Morphological And Physiological Response of Two Accessions of Citrullus colocynthis to Drought Stress Induced by Polyethylene Glycol

Zahra Mohammadzade and Forouzandeh Soltani *

Horticultural science Department, Collage of Agriculture and Natural Resources, University of Tehran, Karaj, Iran.

Abstract

A biotic stresses can directly or indirectly affect the physiological status of an organism by altering its metabolism, growth, and development. In order to study the effect of drought stress on Citrullus colocynthis samples a factorial experiment was conducted in Horticultural science Department of University of Tehran in 2013. The first factor was two accessions of Citrullus colocynthis (Yazd and Khorasgan) and the second factor was water deficit induced by different osmotic potential levels 0 (the control), -0.4 MPa (slight), -0.8 MPa (moderate) and -1.2 MPa (severe) using polyethylene glycol. The results indicated that fresh and dry weight of seedlings and leaf area decreased in both accessions as osmotic potential increased. Khorasgan samples showed higher net photosynthetic rate than Yazd accession in all osmotic condition. Total phenolic content, antioxidant capacity and proline content of leaves varied between two accessions which Yazd accession represented higher value at different osmotic condition. The present data suggest a relation between proline and total phenolic content and water stress also well-developed antioxidant defense mechanism activated during water stress. Based on this study Yazd accession was more tolerant to drought stress and could use in breeding or grafting program to improve Citrullus species growth under water deficit condition.

Keywords: Accession; Citrullus colocynthis; Osmolyte; Polyethylene glycol; Water deficit.


Introduction

Citrullus colocynthis L. Schrad, closely related to watermelon, is a member of the Cucurbitaceae family. This plant is a drought-tolerant species with a deep root system and widely distributed in Asia and Africa (Ying et al., 2010). Although it is found mostly in the southwest, southeast, central, and eastern parts of Iran, However grows all over the country in spring-summer season. It is also a well-known medicinal plant in traditional Iranian medicine (TIM) and is used alone or in compounds for many medicinal purposes (Rahimi and Shams Ardekani, 2012).

Agricultural productivity in arid and semi-arid regions of the world are under the threat of multiple abiotic stresses mainly drought and salinity (Kusvuran et al., 2011). Drought stress is the most important limiting factor of field crops in Iran (Keyvan, 2010). Climatic changes due to global warming can cause serious reductions in yield and crop quality. Among the agricultural crops such as field crops and fruit trees, the
vegetables are more vulnerable for climatic changes (Turkes, 1999). Temperature and drought are two important environmental parameters that can limit watermelon production. Therefore most agricultural and agronomic practices are designated to optimize crop growth by avoiding or reducing abiotic stress through selection of drought resistant cultivars (Kirnak and Dogan, 2009). Polyethylene glycols (PEG) with molecular mass of 6000 and above are non-ionic, water-soluble polymers which are not expected to penetrate intact plant tissues rapidly. Therefore PEG solutions are mentioned as suitable osmolyte in biological experiments because of its specific characteristics such as immobility and non-toxicity. Osmotic stress generated by polyethylene glycol PEG-6000) are used to evaluate plant response to drought stress by some researchers (Ranjbarfordoeil et al., 2000). Understanding the mechanisms of plant tolerance to drought stress is crucial to plan and develop drought-resistant plants (Wang et al. 2009 a, b). Plants have evolved a number of mechanisms to adapt and survive all kinds of biotic and abiotic stresses. These include photosynthetic mechanisms, osmoregulation and antioxidant enzymes (Liu et al., 2008; Guo et al., 2012). Many plant species naturally accumulate protein and proline as major organic osmolytes when subjected to different abiotic stresses. These compounds are thought to play adaptive role in mediating osmotic adjustment and protecting sub cellular structures in stressed plants (Ashraf and Foolad, 2007; Singh, 2003). The accumulation of free proline under stress conditions has been correlated with stress tolerance in many plant species, and concentrations are generally higher in stress-tolerant plants than sensitive plants (Ashraf and Foolad, 2007; Kavas et al., 2013).

