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MORPHOLOGICAL, CHEMICAL AND BIOCHEMICAL RESPONSE TO DROUGHT STRESS IN POMEGRANATE (*Punica granatum* L.) FRUIT

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ABSTRACT

The effect of drought stress on some important morphological, chemical and biochemical attributes of fruit including fruit weight and size, total arils, peel and seed weight, peel thickness, fruit diameter and length, soluble solids (TSS), pH, titratable acidity (TA), maturity index (MI), total anthocyanin in arils, total phenolic in arils and peel, antioxidant activity in fruit juice and peel of pomegranate (*punica granatum* L. cv. Rabab) were investigated. With reduce of soil moisture content, fruit weight and volume, total arils, peel and seed weight were reduced. TSS content was increased with moderate drought stress, but pH and TA in the severe drought stress treatment were depicted the highest amount. MI in moderate drought stress showed the best state. The juice anthocyanin between different treatments did not significant difference. The highest total phenolic of juice pertained to severe drought stress. Total phenolic of fruit peel in different soil moisture treatments was not significant difference. The high antioxidant activity of the juice pertained to severe drought stress.

Keywords: Pomegranate, Drought stress, Fruit, Antioxidant activity

INTRODUCTION

The environmental stresses such as drought, heat and cold, salinity and heavy metals are considered as the main factors to reduce the growth and performance of the plants (Anjum et al., 2011). Drought is an important limiting factor for the growth and development of plants in arid and semiarid regions. Drought stress leads to a morphological, Physiological, biochemical and molecular changes (Bajguz, Hayat 2009). Effects of drought on the growth, yield, the cell membrane stability, cellular turgor, osmotic adjustment and water relation of plant, the pigment content and photosynthetic activities have always been attractive for researchers (Passioura, 2007; Mittler, 2006). In most fruit trees, drought stress leads to change in the fruit quality *via* changes in the concentrations of pH, TA, TSS, anthocyanin, total phenolic and other chemical compounds (Mpelasoka et al., 2001; Santos et al., 2007; Hatier et al., 2009; Garcia-Tejero et al., 2010; Mellisho et al., 2012).

Pomegranate (*Punica granatum* L.) is the oldest known fruit (Blumenfeld et al. 2000) that in a widespread manner has planted in tropical and subtropical regions of several countries of the world (Sarkosh et al., 2006). This plant is naturally found in forest habitat of the south Caspian Sea (Iran) and north of Turkey (Janick 2007). Although this plant grows in the vast scopes of different climes, it has a high resistance to dry conditions (Galindo et al. 2014). Pomegranate is one of the most important orchard products of Iran. The area under cultivation of pomegranate in Iran around 550000 hectares (Sheidai et al. 2005) and the annual production 665000 tonnes (Akbarpour et al., 2010) have been reported.

Pomegranate in a diverse manner has been used in traditional as well as modern medicine (Miguel et al., 2010). The different components of this tree include flower, leaf, fruit, and trunk skin, possessing numerous medical qualities (Stover, Mercure 2007). Its fruit has a high antioxidant and contains a considerable amount of minerals, carbohydrates, acids, polyphenols and phytosteroids (Schwartz et al. 2009; Seeram et al., 2008). In the recent years extensive researches have been carried on the physical and chemical characteristics of different cultivars of pomegranate and in this route the superior cultivars have been introduced (Akbarpour et al., 2010; Zarei et al., 2010; Tehranifar et al., 2010). Except the cultivar type, the environmental conditions also have a noticeable impact on the physical, chemical and biochemical features of pomegranate fruit. Meighani et al(2014) reported that the environmental stresses during the fruit growth are an effective factor in the browning of the pomegranate arils. Drought stress on the pomegranate fruit by regulative deficit irrigation studied (Mellishoa et al., 2012). They have reported that the fruit's size and even the accumulation of chemicals in the fruit were dependent on the rate and period of drought stress.

The aim of the present research was to investigate the influence of different soil moisture level on some important physical, chemical and biochemical characteristics of the pomegranate cv. Rabab fruit.

MATERIALS AND METHODS

Plant material and experimental location

The experiment was conducted in the 4 year old pomegranate cv. Rabab trees that were cultivated in the distance of 3 x 4 meters and were irrigated *via* the bubbler irrigation system. The experiment was carried out, during 2013 – 2014, in the Horticulture Station of the Agriculture and Natural Resources Research and Training Centerof Yazd province, Iran. The average annual precipitation and evaporation were 69 mm and 3090 mm respectively. The average annual temperature was 20 ºC and the maximum and minimum temperature was 44ºC and -6.5ºC respectively. The soil of experimental area were sand-loam texture, EC = 4.12 (dsm^{-1}), and pH =7.21.

