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Alternate Irrigation of Avocados: Effects on Growth, Cropping, and Control of *Rosellinia Necatrix*

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Rosellinia necatrix (R.n.) is the most important soil fungus attacking avocados in southern mainland Spain. Selection of tolerant rootstocks is still at the research level.

Avocados are very sensitive to dry soil conditions, especially under high evaporative demand (Cantuarias *et al*., 1998). In summer it is generally recommended to keep soil matric potentials above -30 kPa. As a result, anaerobic conditions are frequently induced under both micro sprinkler and drip irrigation because soil matric potential is highly variable due to soil heterogeneity, variability between emitters' flow, and non uniform application rates over the soil surface. Alternate irrigation has markedly reduced the incidence of *Phytophthora sp.* in citrus in pot and field experiments (Lutz *et al*., 1988). In order to study its effect on adult, field grown avocado trees, two experiments were established.

Experiment A. Started in 2000 to study the effect of alternate irrigation on growth and cropping in an orchard with a low incidence *of R.n.*

Experiment B. Started in 1999 to study the effect of soil amendments on trees heavily affected by *R.n.* All trees were alternately irrigated.

Experiment A

The experiment followed a previous cultivar/rootstock experiment (Hermoso et al., 2003). Hass and Fuerte, on Topa-Topa and Lula rootstocks, were planted in 1981 and studied until 2000. The design was on randomized blocks with 5 tree plots and 4 replicates of each cultivar/rootstock combination. Each cultivar/rootstock combination had 20 trees. The soil was derived from shale, well drained, near neutral, with less than 1% Ca and Mg carbonates. From 1995, irrigation water electrical conductivity was low (near .6 $ds.m^{-1}$). From 2000 the 5 tree plots were split in groups of 2 and 3 trees. One of them was kept with fixed irrigation and the other was changed to alternate irrigation. Each tree, planted at 8 x 8 meters (m), had one micro sprinkler on either side at 1.5 m from the trunk, with a wet diameter of 4 m. The alternate irrigation trees had the two micro sprinklers on different PE tubes so that irrigation could be easily switched with valves set at the heads of the rows. The sprinkler flows were 25 and 50 $l/hour^{-1}$ at 1 MPa (1 bar) pressure in fixed and alternate irrigation. The water distribution of both sprinklers is shown in Figure 1. Soil matric potential (Ψm) was recorded in 4 tensiometers per sprinkler at 50 65 cm distance and 25 and 50 cm depth. Four sprinklers were controlled in each treatment. In summers or dry winters alternate irrigation sides were interchanged about 20-30 days after the non irrigated areas reached mean Ψm of -75 kPa (Figure 2a, b, c). Mean soil water content was then 6% 7% most of it unavailable for plant growth. In winters with intermittent rain the system was interchanged every two and a half months (Figure 2 d). When irrigation was first applied to a dry area an extra 8-hour irrigation was given on top of the regular (5 to 8 h) irrigation in order to wet the top 25-30 cm.

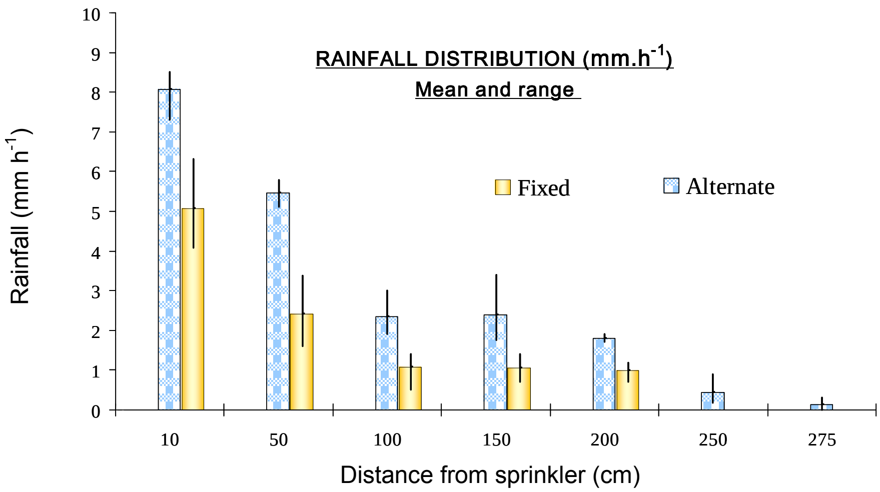

Figure 1. Rainfall distribution with fixed and alternate irrigation.

