EFFECT OF CONTINUOUS DEFICIT IRRIGATION ON YIELD AND QUALITY OF KORONAIKI OLIVE (OLEA EUROPAEA L.) CULTIVAR

EFFET D'IRRIGATION DEFICITAIRE CONTINUE SUR LE RENDEMENT ET LA QUALITE DE LA VARIETE D'OLIVE KORONAIKI (OLEA EUROPAEA L.)

Jaefar Nikbakht[1], Mehdi Taheri[2] and Mohsen Sakkaki[3]

ABSTRACT

This study was carried out to evaluate the effect of four levels of irrigation (i.e., 100%, 75%, 50% and 25 % of tree water requirement) on some quantity and quality parameters of olive (Olea Europaea L. cv. Koronaiki). Drip irrigation system with loop layout was used to irrigate. Results indicated that water stress decreased initial and final fruit set significantly, but effects of water stress regimes in final fruit set was not significant. The fruit oil content and water use efficiency were increased under the irrigation level of 75%. Irrigation level of 75% reduced water use by 29 %.

Key words: *Regulated deficit irrigation, Drip irrigation, Olive, Oil percent.*

RESUME

Cette étude a été effectuée pour évaluer l'effet de quatre niveaux d'irrigation (demande en eau d'arbre de 100%, 75%, 50% et 25%) sur certains paramètres de quantité et de qualité d'olive (Olea Europaea L. cv. Koronaiki). Le système d'irrigation goutte à goutte avec la disposition de boucle a été utilisé à cette fin.

Les résultats ont indiqué que le stress hydrique a réduit significativement le fruit initial et final, mais les effets de régimes de stress hydrique sur le fruit final n'étaient pas tellement significatifs. Le contenu d'huile de fruit et l'efficience d'utilisation de l'eau ont augmenté dans le niveau d'irrigation de 75%. Le niveau d'irrigation de 75% a réduit l'utilisation d'eau de 29%.

1 Assistance Professor, Department of Water Engineering, Zanjan University, Iran; E-mail: Jaefarnikbakht@yahoo.com.
2 Assistance Professor, Zanjan Research Center of Agriculture and Natural Resources, Iran; E-mail: Tahritekab@yahoo.com.
3 M.Sc. Student of Irrigation and Drainage, Zanjan University, Iran, E-Mail: mohsen_sakaki@yahoo.com.

Mots clés : *Irrigation déficitaire réglée, irrigation goutte à goutte, Olive, pour cent d'huile.*

1. INTRODUCTION

In arid and semi-arid regions such as Iran, water is one of the most important resources what limits agricultural production. Proper management of irrigation water in these regions increases water use efficiency and decreases water consumption. Deficit irrigation is one of the best strategies in water scarcity conditions or when the price of water is high. By deficit irrigation, the crop yield per area unit decreases but more area can be irrigated. In this case, water use efficiency increases (Tvakkoly, 2000). Tognetti et al., (2006) studied effect of deficit irrigation on olive trees (Olea europaea L.) of cvs. Frantoio and Leccino at the experimental farm of CNR-ISAFOM (south of Italy) in 2003 and 2004 with four irrigation level (0, 33, 66 and 100% of evapotranspiration). The regulated deficit irrigation decreased canopy volume and trunk diameter. This could reduce pruning costs. Fruit production and water consumption increased from 0% to 66% treatments but from 66% to 100%, the trend was decreasing. So, 0, 33 and 66% had the most water use efficiency of fruit product. Lniesta et al., (2009) conducted experiments between 2004 and 2006 in an experimental olive (O. europaea L. cv. 'Arbequina') orchard located at the CIFA Experimental Station, Córdoba, Spain. Oil extracted from olives under deficit irrigation treatments was more than that from the complete irrigation treatments. Therefore water use efficiency of oil product of deficit irrigation treatments was more than complete irrigation treatments. Grattan et al., (2006) carried out the 2-year experiment (2002-2003) in California's Sacramento Valley with 30 month-old olive trees that were drip irrigated. The irrigation treatments were 15, 25, 40, 57, 71, 89, and 107% ETc. The number of fruits per branch, the number of fruit per inflorescence, fruit density (number of fruit per cm branch) and resulting fruit set all increased with an increase in applied water up to 71–89% ETc. As irrigation increased to 107%, all these parameters decreased. Fruit yields and individual fruit size increased with increasing of irrigation water level from 15 – 107% ETc. Oil content increased with an increase in applied water from 15-71% ETc but it decreased from level of 89% to 107% ETc.