Experimental treatments

The design of the experiment was randomized complete block with four replications and each replication was consisted of nine trees. Soil moisture treatments were; 100% (control), 75% (moderate stress) and 50% (severe stress) field capacity. Drought levels were maintained for one growth season. The soil moisture measurement performed by time domain reflectometer system (TDR model TRAM) in depth of root development and in the four depths *viz*. 0-25, 25-50, 50-75 and 75-100 cm. For accessing the required water in the field capacity, along with the needed measurements in this regard included measurement of the weight moisture in different depths, measurement of the soil bulk density and calculating the volume moisture for calibrating the TDR, the factors such as initial soil moisture rate, the pure depth of irrigation water, the wetness at the feet of each tree, need for leaching and performance of irrigation system were also considered. The information related to the evaporation from the class A evaporation basin was procured from the statistics of the Yazd climatology station. The entire operations of fertilization, pruning and control of weeds in an orchard were carried out based on the usual conditions.

Morphological properties

After the harvest of fruits from each tree their respective counting and weight was performed and the average fruit weight for each tree was calculated. In continuation, the respective measurement of diameter and length of each of the fruits and length and diameter of their calyx was carried out by Collis digital and the average for each tree was calculated. To measure the fruit volume, the sphere volume calculator formula ($\frac{4}{3}\pi r^3$) was adopted in which the diameter of fruit was used (Wetzstein et al., 2011). With the selection of a fruit from each tree, the fruits were reselected and with the use of a digital balance (0.001 scales) precision, the respective separation of arils from peel were carried out. The weight of arils and peel was measured and in proportion to the peel thickness measurement in three sections; primary, middle and end of the fruit were performed and an average was obtained and considered as the index of the peel thickness. With smash of the arils proportionately the juice and seeds were separated and each of them was rescaled. With these conditions the juice weight, seed weight and percentage of the components constituting the fruit were determined. The juice was used for measuring of chemical and biochemical characteristics. Even the peel of fruits were introduced in the laboratory temperature conditions, dried, later milled and used for measuring of the total phenolic and antioxidant activity.

Total soluble solids pH, titratable acidity and maturity index

With the extraction of juice immediately the total soluble solids (TSS) was measured by refractometer (Mini Digital, Taiwan). Results were reported as ◦Brix at 21^{o}C. For the determination of pH, pH meter (Metrohm 827) was used at 21ºC. The titratable acidity (TA) was measured by titration to pH 8.2 with 0.1N NaOH solution and Calculate using the following formula (AOAC, 1984):

% acid = [mls NaOH used] x [0.1 N NaOH] x [milliequivalent factor] x [100] grams of sample

The maturity index (MI) of fruit was also calculated with the dividing of TSS to TA (TSS/TA).

Total anthocyanin, total phenolic and antioxidant activity

Total anthocyanin pigment was measured by using of the pH difference method between the two buffered systems (Giusti, Wrolstad 2001). In this method, after the preparation of the juice extract and its dilution (1:10), in the two buffers with acidity 1 (potassium chloride) and 4.5 (sodium acetate), the absorption of samples in the 510 and 700 nm wavelengths was measured by spectrophotometer (Jenway 6105, England). The total anthocyanin was calculated based on the Cyanidin 8-glucoside as an anthocyanin dominant pomegranate as following formula:

A= (A510 – A700) pH1.0 - (A510 – A700) pH4.5

Total anthocyanin= [(A×MW×DF×100)/ (ε *1)]

It was converted to mg of total anthocyanin content /100 g pomegranate juice. MW is the molecular weight, DF is the dilution factor, and ε is the molar absorptivity, calculate pigment content as cyanidin-3-glucoside, MW = 449.2 and ε= 26900

The total phenolic content was measured by using the Folin-Ciocalteau method (Singleton, Rossi 1965). 0.3ml diluted pomegranate juice in the ratio of 1:100 was mixed with 1.5 ml diluted Folin-Ciocalteau reagent. After five minutes, 1.2 ml of 7.5% Na_2CO_3 (Sodium carbonate) was added to it and after 1.5 hours in the laboratory temperature and dark conditions, its absorption by spectrophotometer (Jenway 6105, England) at 760 nm. Gallic acid was used for comparison with standard curve. The total phenolic content was stated as mg of Gallic acid in a litter of fruit juice (ppm). This procedure was also carried out for the methanolic extract of fruit peel and the total phenolic content was stated as mg of Gallic acid in a kg (m/kg) of fruit peel.