Drought and salt-tolerant accessions might exist in gene pools of various plant species (Suyum et al., 2012). Kusvuran (2010) have reported that drought stress in the melon genotypes caused significant reductions in fresh and dry weight of shoot, leaf Relative water content (RWC), membrane injury and lesser extend in leaf area in comparison to their control plants. Min oh et al (2010) and Ahmad et al (2012) reported that Water stress increased the total phenolic concentration and antioxidant capacity in lettuce and Garden cress. Kusvuran et al., (2012) reported that wild watermelon exhibits exceedingly high drought tolerance, although it carries out C3-type photosynthesis. Petridis et al (2012) found that a close relationship between net photosynthetic rate and proline content was recorded, pointing the important role of this osmolyte in the maintenance of photosynthetic activity. Accumulation of proline has been reported under the drought stress in another various crops such as Wild watermelon (Zulu, 2009) melon (Kavas,2013) chick pea (Cicer arietinum), (Ayerb and Tenori, 1998) corn (Zea mays), (Serraj and Sinclair, 2002) and bread wheat (Keyvan, 2010). This study aimed to determine response of two accessions of Citrullus colocynthis to level of water deficit induced by PEG. Furthermore evaluation some physiological Characteristics such as, photosynthesis, Total phenol content, Total antioxidant capacity and proline accumulation, that would help us to find tolerant mechanism in colocynth plant.

**Materials and Methods**

**Plant materials, growth conditions, and stress treatments**

This study was conducted in the factorial experiment through randomized completely blocks design (RCBD) with three replications in Horticultural science Department of University of Tehran in 2013. We used two accessions of *Citrullus colocynthis* which collected from arid and semi-arid climatic condition, Yazd and Khorasgan cities and The second factor was different concentrations of polyethylene glycol to simulate osmotic stress levels including: 0 (the control), -0.4 MPa (slight), -0.8 MPa (moderate) and -1.2 MPa (severe), for seedlings that germinated healthily and uniformly. Investigations was conducted under greenhouse conditions where day and night temperatures in the greenhouse were maintained at 24°C and 16-18 °C, respectively, and relative humidity around 60%. Seeds were germinated in mixture of peat: perlite1:1 ratio in plastic pots. Seedlings were watered twice a day with Hoagland’s solution. After the appearance of forth leaf seedling were treated by PEG and gradually the osmotic potential increased up to -0.4, -0.8
and -1.2 MPa. Control plants were grown in the same way and watered with Hoagland’s solution without PEG.

**Plant growth**

At the end of experiment fresh and dry weight of seedling were recorded. Fully expanded colocynth leaves were chosen for measuring leaf area. Leaf areas were calculated using a Leaf Area Meter (DELTA-T, ENGLAND).

**Leaf Relative water content (RWC)**

Relative water content of leaves were determined by the method described by Smart and Bingham (1974), which calculated as $RWC = \frac{100 \times (FW - DM)}{(TW - DM)}$. FW and DM denote fresh weight (g) and dry weight (g). Turgid weight (TW) was calculated after fully hydrating fresh leaves in darkness at 4 °C for 24 h. Results were expressed as percentages.

**Electrolyte Leakage**

Electrolyte leakage was used to assess cell membrane permeability according to the method described by Lutts et al. (1996). Leaf samples were cut into 1 cm segments and placed in individual vials containing 10 mL of distilled water. These samples were incubated at room temperature (25 °C) on a shaker (100 rpm) for 24 hours. Electrical conductivity of samples (EC1) was measured after incubation. The same samples were then placed in an autoclave at 120°C for 20 minutes and the second measurement (EC2) was done after cooling the solution to room temperature. The electrolyte leakage was calculated using EC1/EC2 ratio and was expressed as percent.

**Leaf gas exchange and photosynthesis measurements**

Net photosynthetic rate (Pn), transpiration (E) and stomatal conductance (gs) were measured on the median portion of the youngest fully expanded leaf, one day prior to plant sampling at 9:00–11:00 a.m. using IRGA(TPS-2 Portable photosynthesis System). Three plants from each treatment group were used for the measurement. During the measurement the air temperature was 27 and photosynthetic active radiation was 450 μmol m-2 s-1 in greenhouse. Several precautions were taken to avoid errors during measurements. Leaf surfaces were cleaned and dried using tissue paper before enclosed in the leaf cuvette (Ibrahim and Jaafar, 2011).

**Total phenolic compounds**

Total phenolic content was determined using the Folin-Ciocalteau method Chun et al., (2003). Gallic acid was used as a standard phenolic compound. One mL of the filtered extracts was mixed with 2.5 mL of 10% Folin-Ciocalteau reagent. After 5 minutes, 2 mL of saturated sodium carbonate (75 mg L-1) was added and the solution was incubated for 90 minutes at 30°C. The absorbance of the resulting blue-colored solution was measured at 765 nm.

