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Influence of irrigation on a traditional rainfed olive orchard (cv Cornicabra)

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SUMMARY – Irrigation is a way of increasing yield and shoot growth in olive trees. In this work, the influence of irrigation on a traditional rainfed olive orchard (cv Cornicabra) has been studied using olive trees fifty years old, planted at a distance of 12 x 12 m in Almodóvar del Campo (Ciudad Real, Spain). Shoot growth, crown volume, yield, size and humidity of fruit and flesh/pit ratio were measured. Irrigated trees showed an increase in yield and shoot growth only during the last year of the experiment (2002).

Key words: Shoot growth, crown volume, yield, fruit size, humidity fruit, flesh/pit ratio.

***RÉSUMÉ –** "Influence de l'irrigation sur une oliveraie traditionnelle non irriguée (cv Cornicabra)". L'irrigation est un des facteurs principaux qui affecte la production et la croissance des oliviers. Dans cette expérience, la réponse à l'irrigation d'une oliveraie adulte qui avait toujours été menée en sec a été évaluée, pour laquelle des oliviers du cv Cornicabra de plus de 50 ans ont été employés dans un cadre de 12 x 12 m dans la localité de Almodóvar del Campo (Ciudad Real, Espagne). Les paramètres suivants ont été mesurés : la croissance des pousses, volume du houppier, production, taille et humidité de l'olive et la relation pulpe/noyau. Lors de la première année il n'y avait aucune différence significative entre irrigation et non irrigation tandis que pendant la deuxième année la production des arbres irrigués était le double et une croissance végétative plus grande a eu lieu.*

***Mots-clés :** Croissance des pousses, volume du houppier, production, taille de l'olive, humidité de l'olive, relation pulpe/noyau.*

Introduction

There are 800 million olive trees in the world, covering a surface of approximately 9 million hectares. Ninety-five percent of the olive production is found in the Mediterranean basin, where Spain is the first producer. Castilla-La Mancha is the second largest producer of olive oil in Spain, surpassed only by Andalusia. The surface of olive orchards in Castilla-La Mancha covers 341,457 hectares, 15,220 of which are irrigated.

The irrigation applied to the olive tree is aimed at returning the water lost by both evaporation and transpiration to the soil. Therefore, the water consumption on the part of the olive orchard or evapotranspiration (ETc) can be considered to be the result of these two phenomena (evaporation and transpiration). For the calculation of ETc the equation proposed by FAO (Doorenbos and Pruitt, 1977) is normally used, corrected by a factor (Kr), whose value depends on the percentage of coverage (Barranco *et al.*, 1998). The response of the olive tree to irrigation can result in an increase in the production of olives between 50 and 60% when it shifts from dry conditions to irrigation (Michelakis *et al.*, 1994; Pastor *et al.*, 1999). Water stress first affects the vegetative growth (Hsiao, 1973). Its influence on this aspect can result in a smaller trunk diameter (Michelakis *et al.*, 1994), lower growth of shoot length (Proietti and Antognozzi, 1996; Girona *et al.*, 2000) and of its diameter (Girona *et al.*, 2000), which causes a lower crown development (Michelakis *et al.*, 1994; Girona *et al.*, 2000). When the water stress is very acute, when dryness occurs during certain moments of high climatic demand, it can even halt growth (Proietti and Antognozzi, 1996). If the olive is grown for oil production, a certain degree of water stress during the period between the pit hardening stage and the end of September does not affect production (Girona, 2001), nevertheless, if the olive is to be used for pickling, a loss in yield quality occurs due to lower fruit size as a consequence of the water stress (Proietti and Antognozzi, 1996; Pastor *et al.*, 1999).

The aim of this trial was to determine the influence of irrigation on the growth and the yield of olive trees.

Materials and methods

The experiment was carried out on olive trees (cv Cornicabra) fifty years old planted at a distance of 12 x 12 m in Almodovar del Campo (Ciudad Real, Spain).

