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Agricultural Water Management 75 (2005) 152–167
Agricultural water management
www.elsevier.com/locate/agwat

Regulated deficit irrigation during the kernel-filling period and optimal irrigation rates in almond

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Accepted 23 December 2004

Abstract

The use of Regulated deficit irrigation (RDI) in almond, applied during the kernel-filling phase, was evaluated over four consecutive years. To determine the reference optimal irrigation rate, three treatments were applied: T-100, which was irrigated by replacing crop evapotranspiration; T-130, which was irrigated by applying 30% more water than in T-100 and T-70, which received 30% less water than T-100. The RDI treatment received the same irrigation rate as T-100, but during the kernel-filling period irrigation was reduced to 20% of T-100. The optimum yield response was observed in treatment T-100, while T-130 trees never improved on T-100 kernel production over the 4 years of the study. During the first two experimental years, kernel dry matter accumulation did not decrease with drought in the RDI treatment. However, both cropping and kernel growth were reduced during the third and fourth years of the experiment. A possible explanation for this decrease could be found in a hypothetical depletion of the carbohydrate reservoir in RDI trees and also to the negative soil water balance that was evident in the T-70 and RDI treatments during winter and spring of the last 2 years. Although yield reductions for RDI trees were significant (20% with respect to T-100), the water savings obtained (about 60% of that applied with respect to T-100), may help to promote the adoption of RDI in areas, where water availability has been reduced. Bearing in mind the water conservation aspect in almond, RDI, as applied in this case, seemed more interesting than a seasonal sustained deficit irrigation strategy like T-70.

Keywords: RDI; Kernel growth; *Prunus amygdalus*; Soil water content; Cumulative effects

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0378-3774/$ – see front matter
doi:10.1016/j.agwat.2004.12.008

1. Introduction

The limited availability of water for irrigation in semi-arid zones means it is necessary to develop water conserving irrigation techniques. Almond orchards in Mediterranean regions are mainly found in dry areas because of their capacity to withstand water stress (Castel and Fereres, 1982; Marsal et al., 1997; Wartinger et al., 1990), salinity (Franco et al., 2000; Nightingale et al., 1991) and other adverse conditions. The adoption of irrigation techniques in these areas can increase production by as much as 10-fold (Girona, 1992), whereas traditional non-irrigated almond orchards are being abandoned because of low profitability. New irrigation techniques that permit significant increases in production with limited irrigation are therefore, of great interest. Regulated deficit irrigation (RDI) strategies are based on only reducing irrigation during certain periods of the annual plant cycle. These periods are selected when ongoing growth processes are less sensitive to water stress and when the derived effects of water stress are advantageous for yield, as in the case of reducing vigor in high density orchards (Chalmers et al., 1981). In almond orchards, intensification is not an issue and thus, RDI strategies should primarily focus on reducing irrigation during periods of annual development with a low sensitivity to water stress. A successful design for deficit irrigation scheduling should produce the maximum possible yield for the minimum possible rate of water application.

Dry matter accumulation is one of the processes that is least sensitive to water stress. In peaches, this process usually remains unchanged when applying deficit irrigation during pit hardening and the phase of expansive fruit growth (Li et al., 1989; Girona et al., 1993, 2003). In the case of almond, for the majority of cultivars, the period of kernel dry matter accumulation occurs during late summer, when the evaporative demand is at its maximum and while other growth processes are very much reduced (Girona, 1992; Kester et al., 1996). Goldhamer and Viveros (2000) reported a slight reduction in kernel dry weight for severe drought conditions (withholding irrigation) during a period of 50 days before harvest, whereas under less severe conditions no negative effect on kernel dry weight was observed (Girona et al., 1997; Goldhamer and Viveros, 2000; Esparza et al., 2001a). Nevertheless, little has so far been reported on the effect of drought on kernel growth and the limiting effect of its container – the shell – has also rarely been considered (Girona et al., 1997). Long term experiments on the application of RDI during the kernel-filling period are also needed, since changes in flowering (Goldhamer and Viveros, 2000) and carbohydrate reservoirs may have a long-term impact on almond yield components (Esparza et al., 2001b). A recent report indicated that water deficit immediately prior to harvest induced an increase in flowering during subsequent years, whereas drought after harvest produced the opposite effect and reduced flowering (Goldhamer and Viveros, 2000). This indicates that when analyzing water deficits, rather than looking at their effects on kernel filling, over 1 or 2-year period, their long-term effects on cropping should also be studied in order to understand their putative variations on yield components. Along these lines, besides producing a reduction in flowering and/or fruit set as a result of water stress, a reduction in the renewal of fruiting positions may also explain reductions in cropping, as in the case cited by Esparza et al. (2001a), after a 3-year drought during harvest.