As Agricultural-Jahad Ministry has decided on increasing the area of olive orchard in Iran and also selected the Tarom region (Zanjan) as olive producing center, the area of olive orchard in this region is increasing. In view of the limited water resources in this region, the present research was carried out to investigate the effect of deficit irrigation on olive tree.

2. MATERIALS AND METHODS

This research was carried out in 1388[4] (from April to November) in The Olive Research Station located at Gilvan in Tarom region (Zanjan Province of Iran). Table 1 shows the Climatic conditions of region. The research was done on young (3 years old) olive trees (Koroneiki cv.) based on randomized complete blocks with four irrigation treatments and four replications. The irrigation treatments included 100% (control treatment), 75%, 50% and 25% of olive water requirement (OWR).

4 Add 621 to get the corresponding English year.

Table 1. Climate conditions of Gilavn region

Average altitude	350 m
Climate type	Subtropical
Annual mean of rainfall	200 mm
Annual mean of air temperature	17.5 °C
Annual mean of Relative Humidity	68%
Annual mean of Sunshine	2780 h

Deficit irrigation was continuously applied from the beginning to the end of irrigation season. The distance between trees and rows were 7.5m. Drip irrigation system with loop layout was used to irrigate the trees. Four in-line long path emitters with 4 LPH discharge were installed in every loop. By Gilvan synoptic station data (mean daily data) and FAO-Penman-Montieth equation (FAO-56) and equation 1, OWR amounts were calculated.

$$ETc\ (OWR) = ET0*Kc \quad \ldots (1)$$

Where, ETc (OWR): Crop evapotranspiration (olive water requirement), ET0: FAO Reference evapotranspiration (FAO-56) and Kc: Crop coefficient (FAO-56; Allen et al., 1998). To calculate irrigation depth correctly, canopy diameter and water EC were measured every week (Keller and Bliesner, 1990). To evaluate of continuous deficit irrigation on olive trees, following parameters were measured:

Percentage of complete flower formation,

Percentage of first fruit formation,

Percentage of secondary fruit formation:

In spring, 5 Inflorescences of 4 branches on 4 sides of trees (all irrigation levels) were selected and marked. The numbers of initial flowers in selected inflorescences were counted. Number of complete flowers, number of first fruit, number of secondary fruit produced on selected 5 Inflorescences were counted. By dividing the number of complete flowers to the number of initial flowers, percentage of complete flower formation, by dividing the number of first fruit to the number of initial flowers, percentage of first fruit formation and by dividing the number of secondary fruit to the number of initial flowers, percentage of secondary fruit formation every treatment were achieved.

Percentage of olive oil

20 numbers of fruit was obtained from 4 sides of trees randomly. After separating the pulp of the fruit, pulp was dried for 48 hours in the oven at 80 °C. By Soxhlet apparatus, oil content was extracted from 2 grams of dry mass. By dividing the extracted oil to fruit weight, olive oil percent for each treatment was calculated.

Water use efficiency

By dividing the weight of fruits (kg) to water used (m3) in irrigation of trees, water use efficiency was calculated.

3. RESULTS AND DISCUSSION

Table 2 shows variance analysis of evaluated parameters. According to Table 2, the effect of deficit irrigation on evaluated parameters was significant. Figure 1 shows the effect of different irrigation level on percentage of complete flower formation. According to Figure 1, there is no significant difference between T1, T2 and T3, but T4 has significant difference with the rest treatments. Treatment of 75% of OWR had the most complete flower. Deficit irrigation reduces soil available water for crop using, so matrix potential in soil increases. Occurrence of this case during formation of complete flower has caused severe effects on growth of inflorescence and flowers.