**Antioxidant activity by DPPH (2, 2-diphenyl-1-picryl-hydrazyl-hydrate)**

Antioxidant activity was estimated by the method of Abe et al., (1998). 100 mg of fresh plant material was extracted by methanol 99% (v/v %). Extract centrifuged at 3500 rpm for 5 minutes and DPPH solution was added. After an incubation period of 30min at 25 °C, the absorbance at 517 nm was recorded. The free radical-scavenging activity of each solution was then calculated as percent inhibition according to the following equation: % inhibition = (A blank – A sample)/A blank × 100.

**Proline determination**

Proline was extracted from a sample of 0.5 g fresh leaf material I samples in 3% (w/v) aqueous sulphasalycylic acid and estimated using the ninhydrin reagent according to the method of Bates et al. (1973). The absorbance of fraction with toluene aspirred from liquid phase was read at a wave length of 520 nm. Proline concentration was determined using a calibration curve and expressed as μmol proline g-1FW.

**Statistical analysis**
All measurements were subjected to analysis of variance (ANOVA) to discriminate significant differences (defined as $P \leq 0.05$) between group means. Data were shown as the mean ± standard error (SE). These mean data were analysed statistically using a factorial design by SAS (version 9.2; SAS Institute, Cary, NC) and mean results were compared by Duncan’s multiple range test at 5% significance level ($P<0.05$).

**Results**

**Shoot fresh with dry weight**

Drought stress significantly decreased shoot fresh and dry weight of treated plants in comparison to the control plants. Khorasgan accession had high reduction in fresh and dry weight of shoots, However Yazd accession showed relatively low reduction in fresh and dry weight. Likewise, it was observed that dry and fresh weights of treated plants showed significantly reduction in both accession as osmotic potential increased ($P \leq 0.01$; Table 1).

**Leaf area**

Leaf area decreased to 1073 mm$^2$ in Yazd accession and around 987.7 mm$^2$ in Khorasgan accession at sever stress condition (-1.2 MPa). As osmotic potential increased both accessions revealed reduction in leaf area which was 65.50 % in Khorasgan samples at -1.2 MPa. In control treatment, Khorasgan accession had more leaf area than Yazd accession (Table 1) and with increasing in osmotic potential both accessions revealed sharply reduction in leaf area.

**Relative Water Content (RWC)**

Changes in RWC under drought stress are shown in Table 1. Significant decrease in Yazd accession started at control level and continued with further incensement as osmotic potential reached to sever condition at -1.2 MPa, and similar trend of reduction in Khorasgan accession, was observed. In Yazd accession amount of RWC was 40.63% at control treatment and reached to 23.22% and in Khorasgan accession was from 39.93%–20.59 %. Therefore was revealed Relative water content significantly decreased, particularly in Khorasgan accession ($P \leq 0.01$).

**Table 1**

Effect of PEG induced water deficit stress on growth parameters and gas exchange Changes in two accessions of *Citrullus colocynthis*.

<table>
<thead>
<tr>
<th>Accessions</th>
<th>Osmotic potential level</th>
<th>Fresh weight (g)</th>
<th>Dry Weight (g)</th>
<th>Leaf area (mm$^2$)</th>
<th>RWC (%)</th>
<th>Electrolyte leakage (%)</th>
<th>Photosynthesis rate (μmol H$_2$O.m$^{-2}$.s$^{-1}$)</th>
<th>Stomatal conductance (mmol.m$^{-2}$.s$^{-1}$)</th>
<th>Transpiration rate (mmol H$_2$O.m$^{-2}$.s$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yazd</td>
<td>0</td>
<td>7.06a</td>
<td>0.71a</td>
<td>1982c</td>
<td>40.63a</td>
<td>19.84f</td>
<td>23.72a</td>
<td>578.7a</td>
<td>4.92b</td>
</tr>
<tr>
<td></td>
<td>-0.4</td>
<td>6.33c</td>
<td>0.67b</td>
<td>1424e</td>
<td>33.93c</td>
<td>25.94e</td>
<td>21.3c</td>
<td>513.5c</td>
<td>4.66</td>
</tr>
<tr>
<td></td>
<td>-0.8</td>
<td>5.3d</td>
<td>0.59d</td>
<td>1169f</td>
<td>28.84d</td>
<td>27.64d</td>
<td>20d</td>
<td>393e</td>
<td>4.35e</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>4.14f</td>
<td>0.5e</td>
<td>1073g</td>
<td>26.6e</td>
<td>30.12b</td>
<td>17.18f</td>
<td>352.3f</td>
<td>4.17f</td>
</tr>
<tr>
<td>Khorasgan</td>
<td>0</td>
<td>6.63b</td>
<td>0.65c</td>
<td>2863a</td>
<td>39.93b</td>
<td>20.15f</td>
<td>21.8b</td>
<td>557.5b</td>
<td>5.7a</td>
</tr>
<tr>
<td></td>
<td>-0.4</td>
<td>4.83e</td>
<td>0.41f</td>
<td>2211b</td>
<td>24.42f</td>
<td>26.29e</td>
<td>19.15e</td>
<td>435.5d</td>
<td>4.85c</td>
</tr>
<tr>
<td></td>
<td>-0.8</td>
<td>4.1f</td>
<td>0.35g</td>
<td>1636d</td>
<td>23.21g</td>
<td>28.33c</td>
<td>16.23g</td>
<td>332.5g</td>
<td>4.36e</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>3.57g</td>
<td>0.26h</td>
<td>987.7h</td>
<td>20.95h</td>
<td>34.67a</td>
<td>17.73h</td>
<td>206h</td>
<td>4.04g</td>
</tr>
</tbody>
</table>

