td>1.49c</td>
</tr>
<tr>
<td>K2SO4</td>
<td>1.4g/l</td>
<td>1.36c</td>
<td>1.67c</td>
</tr>
</tbody>
</table>

Means having the same letter (s) in a column are not significant at 5% level

**Table 6. Effect of antioxidant responses of carnation plants under high temperature stress on minerals%, total carbohydrates %, phenol and proline content during the two seasons of 2014/2015 and 2015/2016.**

<table>
<thead>
<tr>
<th>Chemical constituent parameters</th>
<th>Treatments</th>
<th>Character</th>
<th>Total carbohydrates (mg/g dry weight)</th>
<th>Phenol (mg/g dry weight)</th>
<th>Proline (mg/g dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Shade</td>
<td>54.05m</td>
<td>55.38b</td>
<td>59.9ab</td>
<td>59.4a</td>
<td>53.11a</td>
</tr>
<tr>
<td>Control</td>
<td>53.85m</td>
<td>55.07b</td>
<td>60.1a</td>
<td>54.5a</td>
<td>54.11a</td>
</tr>
<tr>
<td>C-H2O3 (0.01g/l)</td>
<td>55.75e</td>
<td>56.86b</td>
<td>51.1fg</td>
<td>50.4i</td>
<td>50.32g</td>
</tr>
<tr>
<td>C-H2O4 (0.02g/l)</td>
<td>56.34b</td>
<td>57.75b</td>
<td>42.2j</td>
<td>42.4j</td>
<td>57.96b</td>
</tr>
<tr>
<td>C-H2O5 (0.01g/l)</td>
<td>55.32b</td>
<td>56.42b</td>
<td>50.50g</td>
<td>47.4f</td>
<td>50.73g</td>
</tr>
<tr>
<td>H2O (0.02g/l)</td>
<td>56.14e</td>
<td>57.55b</td>
<td>44.4h</td>
<td>44.1i</td>
<td>59.92b</td>
</tr>
<tr>
<td>H2O (0.05g/l)</td>
<td>55.14e</td>
<td>56.21b</td>
<td>52fe</td>
<td>52ef</td>
<td>50.94d</td>
</tr>
<tr>
<td>H2O (0.10g/l)</td>
<td>55.98d</td>
<td>57.09b</td>
<td>46.4b</td>
<td>42.5k</td>
<td>50.12b</td>
</tr>
<tr>
<td>Ca(NO3)2 (0.05g/l)</td>
<td>56.56a</td>
<td>63.31a</td>
<td>51.4i</td>
<td>42.9m</td>
<td>9.90k</td>
</tr>
<tr>
<td>Ca(NO3)2 (0.10g/l)</td>
<td>55.85f</td>
<td>56.64b</td>
<td>49.4g</td>
<td>46.5h</td>
<td>50.11d</td>
</tr>
<tr>
<td>MgSO4 (0.05g/l)</td>
<td>54.52k</td>
<td>55.87b</td>
<td>50cd</td>
<td>52.1e</td>
<td>51.47b</td>
</tr>
<tr>
<td>MgSO4 (0.10g/l)</td>
<td>54.93l</td>
<td>56.31b</td>
<td>53ef</td>
<td>49.1e</td>
<td>51.14d</td>
</tr>
<tr>
<td>K2SO4 (0.7g/l)</td>
<td>54.27l</td>
<td>55.63b</td>
<td>58bc</td>
<td>53b</td>
<td>51.58b</td>
</tr>
<tr>
<td>K2SO4 (1.4g/l)</td>
<td>54.71l</td>
<td>56.07b</td>
<td>55dc</td>
<td>50d</td>
<td>51.26c</td>
</tr>
</tbody>
</table>

Means having the same letter (s) in a column are not significant at 5% level

Phenol and proline (mg/100g DW):

Data presented in Table (6) show that all treatments decreased total phenols and proline when compared to control, the minimum values of total phenols and proline resulted with applying calcium nitrate at 0.05g/l (0.41 and 9.50 mg/100g dw, respectively), during the first season.

Data in the second season clearly indicated that it had almost the same trend observed in the first season.

Proline, an amino acid, plays an important role in plants. It protects the plants from various stresses and also helps plants to recover from stress more rapidly (Shamsul et al., 2012).

It may be possible, by manipulating factors involved in the bioactivity of phenolic compounds, to trigger acclimated mechanisms in plants under stress caused by temperature (Rosa et al., 2001).

Pigments content (total chlorophyll and carotenoids):

Chlorophyll contributes by far the amount of total photosynthesis for plant growth.

Data presented in Table (7) showed that plants treated with the higher level of potassium sulfate at 1.4 g/l significantly induced the highest amount of total chlorophyll (43.11 mg/g f.w) in the first season over the other treatments. Also, in the second season plant treated with potassium sulfate at 0.7 g/l and calcium nitrate at 0.05 g/l had non significant difference in between when compared with non-treated plants.

The same Table revealed that carotenoids was nearly about the same trend as reported in the total chlorophyll.

Heat stress at short term resulted in transient increase in the content of Chl. but, long term of heat stress led to lose of Chl and that may be related to damage of reaction centers (Kyle, 1987). Under heat stress, external Ca2+ treatment inhibits the loss of chlorophyll, that is due
to its reducing photo oxidation (Wise and Naylor, 1987) or by maintaining membrane integrity (Coria et al., 1998).