Rooting density

Rooting density was studied at 0-10 and 10-20 cm depth on 25 x 25 cm monoliths. They were excavated at 0, 50,100,150 and 200 cm from the sprinkler with fixed irrigation and at 0, 50,100,150,200,250 and 275 cm from the alternate irrigation plots. After washing over a sieve, root length was estimated by a modified Newman method (Newman 1966, Farré 1979). Rooting density was considerably smaller under alternate irrigation for total and thick (over 2 mm diameter) roots (Figure 3).

Fruit ripening

Mesocarp percentage dry weight was studied in January 2004, for Fuerte and in February 2004, for Hass. Alternate irrigation had consistently higher values, with a mean difference of 1.8%, equivalent to about 3 weeks earlier ripening.

Fruit rots

Fruit rots after harvests were evaluated in the same lots of fruits. There were no significant differences between fixed and alternate irrigation. The percentage of totally clean fruits was significantly higher on Topa-Topa (24%) than on Lula (10.4%) rootstock.

Due to the considerable variation between years for both dry weight and fruit rots, they will have to be studied further to confirm their relationship with the irrigation system.

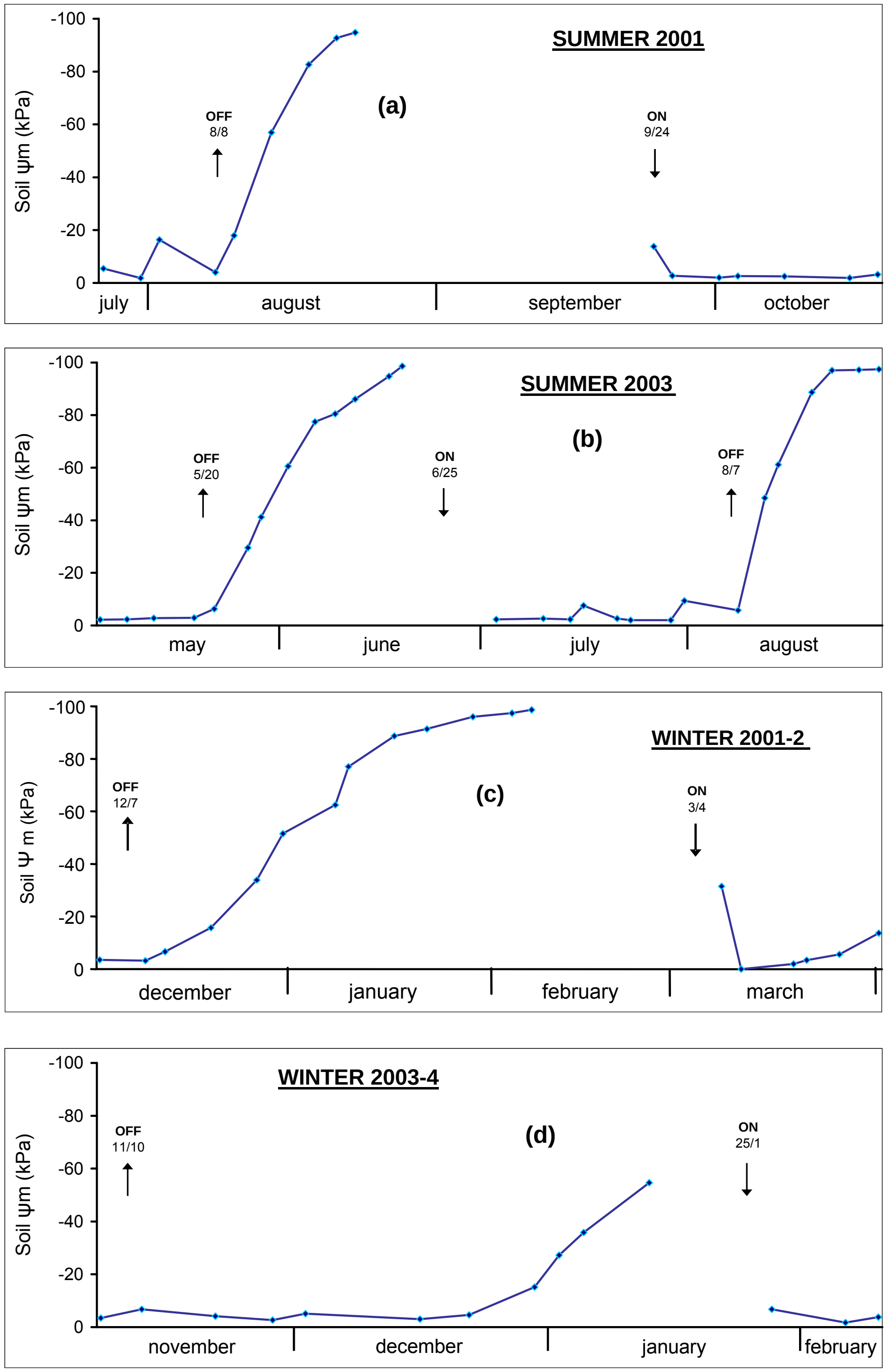

Figure 2. Soil matric potential with alternate irrigation. (a) Summer 2001. (b) Summer 2003. (c) Winter 2001-2. (d) Winter 2003-4.

