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Effects of Drought and Salinity on Yield and Water Use Efficiency in Pomegranate Tree

Mojtaba Tavousi[1]*, Freidoon Kaveh[2], Amin Alizadeh[3], Hossein Babazadeh[4] and Ali Tehranifar[5]

1Ph.D. candidate, Water Sciences Department, Science and Research Branch, Islamic Azad University, Tehran, Iran
2Associate Professor, Water Sciences Department, Science and Research Branch, Islamic Azad University, Tehran, Iran
3Professor, Water Engineering Department, Ferdowsi University, Mashhad, Iran
4Assistant Professor, Water Sciences Department, Science and Research Branch, Islamic Azad University, Tehran, Iran
5Associate Professor, Horticulture Sciences Department, Ferdoowsi University, Mashhad, Iran

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** Corresponding Author E-mail: m.tavousi@gmail.com*

Abstract
About half of the irrigated land in the world is affected by salinity and sodium or flooding. Both salinity and drought stress cause plants limited access to water and reduction of the growth rate of plants is associated with metabolic changes. Pomegranate is one of the plants that are planted in arid and semi-arid areas. Pomegranate is native to Iran and has highest acreage in the producing pomegranate among countries. To study the combined effects of salinity and drought stress on water use efficiency and crop yield in years 2010-2011 and 2011-2012 pilot projects at the Islamic Azad University of Ferdows on four years pomegranate trees was carried out. Key factors include five different irrigation amount and three levels of irrigation water salinity. At the end of the second year total yield and efficiency of pomegranate juice consumption was measured. The results showed that the crop yield and water use efficiency significantly affected by salinity and drought stresses were applied in combination. The study of separate effects of stress showed that deficit - irrigation causes a significant decrease in crop yield compared to full irrigation if the salinity stress had no significant effect on crop yield. In general it can be said that the pomegranate tree is susceptible to dehydration and resistant to salt stress. The calculations showed that salinity stress can reduce water use efficiency. Drought stress on water use efficiency did not decrease as much as 10% but greater amounts of deficit irrigation reduced water use efficiency.

Keywords: *Drought, Salinity, Yield*

Introduction
Environmental stresses are of the most important determinants of distribution pattern of plants in the world. In Iran, due to the severe limitations of water resources in many areas, the drought is most important affecting stress on crops. Researchers cited annual yield loss caused by drought in the world, about 17% which can increase to over 70% per year [1]. Response to the lack of water and plant species, length and duration of stress, age and developmental stage of the plant, and cells and plant and components of under cell depends on its structure [2].
Salinity is one of the main stresses on the cultivation of plants. Salinity stress is an important limiting factor in agricultural systems, which causes difficulties in the process of growth and development of plants [3]. Deficit-irrigation is an optimum solution to produce in water deficit [4]. According [5] one of the most important factors in the planned irrigation is water use efficiency (WUE) or amount dry matter production per unit of

water used that it's determining factors, economic yield, biological yield and water consumption can be named.

According to de-Kandvl and based on available evidence is native to Iran and neighboring countries [6]. Pomegranate among producing countries, Iran has the largest area under cultivation and Iranian pomegranate is a special place for export. Khattab et.al, [7] evaluated the effect of different level of irrigation on chlorophyll growth and crop yield of twenty years pomegranate trees in Egypt. Their results showed that all the components of chlorophyll and crop yield were significantly affected by the amount of intake water. Treated had received the highest water had maximum chlorophyll growth and reduce the amount of water, these parameters were reduced. Bhantana and Lazarovitch [6] examined the effect of salinity on the amount of evapotranspiration, plant coefficient and the effects of salinity on growth of pomegranate cuttings were observer of significant effects of salinity on total daily evapotranspiration. They say that if the results are assumed to mature trees, pomegranates also true pomegranate should be considered as salt sensitive plants than relatively resistant to salinity.

Research Girona et. al, [8] and Romero et.al, [9] on peanut yield showed that deficit irrigation performance adjusted cause non-significant decrease in grain yield without affecting grain size. Pulvento et.al, [10] suggest deficit irrigation in apricot is usefulness.