The antioxidant activity of fruit skin and juice was measured by Shimada et al (1992) method. From the diluted fruit juice with 85% methanol in the ratio of 1:100 and the prepared methanolic extract from the fruit peel in the concentration of 0.2 ml was used. From each of the samples, 500 µl was taken and mixed with 500 µl distilled water and they were centrifuged at 10000 rpm for 5 min at room temperature. Later 75 µl of phase leach with the 2925 µl DPPH solution (0.0024 gm. DPPH with 85% methanol was made up to a volume of 100 ml) and vortexes. Eventually, the absorption of samples was read after placement in the dark for a period of 30 minutes at 517 nm by spectrophotometer (Jenway 6105, England). Concurrently, with this act absorption of the control sample was also measured (where instead of extract 0.2 ml 60% methanol was used). The antioxidant activity was calculated by following equation.

Antioxidant activity (%) = [(Abs control - Abs sample)/Abs control] × 100.

Statistical analysis

Data were analyzed by SPSS statistics version17.0 software using analysis of variance (ANOVA) and differences among means were determined for significance at $P< 0.05$ whit Duncan test. All data were tested for homogeneity and normality test.

RESULTS AND DISCUSSION

Water consumed

The consumed water amount for each one of the soil moisture treatments in comparison to the evaporation from class A evaporation basin during the experimental period is shown in the Figure-1. The rate of water consumed by trees (evapotranspiration) during this period (from March to October) in 100%, 75% and 50% field capacity were 881.2, 675.6 and 469.8 mm respectively. The evaporation rate also was 1933 mm. The evapotranspiration values for the 100%, 75% and 50% field capacity treatments were equivalent to 45.6%, 35.0% and 24.3% of the evaporation respectively.

Morphological properties

The physical and morphological fruit characteristics under the drought stress conditions are shown in the table 1 and 2. In most of the cases, including the fruit weight, fruit volume, aril weight, peel weight, seed weight and juice weight among different soil moisture treatments had a significant difference in the 1% level ($P<0.01$). Fruit weight was 262.75g in the control and 177.10g in the severe stress treatments. The fruit volume also reduced from 262.30 cm^3 in control treatment to 165.40 cm^3 in severe stress. With the fruit weight reduction, both aril and peel also reduced due to the drought stress. The effect of severe drought stress on the peel was more than arils. With the increase of drought stress from moderate stress to severe stress, the peel weight reduced from 97.42g to 85.92g and have significant difference ($P<0.01$). A significant difference was not observed between the moderate stress and severe stress treatments in the arils weight. Significant differences were not observed between soil moisture treatments in aril percent and peel percent, although the highest aril percent pertained to control with 53.33%. The highest peel percent was related to moderate stress treatment. Fruit seed is an important fruit quality for pomegranate. Fruit seed weight was significantly higher in control ($P<0.01$), but it showed the highest seed percent in relation to the other fruit component related to the severe stress treatment (6.91%) which had a significant difference with the other soil moisture treatments ($P<0.01$). The highest juice fruit obtained from arils of the pomegranate in the control treatment (125.93g) and had significant difference with the other soil moisture treatments ($P<0.01$). There are significant difference ($P<0.01$) among soil moisture treatment on fruit juice percent. The highest percent of fruit juice obtained from control treatment (47.06%). Mpelasoka et al(2001) reported that stress due to water shortage in the soil besides reducing the fruit size of an apple, can cause performance reduction, although it possibly could lead to fruit stiffness and the improvement of storage conditions. Garcia-Tejero et al (2010) with enforcement of different drought stress conditions on the orange trees concluded that although the fruit size is much influenced by the number of fruits on the tree, still the drought stress can lead to its size reduction. Lopez et al (2008) investigated the influence of low irrigation in the second growth stage of pear fruit and reported that the low irrigation along with pruning in this fruit growth stage can lead to optimum fruit growth. While, the low irrigation due to reduction of fruit accessible water amount, can alone reduce the fruit growth. Mellisho et al (2012) during a research found that increase and or decrease in the size and performance of fruit and even the accumulation of chemicals in pomegranate fruit is influenced by the rate and period of drought stress. The severe drought stress, especially during the rapid growth of fruit, besides reducing the performance leads to reduction of fruit quality and namely the fruit size. Wetzstein et al (2011) carried out their investigations on the pomegranate cv. Wanderful and reported that although the fruit size was influenced by the genotype, the highest effect on the fruit size and volume increase in the mentioned cultivar pertained to the existing arils number in each fruit and the average weight of each aril did not have an effect on fruit size and weight increase. They found that the formed arils number was effective due to pollination. It seems that the drought stress is a factor which is effective for the inappropriateness of pollination conditions and abortion seed which were followed by a reduction in the number of arils.