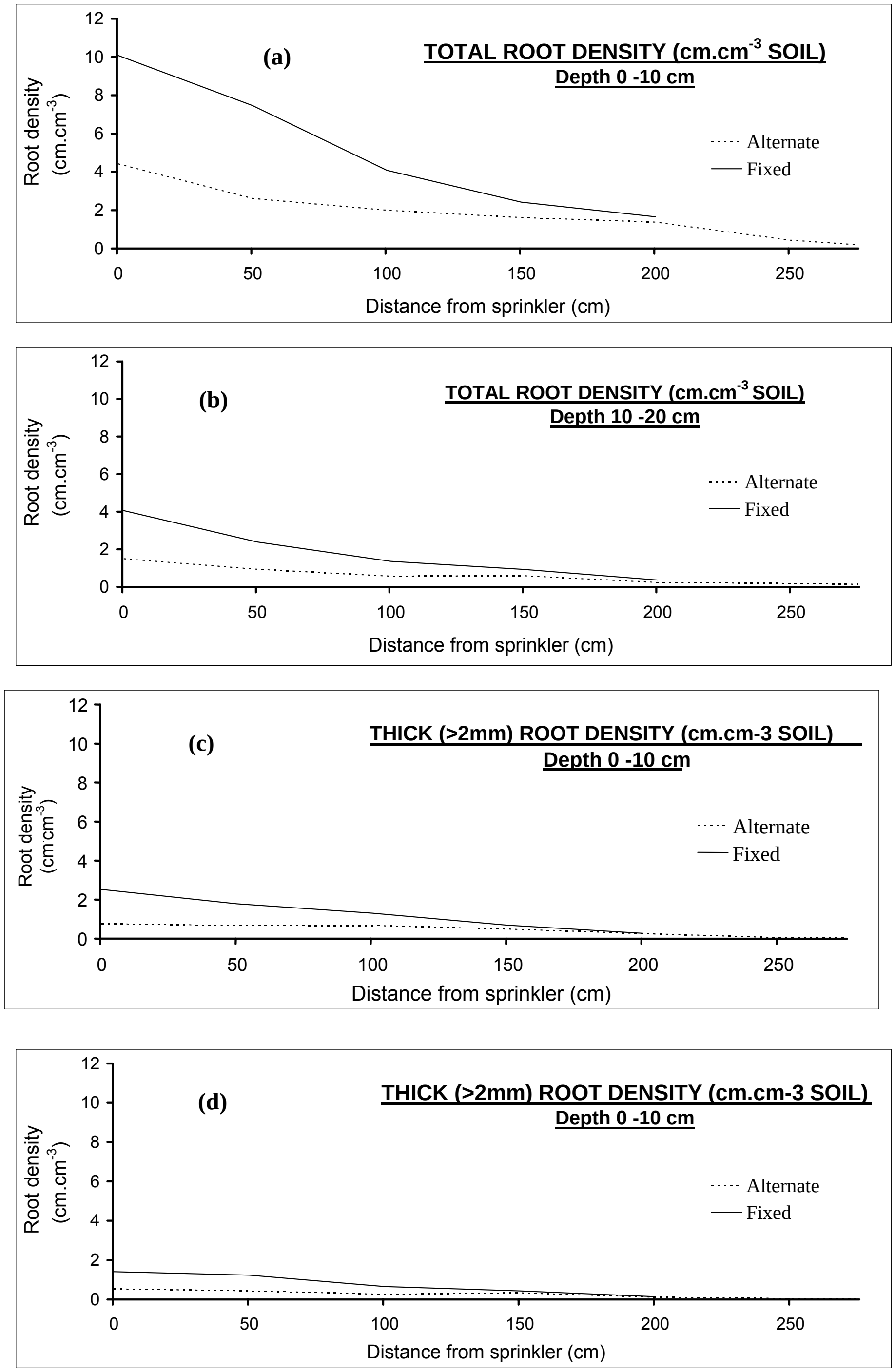

Figure 3. Root density with fixed and alternate irrigation.