*Different letters in each column show significant differences at $P \leq 0.01$.*

Increased (P ≤ 0.01; Table1). Accordingly under – 1.2 MPa osmotic potential Khorasgan accession growths was further damage (% 53 of control values) than that of Yazd accession.

**Electrolyte Leakage**

The value of Electrolyte Leakage in Yazd accession was lower than that of Khorasgan, for all stress levels. Based on the Table 1, at both accessions Electrolyte Leakage at control and slight stress (– 0.4 MP) treatment revealed no significant change. However, a moderate stress (-0.8MPa) cause a significant increase in Electrolyte Leakage whereas drastic increase in Electrolyte Leakage was observed at severe stress (-1.2 MPa) level.
Photosynthesis

Under osmotic stress, the net photosynthetic rate of Yazd accession was higher than that of the Khorasgan accession. In Yazd acc. the photosynthesis rate was found to be higher in 0MP (23.72µmol/m²/s), followed by -0.4 MPa (21.8µmol/m²/s), -0.8 MPa (20 µmol/m²/s) and lowest in -1.2 MPa that just recorded 17.18 µmol/m²/s (Table3). Likewise, it was observed that the photosynthesis rate values was in control treatment (20.25µmol/m²/s), -0.4 MPa (19.15µmol/m²/s), -0.8 (16.28µmol/m²/s) and lowest in -1.2 MPa (14.4µmol/m²/s) (Table 1). As osmotic stress increase in an ascending order -1.2>-0.8>-0.4>0MP, the stomatal conductance (gs) decreased steadily (Table 1). The Yazd accession had significantly greater stomatal conductance than Khorasgan accession. Stomatal conductance value of Yazd accession were in control treatment 557.5 mmol.m⁻².s⁻¹ followed by -0. 4 MPa: 513.5 mmol.m⁻².s⁻¹, -0.8 MPa: 393 mmol.m⁻².s⁻¹ and the lowest amount in -1.2 MPa 352.3 mmol.m⁻².s⁻¹. Khorasgan accession at un-stress condition revealed conductance around 578.6 mmol.m⁻².s⁻¹, -0. 4 MPa 435.5 mmol.m⁻².s⁻¹, -0.8 MPa 332.5 mmol.m⁻².s⁻¹ and in -1.2 MP 206 mmol.m⁻².s⁻¹ (Table 1).

The response of accessions were grown under drought stress in terms of Transpiration was found to be different from one another. Results of this research showed that under normal condition Khorasgan accession had highest transpiration and Yazd accession showed lowest transpiration, Also, the mean comparison of transpiration in various treatments of drought stress represented that the treatment of drought stress (-1.2MP ) had the highest amount (28.95%) which of a statistical point of view had a significant difference (P<0.01; Table 1) with another levels.

Total phenol

As osmotic potential were increased from -0.4 to -0.8 total phenolic content in leaves of Khorasgan accession were enhanced by, 1.28 and 1.33 and, compared to 0 MPa (control). A similar trend was observed in leaves of Yazd accession where at 0 MPa total phenolic content registered the lowest production (46.06 mg Gallic acid/g fresh weight) compared to -1.2MPa that recorded 86.59 mg Gallic acid/g fresh weight (Fig 1).