The highest fruit peel thickness was pertained to moderate stress (5.73 mm) and was significant difference with the other treatments ($P<0.05$). Akbarpour et al (2009) reported that the medium peel thickness of this cultivar is 6.01 mm which had the highest amount among the investigated cultivars. This rate was reported 4.61 mm for the cultivar Rabab (Ehteshami et al., 2012). It seems that despite the fact that skin thickness has been introduced as a cultivar, the moderate drought stress has led to an increase of skin thickness. The fruit length due to enforcement of drought stress reduced, nevertheless a difference between the soil moisture treatments were observed in 5% level. The highest fruit length pertained to control (82.29mm) and showed a significant difference (P<0.05) to other soil moisture treatments. Drought stress reduced the fruit diameter from 78.95 mm in the control to 67.97 mm in the severe stress treatment, although a significant difference was not observed between moderate stress and severe stress treatments. Due to drought stress enforcement the fruit length to diameter ratio (L/D) increased.

The highest correlation was observed between fruit weight with aril weight (r=0.91), peel weight (r=0.876) and seed weight (r=0.746). Between the fruit volume and aril weight (r=0.597), peel weight (r=0.616) and seed weight (r=0.642) a positive and significant correlation was observed (P< 0.01). With increase in the juice fruit, the weight of each of the fruit components *viz*. arils weight, skin weight and seed weight had a considerable increase in a manner that it exhibited a positive and significant relationship (P<0.01). A direct relation was observed between fruit weight and fruit volume or fruit diameter (r=0.993 and r=0.676 respectively).

Total soluble solids pH, titratable acidity and maturity index

Chemical properties of fruit juice pomegranate in this study showed significant differences in all parameters (Table-3). A significant difference (P<0.01) was observed between control and other drought stress treatments. Moderate stress treatment had more TSS (15.64^{o}Brix). TA also showed a significant difference (P<0.01) between the different of soil moisture treatments. The highest amount pertained to severe stress treatment (5.61%). Drought stress reduced the fruit pH from 3.51 in the control to 3.36 in the severe stress treatment. MI rate in severe stress treatment had a considerable reduction and it reached to 2.83 which had a significant difference with the other treatments (P<0.01).

The results showed that although drought stress leads to a reduction of the values related to the physical characteristics of fruit such as fruit weight and volume, but it led to the improvement in many of the fruit chemical parameters such as pH, TSS and TA (Table-3). Mellisho et al (2012) were reported that TSS increased with moderate drought stress in fruit juice pomegranate. They did not observe change in the rate of pH and TA in different drought stress levels. Garcia-Tejero et al (2010) reported that the quality of the orange fruit *via* TA and TSS increase with drought stress. However, Mpelasoka et al (2001) studied enforcement of drought stress on apples and concluded that the drought stress can increase TSS concentration in the fruit, although it did not have a significant effect on the TA.

In the experimental conditions, TA and TSS for the Rabab pomegranate were reported 19.56^{o}Brix and 1.35g citric acid in 100g of juice respectively (Zarei et al., 2010).

The highest correlation pertained to TA with MI. With the increase of TA the MI of fruit reduced (r= -0.793). Similarly with increase of juice pH, the fruit MI also increased (r= 0.660). With increase of juice TA, juice pH reduced (r= -0.774). Considering the aforementioned data it was determined that severe drought stress leads to reduce pH and increase TA, whereas the MI reduced.

Total anthocyanin, total phenolic and antioxidant activity

The significant difference was not observed between the different soil moisture treatments in the juice anthocyanin concentration (Table -3). Mellisho et al. (2012) reported that with moderate drought stress in the pomegranate, cv. Mollar de Elche, the anthocyanin increased. In most of the plants, the moderate drought stress led to anthocyanin rate increase (Hatier, Gould 2009).

The present experiment showed that the total juice phenolic content increased with drought stress. With the increase of drought stress from control to severe stress, the total juice phenolic content reduced from 1796.48g/l to 2680.12g/l and have significant difference (*P*<0.01). Although, the total peel phenolic content was too high, not significant difference was observed between the different drought stress levels.