According to figure 2, there is significant difference between control treatment (T1) and treatments under deficit irrigation in regard to first fruit formation. As results show, applying water stress to olive trees is caused 31% decreasing at first fruit formation. As Figure 3 shows, regarding percentage of secondary fruit formation, there is significant difference between complete irrigation treatment (T1) and treatments under deficit irrigation. Considering the Figure 3, unlike the first fruit formation that deficit irrigation intensity had no significant effect on it, but it caused significant effect on the secondary fruit formation therefore it caused significant effect on fruit loss. Occurrence of this condition in this stage of growth is because of intense competition between fruits to obtain water and minerals.

Table 2. ANOVA for parameters of olive trees (Koroneiki cv.) under different irrigation level

Variation source	Degrees of freedom	Mean Square				
		% complete flower formation	% first fruit formation	% secondary fruit formation	% olive oil	WUE (kg/m^3)
Block	3	16.432	1.905	1.693	11.184	0.349
Deficit irrigation Treatment	3	470.255**	14.900**	19.146**	24.180**	49.327**
Test error	9	19.672	2.144	2.561	2.103	0.383
CV (%)	---	7.68	17.56	19.56	5.69	10.41

**: P<0.01

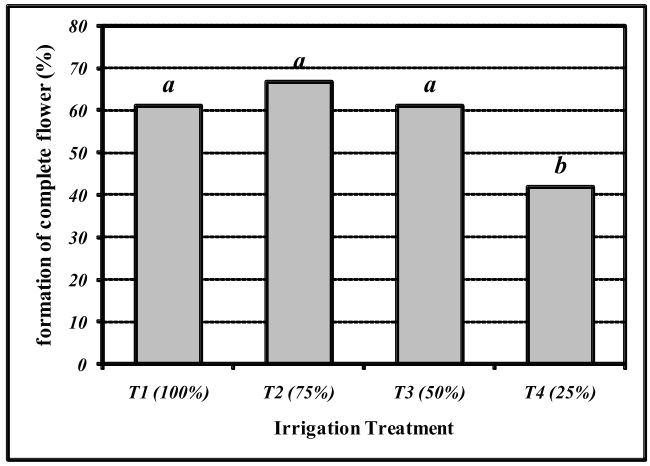

Fig. 1. The effect of different irrigation level on percentage of complete flower formation

According to Figures 1, 2 and 3, in the early stages of growth, applying deficit irrigation and water stress, causes low effect on trees and only trees under the highest level of water stress (T4) were affected significantly. But if in the next stage of growth, water stress is continued, it will affect the rest of treatments under water stress (T2 and T3). Olive tree can resist drought condition like other drought-resistant trees. In this case, water stored in the tree is used up for survival. This causes low first fruit forms from complete flower and low secondary fruit from first fruit. Therefore, olive productions of trees are decreased as shown as in the Figures 1, 2 and 3.

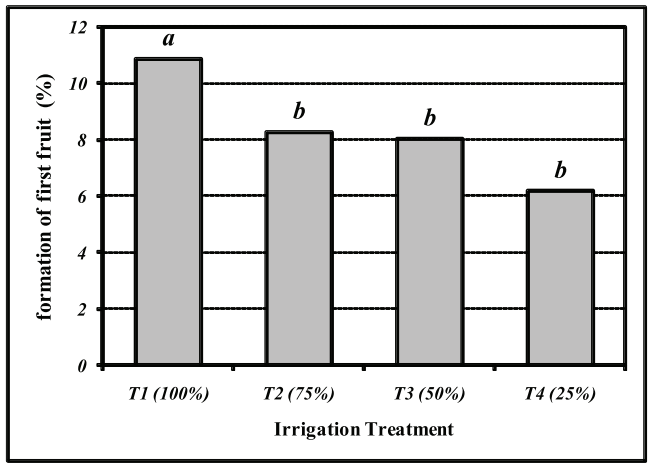

Fig. 2. The effect of different irrigation level on percentage of first fruit formation