![Fig. 1. Changes in total phenolic concentration [Gallic acid equivalent (GAE)] in two accessions of Citrullus colocynthis treated with PEG levels. Bars represent standard error of differences between means (SEM).](image-url)
Fig. II. Effect of PEG induced water deficit stress Total Antioxidant Capacity [DPPH radical scavenging (%)] in two accessions of *Citrullus colocynthis*. Bars represent standard error of differences between means (SEM).

Fig. III. Effect of PEG induced water deficit stress on proline (µ mol g\(^{-1}\) fresh weight) in two accessions of *Citrullus colocynthis*. Bars represent standard error of differences.
Total antioxidant activity

The accumulation of Total antioxidant exhibited similar patterns with total phenolic content. Total antioxidant content of both accessions were increased up to -0.8 MPa while were in steady rang at -1.2 MPa. The maximum amount of antioxidant compound was 69% at -1.2MPa in Yazd accession (Fig II).

Proline content

Leaves proline content of both accessions was elevated linearly with incensement of water deficit. The results depicted on Fig III, showed that together with the onset of stress, Proline content begun to increase among both accessions. In Yazd and Khorasgan samples in control plants free proline accumulation was 1.4 and 1.25 µmolg⁻¹ fresh weight respectively. Under -0.4 MPa free proline content increased up to 4.45 µmol g⁻¹ F. W. and 2.32  µmolg⁻¹ F.W. Consequently. Although this risen was more remarkable in -1.2 MPa, to 7.73 and 5.167  µmolg⁻¹ F.W. However, Khorasgan accession showed lower Proline content compared to Yazd accession (Fig. III)

Discussion

Drought stress is the most important problem in agriculture. Plants adapt to drought through various physiological and biochemical strategies. In this study, a substantial drought-induced alteration in plant growth in two Citrulus colocynthis accessions was observed. This differential growth of accessions may have been due to differential regulation of physiological and biochemical properties involved under drought stress.

Plant growth (Shoot and root fresh, dry weight, leaf area) of both accessions were inhibited by osmotic stress level. Khorasgan suffered the largest growth reduction while the smallest reduction was observed for Yazd accession, suggesting that the former is the most drought-sensitive and the latter the most drought tolerant. Similar results were reported by Kavas et al. (2013), Kirrank and Dogan (2009) in melon crop. At short-term exposure to high levels of osmotic stress, leaf growth is chiefly the result of a reduction in water uptake into the growing zone and an increased number of dead cells (Ghane et al., 2012). Reduction in seedling growth could be the result of restricted cell division and enlargement, as drought stress directly reduces growth by decreasing cell division and elongation (Bibi et al., 2012; Kramer, 1983). Kusvuran (2007) reported to development of optimal leaf area is important to photosynthesis and dry matter yield. Moreover, leaf number and leaf area reduced by water deficit stress. In the present study, Yazd accession protected fresh and dry weight compared to Khorasgan accession. This strongly suggests that drought stress reduced leaf growth and leaf area in Khorasgan accession. Similar results also were obtained by Dasgan and Koc, (2009) Kusvuran et al., (2010).

The increase in electrolyte leakage has usually been considered to be one of the major causes of increased cell membrane permeability of plants growing under different stresses (Ghane et al., 2012). This study has shown a significant increased electrolyte leakage under the influence this stress, and indicate a significant decrease in the weight of seedlings, may related to damage of the plasmalemma occurred. In addition, this incensement was sharp under the -1.2 MPa stress application, particularly in Yazd accession.

Leaf RWC is considered a reliable and widely used indicator for defining the sensitivity of plants to dehydration (Kavas et al., 2013; Sanchez-Rodriguez et al., 2010). Measurement of the tissue water content is a widely used index that indicates the water status of the plant. However, the comparatively smaller decline in RWC in Yazd accession revealed a better maintenance of water status in this accessions indicating drought tolerance through osmoregulation (Sinhababu and Kumar, 2003). The present study showed that the water content of the leaves of the accessions were significantly reduced in response to water-deficit stress. On the basis of relative water content of the tissue, many workers have distinguished the genotypes of crop species as sensitive and tolerant (Ghane et al 2012; Hojati et al., 2011). Similarly, in the present investigation, Yazd accession showed the highest water content as well as growth, which could be defined as the more tolerant cultivar to water-deficit stress.