Zarei et al (2010) reported that the total phenolics content in the juice of cultivar Rabab in the experimental conditions was 786.2 mg in 100 gm of juice. They reported that in this cultivar had total phenolics content more than others studied cultivars. The high accumulation of phenolic compounds in the juice and peel in this cultivar is mark for difficult environmental adaptability such as drought stress. One of the mechanisms resistant to the environmental stresses in the plants is PAL (Phenylalanine ammonia-lays). This enzyme activity has important role in the synthesis of phenolic compounds. The phenolic compounds can improve the resistance rate in the plants (Hura et al., 2007). Santos et al(2007) have investigated that drought stress increased anthocyanin and phenolic components in fruit grapes and improved the fruit quality, although yield was reduced.

The research results on the fruit juice and peel antioxidant activity showed that even though due to higher total phenolic content, the fruit antioxidant activity was high (Table-3), but its amount in the fruit juice increased with drought stress increase and had a significant difference with other soil moisture treatments ($P<0.01$). Corresponding to the fruit peel antioxidant activity in the control treatment was highest (60.59%), although a significant difference was not observed with others treatments (Table -3). The high fruit peel antioxidant activity indicated that higher amount of phenolic compounds in the fruit peel. The pomegranate juice included the compounds such as ellagic tennis, anthocyanin, catechins, gallic and gallic acid that are the antioxidant chemical compounds (Sadeghi et al., 2009). However, Zarei et al(2010) and Ehteshami et al (2012) reported that the antioxidant activity rate of pomegranate juice cultivar Rabab was 51.46 and 70.25 percent respectively. The aforementioned low values in this research could be due to the low anthocyanin present in the juice, although Tatari et al (2011) reported that the concentration of anthocyanin present in pomegranate juice does not have any relationship to its antioxidant activity.

While investigating the relationship between fruit anthocyanin concentration and other juice phenolic compounds with its antioxidant activity, it was determined that anthocyanin present in juice due to negligibility did not have a significant effect. The other phenolic compounds in the juice was higher than anthocyanin and they have had a significant correlation (r=0.670) with antioxidant activity. (The rate of phenolic compounds in the fruit peel also had an effective role in its antioxidant activity and it have had significant correlation (r= 0.590) with antioxidant activity. The juice anthocyanin concentration in pomegranate with the reduction of other phenolic compounds increased, nevertheless the chemical compounds in a fruit during the fruit maturation period and at the time of storage changes (Mousavinejad et al., 2009). The results showed that with increased drought stress, phenolic compounds (except anthocyanin) also increased and antioxidant activity increase. With increase of antioxidant activity, reactive oxygen species (ROS) damages decrease.

CONCLUSIONS

Although pomegranate is introduced as a resistant plant to drought, drought stress can affect the morphological, chemical and biochemical characteristics of fruits. With the drought stress enforcement most of the fruit's morphological factors such as fruit weight, fruit volume, total arils, peel and seed weight were affected and reduced. Even the fruit length to diameter ratio (L/D) was influenced by drought stress. With drought stress, length to diameter ratio was increased. Although, the drought stress led to increase in the fruit peel weight, but it did not have a significant role in the thickness increase. The moderate drought stress led to the improvement of the fruit qualitative indexes such as MI and TSS, although the highest rate of total acidity and the lowest pH rate pertained to severe drought stress. The juice fruit anthocyanin concentration was less affected by drought stress. With the increase of drought stress the total phenolic content in fruit juice increased and caused for increasing of antioxidant activity. The total phenolic content in fruit peel in all of soil moisture treatments was too high and antioxidant activity also increased and not significantly different between treatments. This research indicated that arils in relation to the peel were much affected by the environmental stresses. In fine, it can be safely concluded that the enforcement of moderate drought stress (75% of field capacity) during the growth period of pomegranate trees can be planned for an optimal qualitative and quantitative product harvest.