The orchard was divided into twelve plots of 4 x 3 trees, half of which commenced irrigation in 2001, in a randomized complete-block design with four replications. Both central olive trees of every plot were used for the measurements.

The crop evapotranspiration (ETc) was calculated with the FAO equation (Doorenbos and Pruitt, 1977) and the ETo was obtained from the Penman-FAO equation using data from the automated weather station, located in the orchard itself. The water irrigation amount was 160 and 146 mm in 2001 and 2002. Irrigation was applied from April to September, by means of 8 droppers of 4 l/h per olive tree. The rainfall was 469 and 417 mm respectively, in 2001 and 2002.

In February 2002 eight knots were tied in all orientations on one of the two control olive trees of each plot, in order to indicate the position from which the growth in length and the number of knots of the shoot were measured. The average distance between two knots was obtained by dividing the length by the number of knots. In September, 200 leaves grown during the previous spring and another 200 grown at the end of the summer were picked. A calibre was used to measure the length and width of each leaf. The surface of the leaves was calculated with a leaf area meter ∆-T Devices LTD, Burwell, Cambridge, England. The production of every olive tree was weighed, and a sample of 100 olives was picked from each plot and the fruit fresh weight and its size (length and width) were measured. To determine the fruit dry weight, the samples were dried at 80 ºC until constant weight. The number of fruits per olive tree was estimated from the weight of the yield divided by the average weight of the olives. The SPSS 9.0 program was used for the statistical analysis.

Results and discussion

Until June 2002, the increase in the shoot length was 85 mm in the irrigated olive trees and 60 mm in those in dryland conditions. In December, these values were 102 mm and 67 mm respectively, with significant differences between treatments from the first period to the second (Fig. 1). These results are in agreement with those of Henar (2002) who, in irrigated cv. Morisca, obtained a longitudinal shoot growth of 9 cm/year in olive trees without production, and of 5 cm/year in olive trees with production. On the other hand, Girona *et al*. (2000) had longitudinal shoot growths between 15 and 25 cm/year in irrigated cv. Arbequina; the difference with the results exposed here could be due to the vigour differences between varieties (Del Río y Caballero, 1994). The evolution of growth matches the findings of Michelakis *et al*. (1994) and Henar (2002), who observed two periods of growth; one more intense up to June and the other less active in autumn.

The distance between two knots showed significant differences from February, which indicated that these differences were produced in the first year of the study. In the irrigated olive trees, the distance between two knots was always larger with values of 6.5, 10.7 and 11 mm, whereas in dry conditions the values were 5.9, 9.3 and 9.5, respectively (Fig. 2).

The length, width and area of the leaves had statistical differences between the two treatments, both in the leaves grown in spring and those grown in summer. The leaves of the watered olive trees grown in spring had an average length of 68.04 mm, whereas in dry conditions the length was 61.76 mm. The leaves grown in summer were shorter than those grown in spring, the irrigated leaves measuring 62.3 mm and the dry condition leaves measuring 59.3 mm (Fig. 3). In the watered treatment, the average width of leaves grown in spring was 11.57 mm, whereas in the dryness treatment the average was 10.93 mm. In summer the values were 9.41 mm and 8.85 mm, respectively (Fig. 4). These results are concordant with Hsiao (1973) who affirms that growth is the first parameter affected by water stress.

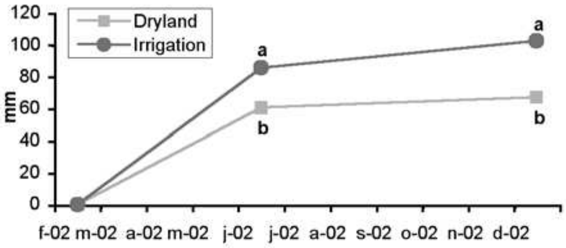

Fig. 1. Length growth of the shoot. Different letters indicate significant differences at p ≤ 0.05.