Table 7. Effect of antioxidant responses of carnation plants under high temperature stress on Photosynthetic pigments (total chlorophyll and carotenoid mg/g F.W.) during the two seasons of 2014/2015 and 2015/2016.

<table>
<thead>
<tr>
<th>Character</th>
<th>Total chlorophyll (mg/g f.w.)</th>
<th>Carotenoid (mg/g f.w.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Shade</td>
<td>15.24 ± 1.90</td>
<td>14.01 ± 1.90</td>
</tr>
<tr>
<td>Control</td>
<td>21.40 ± 2.11</td>
<td>21.11 ± 2.13</td>
</tr>
<tr>
<td>C₆H₆O₂₇ (0.01g/l)</td>
<td>17.30 ± 2.13</td>
<td>23.47 ± 2.14</td>
</tr>
<tr>
<td>C₆H₄O₂₉ (0.02g/l)</td>
<td>24.34 ± 2.13</td>
<td>21.87 ± 2.13</td>
</tr>
<tr>
<td>C₆H₈O₇ (0.01g/l)</td>
<td>21.38 ± 2.13</td>
<td>24.35 ± 2.13</td>
</tr>
<tr>
<td>C₆H₉O₇ (0.02g/l)</td>
<td>28.46 ± 2.13</td>
<td>21.63 ± 2.13</td>
</tr>
<tr>
<td>H₂BO₃ (0.05g/l)</td>
<td>22.19 ± 2.13</td>
<td>19.13 ± 2.13</td>
</tr>
<tr>
<td>H₃BO₃ (0.10g/l)</td>
<td>26.89 ± 2.49</td>
<td>28.49 ± 2.49</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.05g/l)</td>
<td>23.03 ± 2.13</td>
<td>36.71 ± 2.13</td>
</tr>
<tr>
<td>Ca(NO₃)₂ (0.10g/l)</td>
<td>21.76 ± 2.13</td>
<td>21.98 ± 2.13</td>
</tr>
<tr>
<td>MgSO₄ (0.05g/l)</td>
<td>28.61 ± 2.58</td>
<td>28.58 ± 2.58</td>
</tr>
<tr>
<td>MgSO₄ (0.10g/l)</td>
<td>27.27 ± 2.58</td>
<td>30.58 ± 2.58</td>
</tr>
<tr>
<td>K₂SO₄ (0.7g/l)</td>
<td>25.89 ± 3.64</td>
<td>36.34 ± 3.64</td>
</tr>
<tr>
<td>K₂SO₄ (1.4g/l)</td>
<td>43.11 ± 3.50</td>
<td>30.50 ± 3.50</td>
</tr>
</tbody>
</table>

Means having the same letter(s) in a column are not significant at 5% level.

General conclusions:
The extreme temperatures those are consequences of present-day global climate changes are considered as major abiotic stresses for crop plants.

Some agriculture treatments of antioxidants substances were used to improve carnation flowers. This substances should be beneficial in the protection structure and function of the photo systems against excess light (Rajagopal et al., 2005).

According to these results, we conclude that carnation plants may develop an acclimated mechanism against super optimal thermal stress caused, this is much more than the optimum growth temperature. This acclimated mechanism in plant appears to consist of the accumulation of phenolic compounds, cellulose and lignin as a possible form of adapting to this stress. It may be possible, by manipulating factors involved in the bioactivity of phenolic compounds, cellulose and lignin to trigger acclimated mechanisms in plants under stress caused by temperature.

Thus, it may be concluded that application of Ca(NO₃)₂ would reduce loss of carnation in hot environments.

Finally, the results in this study indicate that treated carnation plants by calcium nitrite at 0.05 g/l was more effective than most of the other treatments as increased plant height, leaf and flower numbers, fresh and dry weight of plants, pigments content of leaves and chemical composition.

REFERENCES


تأثر بعض مضادات الأكاسدة والمغذيات على نمو نباتات القرنفل تحت ظروف الإجهاد الحراري

مهند محمد عبد الباسط علي جبر

قسم الخضر والزينة – كلية الزراعة – قسم الخضر والزينة

أجرت التحريات لقياس مقاومة قدرة بعض مضادات الأكاسدة مثل حمض الساليسيليك والاسكوريك تركيز 0.02-2.00 جم/تر/كلل من مكونات

مثل النيوبريك والكاكسيموك والابنابينوسوم بتركيز 0.02-0.10 جم/تر/كلل من مكونات كاهن وكرشي وفيدوسكي وديزيك 0.1-2.0 جم/تر/كلل للأطواج.

وأتت ترتيب الأطواج بتركيز 0.05 جم/تر/كلل لأطواج بتركيز 0.05 جم/تر/كلل لأطواج معتمدات من عمليات التخليل الدي جهاد الحراري وتحسنت الإنتاج الإجاهد الحراري مع تأثير فعال من مكونات المعملات الأخرى التي زادت

من ارتفاع الغلاف. وقد أدت الأطواج والأوراق والنواعات والجاف في النباتات محتوى الأحماض في الأوراق والتركيب الكيميائي. وجد أن استخدام

أثرت الأطواج عند 0.05 جم/تر/كلل على نمو نباتات ورقة على فترة كل تسعة عشر يوماً. وتفصيل الإجاهد الحراري وتحسنت عند

نوعية الزهر من نباتات القرنفل.

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