Materials and Methods:

To study the combined effects of salinity and drought stress on water use efficiency and yield in crop years 2010-2011 and 2011-2012 pilot projects at the Islamic Azad University of Ferdous located in East Khorasan province on four years pomegranate trees was carried out. Every two years, the same quantity and quality of irrigation water were measured and at the end of the second year yield and water use efficiency was calculated. Ferdous city is located near the central desert of Iran; based on the classification Ambrgeh has a dry and cold climate. Long-term average climate conditions as described in Table 1.

Table 1 - The Ferdous city's climate

Weather	Average air temperature (° C)	Average relative humidity (percent)	Annual sunshine duration (hours)	The mean annual precipitation (mm)
Dry and cool	25	37	2900	140

Soil texture tested is sandy loam with field capacity 7.20 and permanent wilting point 10.3 wt%.

Characterizes of the project:

Irrigation treatments included full irrigation as controlsI_1, irrigation with 10 percent practicesI_2, 20 percentI_3, 30 percentI_4 and 40 percent deficit irrigation than the control groupI_5, during their development period. Of three wells with salt water with EC values equal to 1.5 (S1), 5 (S2) and 5.8 dS m (S3) were used for irrigation.

To determine the amount of water needed for different treatments, the depth of the roots was determined. Then according to soil field capacity and permanent wilting point of root and by taking amount allowance depletion of 40 percent, when soil moisture reached this limit irrigation was completed. Irrigation depth was determined from Equation 1.

Treatments with respect to deficit irrigation water at the same time were taken into account.

$$\boldsymbol{I_n = (F_c - PWP)MAD \times Dr_z} \qquad \mathbf{(1)}$$

In the above equation, $\boldsymbol{I_n}$ = specific water depth in millimeters, $\boldsymbol{F_c}$ = soil moisture percent at field capacity, $\boldsymbol{PWP}$= soil moisture percent at permanent wilting point, $\boldsymbol{MAD}$= allowance soil moisture depletion in percent $\boldsymbol{Dr_z}$=growth depth in plant roots in mm.

To understand time reach to desired moisture level, soil moisture sensors model instruments 6440 Davis was used. The total volume of water to the different treatments is presented in Table 2.

Table 2. Total volume of water allocated to different treatments during the growing season

Irrigation treatments	Full Irrigation	Deficit irrigation 10%	Deficit irrigation 20%	Deficit irrigation 30%	Deficit irrigation 40%
The volume of water (m)	3375	3037	2700	2362	2025

At harvest, total crop was harvested and weighed. Water use efficiency by dividing the total yield (in kilograms) by the amount of water (in cubic meters) was calculated [5].

Results and Discussion

The results of applying different treatments of irrigation on total yield in Table 3 analysis results are shown in Table 4.

Table 3. The average value total treatments yield affected by combined effect of drought and salinity stress

Water use efficiency (Kg / m3)	The different yield of treatments (ha)						Irrigation treatments
	Average yield	I_5	I_4	I_3	I_2	I_1	
3.28	$\boldsymbol{a}$ 8.87	5.47	7.31	8.20	10.61	12.78	S_1
2.96	$\boldsymbol{a}$ 8.00	5.27	6.90	7.80	9.76	10.23	S_2
2.66	$\boldsymbol{a}$ 7.18	4.95	6.27	6.95	8.61	9.14	S_3
-----	-----	$\boldsymbol{c}$ 5.23	$\boldsymbol{b}$ 6.82	$\boldsymbol{b}$ 7.65	$\boldsymbol{a}$ 9.66	$\boldsymbol{a}$ 10.71	Average
-----	-----	2.58	2.88	2.83	3.18	3.17	Water use efficiency (Kg / m3)

Table 4. The results of the statistical analysis total yield values

Tree Yield	
45.85*	I
4.74ns	S
29.14*	I×S

Interactive effects of drought and salinity stress on yield components

The results (Tables 3 and 4) shows that total amount yield by five percent is influenced combined effects of drought and salinity stress.

Figure 1 shows the yield of the combined effects of drought and salinity stresses.

Figure 1 shows the results and change trends that significantly affected by the combined effects of drought and salinity stress and increased salinity exacerbate the effects of drought.

As noted, the effect of salinity stress on plants as a result of the drought stress and salinity stress alone to prevent water absorption in root. So in salinity deficit irrigation treatments intensify water shortages effects (Mons, 2002). In order to determine more precisely the separation of the effects of drought, salinity stresses the need to separate stress effects analysis, which will be continued.