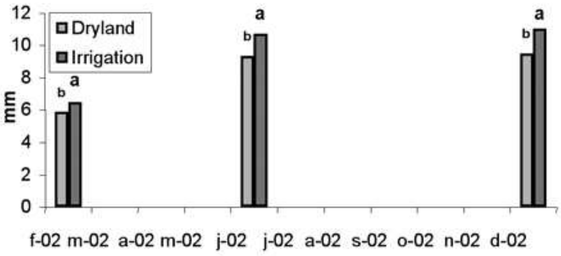

Fig. 2. Average distance between two knots. Different letters indicate significant differences at p ≤ 0.05.

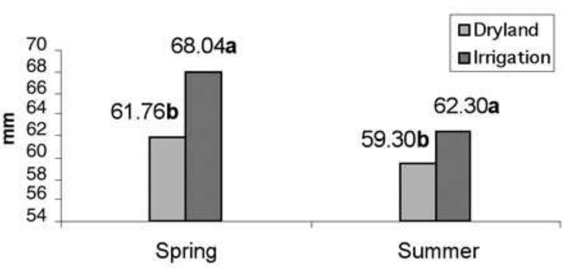

Fig. 3. Length of the leaves grown during previous spring and at the end of the summer. Different letters indicate significant differences at p ≤ 0.05.

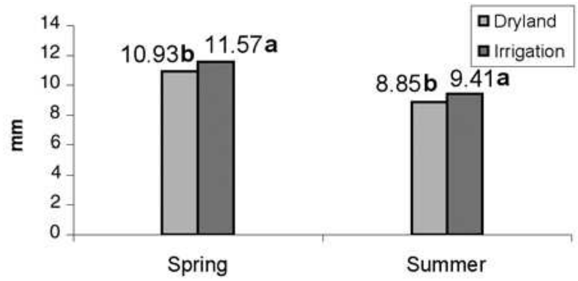

Fig. 4. Width of the leaves grown during previous spring and at the end of the summer. Different letters indicate significant differences at p ≤ 0.05.

The leaves grown in the watered treatment had approximately 15% more surface area than those grown under dry conditions, the summer leaves being smaller than the spring leaves in both cases (Fig. 5). There was no relation between the length and the width of the leaves in any of the studied situations. There was a relation between surface and length with a Pearson's coefficient of 0.706, and between width and surface with a Pearson's coefficient of 0.751. The best observed relation was between area and product length by width with a Pearson's coefficient of 0.956 (Fig. 6).

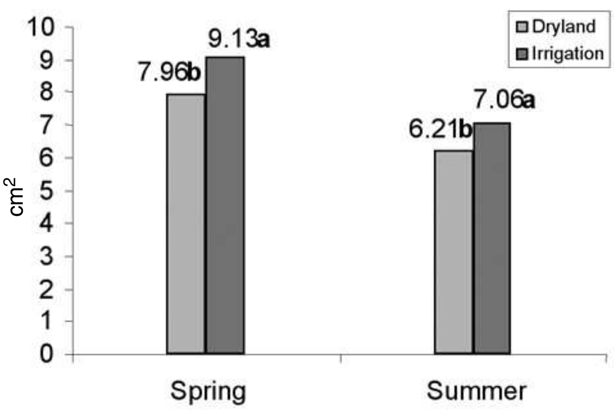

Fig. 5. Surface of the leaves grown during previous spring and at the end of the summer. Different letters indicate significant differences at p ≤ 0.05.

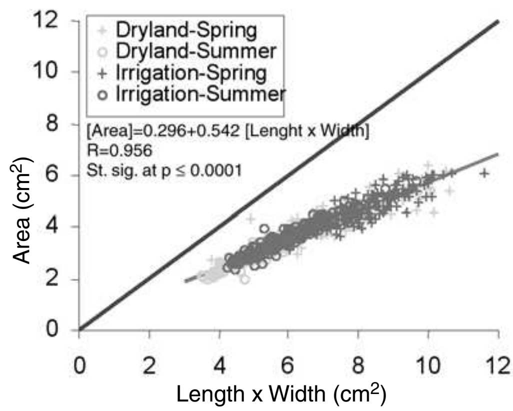

Fig. 6. Area versus length width product.