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Table 1: Effects of different soil moisture levelson fruit weight (FW), fruit volume (FV), total arils weight (TAW), peel weight (PW), seed weight (SW), aril percentage (AP), peel percentage (PP), seed percentage (SP), peel thickness (PT), juice weight (JW), juice percentage (JP), fruit length (FL), fruit diameter (FD), fruit length/diameter (FL/D) of pomegranate cv. Rabab

	Moisture treatments		
Parameter	**Control (100% FC)**	**Moderate stress(75% FC)**	**Severe stress (50% FC)**
FW (g)	262.75^{a}±37.45	196.77b±34.02	177.10^{c}±31.84
FV	262.30^{a}±64.31	182.23^{b}±47.44	165.40^{b}±23.63
TAW (g)	140.63^{a}±21.30	99.34^{b}±21.27	91.17^{b}±21.14
PW (g)	121.66^{a}±25.68	97.42^{b}±19.71	85.92^{c}±16.36
SW (g)	16.64^{a}±3.53	12.39^{b}±2.36	12.38^{b}±2.93
AP 9%)	53.33^{a}±6.05	50.40^{a}±5.71	51.18^{a}±5.60
PP (%)	46.66^{a}±6.05	49.59^{a}±5.71	48.82^{a}±5.60
SP (%)	6.34^{b}±1.06	6.32^{b}±0.78	6.91^{a}±1.08
PT (mm)	4.99^{bc}±1.24	5.37^{ab}±1.43	4.48^{cd}±1.38
JW (g)	125.93^{a}±20.803	86.95^{b}±19.511	78.78^{b}±19.199
JP (%)	47.06^{a}±5.604	44.08^{b}±5.430	44.17^{b}±5.205
FL (mm)	82.29^{ab}±7.706	78.41^{bc}±9.813	76.02^{cd}±9.554
FD (mm)	78.95^{a}±6.693	69.87^{b}±6.850	67.97^{b}±9.213
FL/D	1.04^{b} ±0.055	1.12^{a} ±0.110	1.11^{a} ±0.092

Values with the same superscript letter within each column are significant different ($p<0.05$). Values means are 36 fruit from 36 trees ± standard deviation.

Table 2. Effects of drought stress on total soluble solids (TSS), titratable acidity (TA), pH, maturity index (MI)

	Moisture treatments		
Parameter	**Control (100% FC)**	**Moderate stress(75% FC)**	**Severe stress (50% FC)**
TSS (oBrix)	14.32^{b}±1.551	15.30^{a}±1.872	15.90^{a}±2.072
pH	3.51^{b}±0.234	3.50^{b}±0.321	3.36^{a}±0.300
TA (%)	3.75^{b}±0.898	3.95^{b}±1.260	5.61^{a}±1.084
MI	3.81^{a}±0.843	3.87^{a}±1.123	2.83^{b}±0.875

Values with the same superscript letter within each column are significant different ($p<0.05$). Values means are 36 fruit from 36 trees ± standard deviation.

Table 3. Effects of drought stress on juice total anthocyanin's (JTAS), juice total phenolic (JTP) peell total phenolic (PTP), juice antioxidant activity (JAA) and peel antioxidant activity (PAA), of pomegranate cv. Rabab fruit

	Moisture treatments		
Parameter	**Control (100% FC)**	**Moderate stress(75% FC)**	**Severe stress (50% FC)**
JTAS (mg/L)	1.11^{a}±0.625	1.09^{a}±0.791	1.02^{a}±0.596
JTP (mg/L)	1796.48^{b}±502.95	1886.23^{b}±661.78	2680.12^{a}±501.44
PTP (g/Kg)	173.43^{a}±53.901	162.95^{a}±57.750	173.42^{a}±35.701
JAA (%)	27.25^{b}±6.770	28.92^{b}±7.671	34.46^{a}±5.951
PAA (%)	60.59^{a}±17.010	54.04^{a}±19.401	55.75^{a}±16.820

Values with the same superscript letter within each column are significant different ($p<0.05$). Values means are 36 fruit from 36 trees ± standard deviation

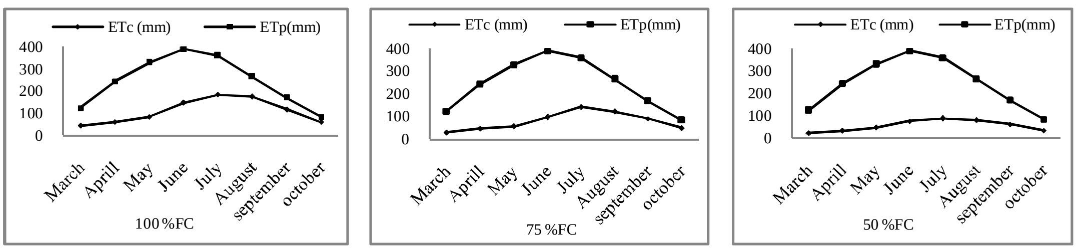

Fig 1- The consumed water in different soil moisture treatments from March to October in comparison to evaporation basin class Ain pomegranate cv. Rabab