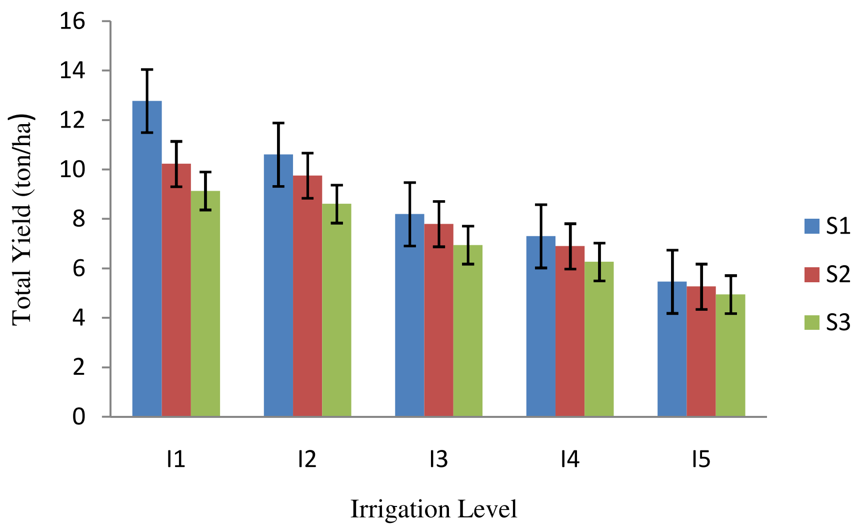

Figure 1. The values of yield affected by the combined effect of drought and salinity stress

The impact of drought stress on crop yield

As is clear from Figure 2 is given by the reduced amount of water, the values of yield declined. With respect to the yield of different irrigation treatments, per cent certain that reduce watering, percent yield reduction is greater. In other words, if the amount of water given to the different treatments to consider the amount of evaporation and plant transpiration, in relation to the amount of evapotranspiration (Equation 2) K_y is greater than the amount obtained and pomegranate can be considered susceptible to deficit irritation.

$$\frac{Y_a}{Y_t} = 1 - K_y\left(1 - \frac{ET_a}{ET_p}\right) \quad (2)$$

In this regard, Y_a و Y_t is the maximum yield and actual yield of plant, respectively ET_a و ET_ppotential evapotranspiration and actual evapotranspiration and $K_y$rate of reduction in yield per evapotranspiration reduction.

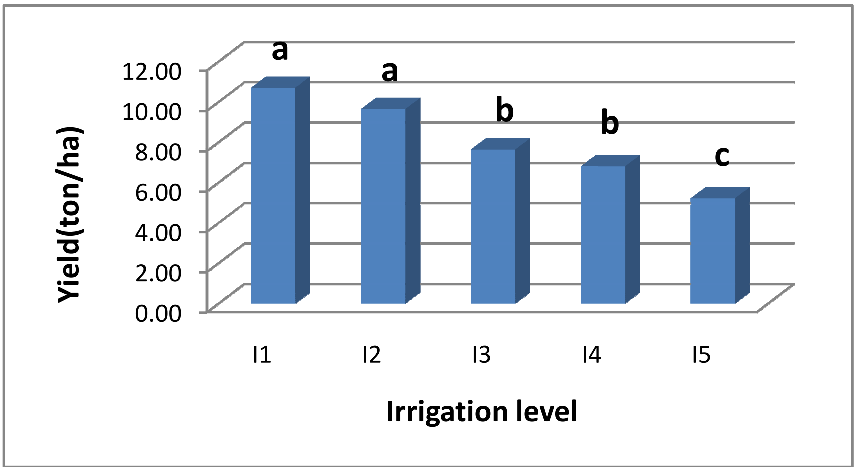

Figure 2. The total yield of the different treatments in deficit irrigation

Results Khatab et al [7] also showed that yield was significantly affected by the amount of water intake and decrease in amount of irritation the yield reduced as well. Girona and Marshall [8] and [11] in their research on almond tree with a view of the drought stress on active chlorophyll growth period, fruit development and postharvest, affect the product seriously and concluded that the almond tree is susceptible to drought stress. If the results of 4 years Norts (2008) on almonds showed that regulated deficit irrigation have not an impact on the final product and almond trees resistant to drought introduced.