In February 2002, crown volume had no significant differences between treatments. On the contrary, the values obtained in June in irrigation (5263 m^3/ha) and in dryness (4034 m^3/ha) were statistically different. In December the significance of the differences was supported between the watered and dryness treatments, with 5989 m^3/ha and 4494 m^3/ha, respectively (Fig. 7). These results are in accordance with Pastor *et al*. (1999), who did not obtain a significant response of crown volume until the second year of irrigation application.

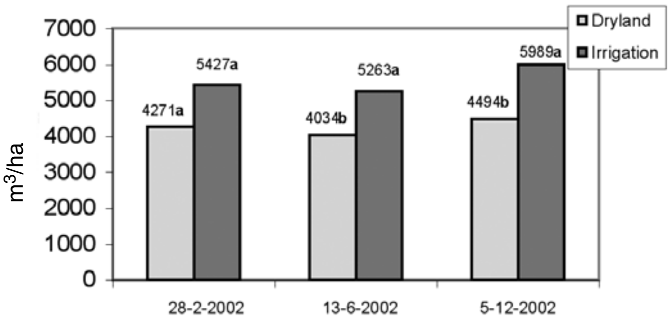

Fig. 7. Crown volume (m^3/ha) in February, June and December. Different letters indicate significant differences at $p \leq 0.05$.

In the years 2000 and 2001 significant differences in yield were not obtained, with 42 kg/tree in the watered treatment and 51 kg/tree in the dryness treatment (Table 1). Nevertheless, in 2002 the value obtained with irrigation (54 kg olive/tree) was significantly higher than in dryness (27 kg olive/tree), as is observed in the number of fruits per olive tree. There were no significant differences in ripeness index, fruit weight or flesh/pit ratio. Pastor *et al*. (1999) observed yield differences between dryness and irrigation since the first year of irrigation, possibly because it was a very dry year (70% of the average rainfall). On the contrary, Girona *et al*. (2000) did not obtain yield differences until the second year of irrigation. Pastor *et al*. (1999) found statistical differences in fruit size and fruit number taking six years of results into consideration. On the contrary, Michelakis *et al*. (1994) did not obtain differences in fruit size and Girona *et al*. (2000) observed statistical differences in fruit size between irrigation treatments since the third year of irrigation.

Table 1. Ripeness index, yield (kg/tree), fruit size (g), humidity fruit, no. (olives/tree) and flesh/pit ratio in dryness and watered treatments during 2001 and 2002

	Ripeness index		Yield (kg/tree)		Fruit size (g)		Humidity fruit (%)		Fruits per tree		Flesh/pit ratio	
	Dryness	Irrig.	Dryness	Irrig.	Dryness	Irrig.	Dryness	Irrig.	Dryness	Irrig.	Dryness	Irrig.
2000	–	–	34.50a	48.83a	–	–	–	–	–	–	–	–
2001	3.4a	3.2a	47.06a	55.11a	2.75a	2.77a	44.57a	45.64a	17113a	19895a	3.7a	3.5a
2002	4.6a	4.3a	26.59b	54.02a	2.65a	2.80a	43.9a	45.64a	10034b	19293a	2.0a	2.1a
Average	4.0	3.8	36.05	52.65	2.70	2.79	44.23	45.64	13573	19594	2.9	2.8

[a, b]Values followed by different letter differ at $p < 0.05$.

Conclusions

The application of irrigation to an adult olive orchard does not have an immediate effect. The response takes at least one year, then irrigation increases vegetative growth and olive orchard yield.

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