Net photosynthetic rate, stomatal conductance and Transpiration decreased in both accessions when they were imposed to drought
stress. After 7 days of stress in -1.2 MPa, Yazd accession maintained significantly the highest values of PN (17.18 µmol CO2 m² s⁻¹), indicating that assimilation till occurred in spite of the constraint. As expected, transpiration and stomatal conductance decreased in both accessions when they were imposed to osmotic stress level as one of the first responses of plants to drought is stomata closure, restricting gas exchange between the atmosphere and the inside of the leaf. The decrease in photosynthesis in drought stressed plants can be attributed both to stomatal (stomatal closure) and non-stomatal (impairments of metabolic processes) factors. At present most researchers agree that the stomatal closure and the resulting CO2 deficit in the chloroplasts is the main cause of decreased photosynthesis under mild and moderate stresses (Mafakheri et al., 2010; Flexas and Medrano, 2002). In the current study, photosynthetic rate was found to have a significant positive relationship with production of the secondary metabolites. The same positive relationship between photosynthesis and the production of secondary metabolites was also observed by Ibrahim and Hawa (2012) and Hura et al. (2011). In many experiments it has been shown that PN decreases when gas decreases (Mafakheri et al., 2010; Srinivasarao et al., 2000).

Plants have the ability to produce antioxidant compounds such as phenolic compounds under drought stress to protect cells against active radicals (Valizadeh et al., 2014). Total phenolic content of tested vegetable extracts correlates with the DPPH radical scavenging activity, thus suggesting that total phenolic compounds can play a major role in the antioxidant activity (Ebrahimzadeh et al., 2008). Our results showed that both accessions with increasing of water deficit, there was a significant increase in their total phenolic concentration and antioxidant capacity. Consequently ‘Yazd accession had higher antioxidant activity than the Khorasgan accession suggesting that the ability of plants to scavenge ROS is accession dependent. Furthermore, numerous studies have shown that drought stress can induce a wide range of antioxidants in a number of plant species (Min oh et al., 2010; Bray, 2002; Keles and Öncel, 2002). Min oh et al. (2010) reported to when lettuce plants were exposed to mild water stress, there was a significant increase in their total phenolic concentration and antioxidant capacity.

In agreement with the present results, shown that total phenolic content of leaves can be a good tool for distinguishing resistant and total phenolics are higher in resistant than susceptible apple varieties (Nadernejad et al., 2013).

During the experiment, we found that Yazd accession had increase of proline content higher than Khorasgan accession. This increase would lower the osmotic potential (i.e. make it more strongly negative) in the cells which would help to maintain turgor and thus sustain the normal physiological and biochemical processes in the face of drought (Guo et al., 2012). The accumulation of free proline under stress conditions has been correlated with stress tolerance in many plant species, and concentrations are generally higher in stress-tolerant as opposed to stress-sensitive plants (Ashraf and Foolad, 2007) but our results was in agreement with (Sanchez et al., 1998) on pea. It may be that proline accumulation increased with a significant decrease in RWC and that this accumulation can maintain membrane integrity (Kavas et al., 2013). Accumulation of proline has been advocated as a parameter of selection for stress tolerance (Mafakheri et al., 2010; Yancy et al., 1982; Jaleel et al., 2007).

Conclusion

The present research work was conducted to evaluate the genetic potential of two accessions of colocynth plants from different climatic condition through artificially created water stress by PEG. It would be cost effective, less time consuming and less laborious to screen the germplasm at early stage. It is concluded that variation among two accessions could be related to their different adaption to water deficiency condition (like Yazd accession) and results of this research could be productive in further breeding programs or grafting with watermelon for drought tolerance aspects.
References


Ardekani, M. 2012.' A Review on Citrullus colocynthis Schrad, From Traditional Iranian Medicine to Modern Phytotherapy '. The journal of alternative and complementary medicine, 6:551-554.


Hura, T., K. Hura and M. Grzesiak. 2011.'Soil drought applied during the vegetative growth of triticale modifies the physiological and biochemical adaptation to drought during the generative development'. Journal of Agriculture and Crop Science, 197: 113–121.


Drought stress responses in *Citrullus colocynthis*


Turkes, M. 1999. 'Vulnerability of Turkey to desertification with respect to precipitation and aridity conditions'. *Turkish Journal of Engineering and Environmental Science*, 23: 363-380.