Effect of salinity stress on total fruit yield

Statistical analysis results show that the salinity has no significant effect on the pomegranate yield (Figure 3).

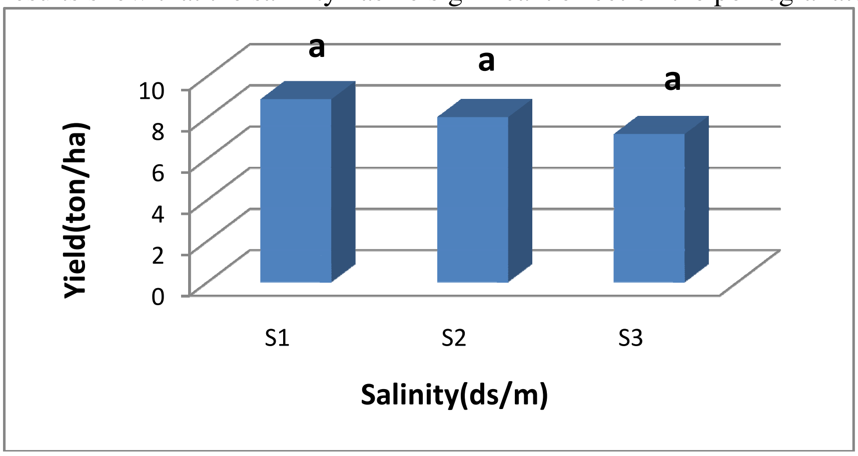

Figure 3. The total yield in the different treatments of salinity

Bhantana and Lazarovitch [6] the effect of irritation salinity on amount evapotranspiration, plant coefficient and development of pomegranate cuttings and on this basis, the increase in salinity reduces the amount evapotranspiration; pomegranate was introduced as plants sensitive to salinity.
Perhaps this statement is true for cutting but it is not possible to measure the yield of the product cannot be generalized to mature trees. In the fruit trees the main parameters of amount of yield and the results indicated that salinity has no impact on yield.

Effect of different treatments on water use efficiency

Although salinity irritation has no significant impact on yield, but we are observe decreasing amount yield against increase in salinity. Thus, water use efficiency is also impressive. Average amount water used in all salinity treatments to 2700 cubic meters as a result of water use efficiency was calculated for different salinities. The average value yield each Irrigation treatments to deficit irrigation treatments at different salinities on the amount of water given to each treatment were divided. The results of these calculations are summarized in Table 3.
It is noted that the increased salinity of water lead to reduce in use efficiency. This result was expected because of other researchers have also shown that salt lead to reduction in water use efficiency. So can point out the research on tomatoes [12], and the corn [13]. Irrigation at low (10% deficit irrigation) had no effect on water use efficiency as compared to the control treatment but severe deficit irrigation reduces water use efficiency was compared to the control. Although expected deficit irrigation increase water use efficiency but this result was observed only in the treatment of 10% deficit irrigation and in the other control observe reduction in water use efficiency in larger quantities of deficit irrigation.
The reduction in water use efficiency applying deficit irrigation the absence of losses in irrigation treatments and sensitivity yield the pomegranate caused by deficit irrigation. One reason for the increase in water use efficiency in deficit irrigation was increase in irrigation efficiency in deficit irrigation. In this research was to determine the exact amount of water required for the control and irrigation method used the tree is not any excess water, thus reducing amount water evaporation and plant transpiration is reduced so due to the sensitive nature of yield pomegranate in water, deficit irrigation had a positive impact on yield of water use.

Conclusion

In this study the effects of water and its efficiency was evaluated on pomegranate quality. Key factors include five different irrigation amount and three levels of irrigation water salinity. At the end of the second year total yield and efficiency of pomegranate juice consumption was measured. The results showed that the crop yield and water use efficiency significantly affected by salinity and drought stresses were applied in combination. The study of separate effects of stress showed that deficit - irrigation causes a significant decrease in crop yield compared to full irrigation if the salinity stress had no significant effect on crop yield. In general it can be said that the pomegranate tree is susceptible to dehydration and resistant to salt stress. Water use efficiency is also impressive. It is noted that the increased salinity of water lead to reduce in use efficiency. Although salinity irritation has no significant impact on yield, but we are observe decreasing amount yield against increase in salinity.

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