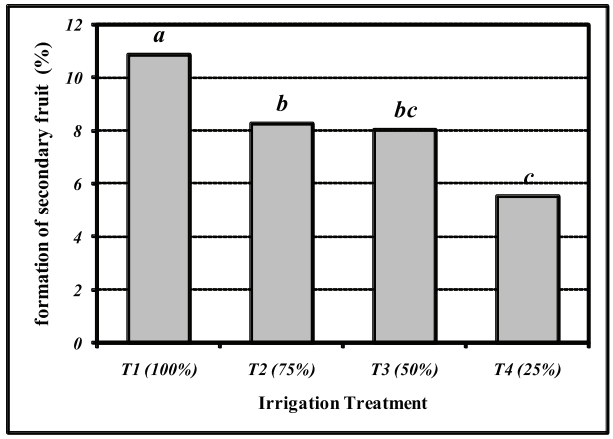

Fig. 3. The effect of different irrigation level on percentage of secondary fruit formation

Figure 4 shows the effect of different irrigation level on percentage of olive oil. According to Figure 4, the highest and least oil percent was obtained from treatments of 75% and 25% of OWR (respectively). From Figure 5, it is seen that despite the total water requirement of trees of T1 (100% OWR) were supplied but extracted olive oil percent was less than treatments of T3 (50% OWR). Therefore, it is concluded, in Koronaiki cultivar increasing water content in fruit decreases extractible oil.

To assess the economically effective degree of deficit irrigation, water use efficiency (WUE) index is calculated. Figure 5 shows the effect of different irrigation level on WUE. As shown in Figure 5, the highest WUE was obtained for T1. The difference between fruit production of T1 (control treatment) and T4 (25% OWR) was not significant. Therefore, because of applying the least amount of water to irrigate of T4 trees, WUE of T4 was obtained the highest. Considering Figure 5, WUE of T1 and T2 (100% and 75% OWR, respectively) are at par (level C). Therefore, applying of 100% OWR to irrigate olive of Koronaiki cultivar is not necessary (regarding WUE index) and by applying 25% deficit irrigation (75% OWR), the same results of 100% OWR are achieved.

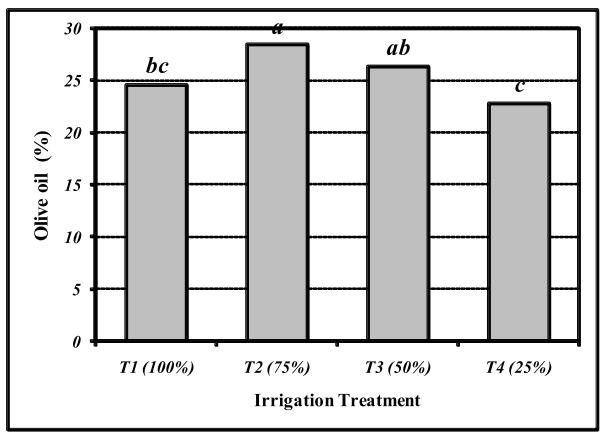

Fig. 4. The effect of different irrigation level on percentage of olive oil

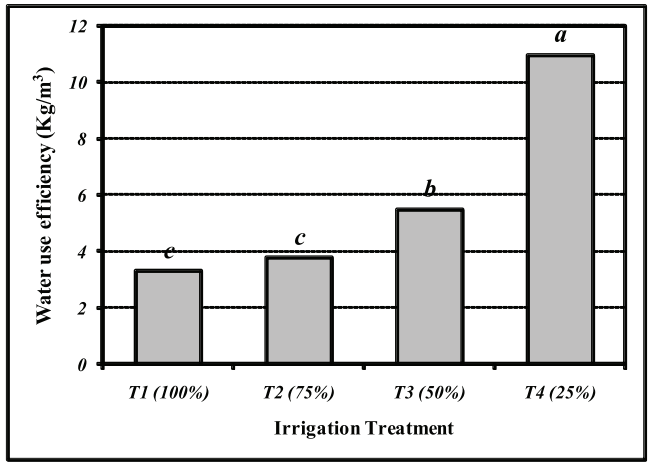

Fig. 5. The effect of different irrigation level on water use efficiency

4. CONCLUSIONS

Based on the results of this research, it is suggested to apply 75% OWR to irrigate oil olive of Koroon the Koronaiki cultivar in this region (Gilvan-Zanjan). In this case, besides saving water consumption, the area of olive gardens can be increased.

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