Leaf nutrient contents

Twenty months after the start of the experiment alternate irrigation significantly reduced mean leaf N from 1.99% to 1.71% and Mg from 1.15% to .79%. Alternate irrigation significantly increased Ca levels from 1.85% to 2.11% and B levels from 36 to 46 ppm. No differences were recorded in the third and fourth experimental years. P, K, Cu, Zn and Mn were not affected by the irrigation treatments.

Table 1. Growth and Cropping

			Crops 2001-2002		Crops 2003-2004	
Irrigation type			Alternate	Fixed	Alternate	Fixed
Number of fruits	Fruits. $Tree^{-1}$. $Year^{-1}$	Fuerte	299	307	157	159
		Hass	434	479	277	218
Mean fruit weight	$g.fruit^{-1}$	Fuerte	258	262	254	255
		Hass	209	208	175	187
Potential yield*	$k.tree^{-1}$. $Year^{-1}$	Fuerte	76.1	76.9	36.7	40.1
		Hass	89.3	97.9	45.1	41.5
Tree efficiency**	$g.cm^{-2}$. $year^{-1}$	Fuerte	104.1	103.9	45.8	52.0
		Hass	133.8	148.6	58.6	58.5
Trunk area growth	% In two years	Fuerte	10.7	10.4	10.3	8.5
		Hass	10.4	11.5	9.5	9.0

* Including fallen fruits near picking time
** Grams of fruit per unit trunk cross sectional area 25 cm above ground

Growth and cropping

Growth and cropping parameters are summarized in Table 1. They have been grouped in 2-year periods to eliminate alternate cropping. None of the differences between irrigation types were statistically significant at the 95% level. Results were similar when data were analyzed by covariance in relation with the 4-year period 1995-98, when all trees were on fixed irrigation. Nevertheless a general trend can be seen. In the first two years after the start of the experiment most parameters were slightly higher on fixed irrigation, but they were equal in the last two years. Similar results were reported by Hermoso et al. (2003) when changing from drip to micro sprinkler irrigation. A new root system had to be developed when changing the irrigation system. When changing from fixed to alternate irrigation, rooting density decreased in the top 20 cm soil layer. A similar situation was reported by Lutz et al. (1988) with alternate irrigation of citrus with a parallel increase in the deep soil layers. In this experiment deep root density (20 50 cm depth) was not studied but it can be assumed that it also increased considerably given the good tree performance in the 3rd and 4th year.

Experiment B

The Hass trees on Topa-Topa and other Mexican seedling rootstocks were 23 to 26 years old at the start of the experiment. The soil was similar to experiment A. Trees heavily affected with *R.n.* were selected and distributed in 9 blocks according to the level of affection. In the more affected blocks practically the whole superficial root system was dead. In the less affected, over 50 per cent were dead. Previous to the start of the experiment the main scaffold branches were heavily pruned to decrease the top/root ratio and whitewashed. The following amendments were applied to the soil surface in 1999, at the start of the experiment: a 7 cm almond shell mulch, potassium silicate, gypsum and chicken manure pellets, alone or in combination (9 treatments). A second application of almond shells was done in 2003. All trees, including controls, were set on alternate irrigation. Their trunk was also sprayed with 250 ml of a 20%

phosphorous acid solution partly neutralized with KOH, twice yearly, for the first 5 years. Every year shoots were tip pruned before flowering to eliminate most flowers. After 6 years there were no marked differences between control and treated trees in leaf colour, root health or percentage of dead trees. The 7 (out of 9) surviving control trees had a healthy root system in the 4 test points (2 per sprinkler at a 50 cm radius).

In order to separate the effects of phosphorous acid from alternate irrigation a parallel experiment was carried out in a neighboring group of trees, most of them apparently healthy from 1999 to 2004. The solution was sprayed on the trunks twice per year for 5 years. Fifty one trees were treated while 60 were kept as controls. The design was on randomised plots. No apparent differences were observed in tree health. Total increment in trunk cross sectional area in 5 years was 21.8% on treated trees and 19.3% in controls.

Conclusions

Alternate irrigation may greatly help to control R.n. in avocado trees growing in the shale derived soils of southern mainland Spain, irrigated with low salinity water. Observations in the last 3 years indicate that the method works best at the initial stage of affection, when less than 50 per cent of the shallow root system is dead. For best results most flowers should be eliminated by shoot tipping before the cauliflower stage. This should be done until over 75 per cent of the shallow root system is in good health.

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