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Effects of irrigation deprivation and ground cover (*Trifolium repens*) in the tree row on brown rot incidence in peach

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ABSTRACT

Brown rot can lead to considerable fruit losses in peach orchards and cultural practices likely to contend this major disease have to be promoted. In order to limit peach brown rot incidence in a three-year-old mid-season maturing peach orchard of the cultivar 'Ruby Bright', four combinations of irrigation and soil management treatments were assessed: conventional (Conv) irrigation (I) and soil management (S) (ConvI+ConvS); modified (Mod) irrigation and soil management (ModI+ConvS); conventional irrigation and modified soil management (ConvI+ModS); and modified irrigation and soil management (ModI+ModS). Conventional irrigation and soil management in the tree row consisted of irrigation scheduling using tensiometer readings and herbicide use, respectively. Modified irrigation and soil management in the tree row consisted of water deprivation during stage III of fruit development and ground cover with white clover, respectively. For four consecutive years (2010–2013), in the conditions of the Middle Rhone Valley in France, the lowest and highest brown rot incidence were detected under (ModI+ModS) and (ConvI+ConvS), respectively, whereas brown rot incidence under (ModI+ConvS) and (ConvI+ModS) was intermediate. This lower brown rot incidence under the modified treatments occurred from one to two weeks before fruit maturity and was still observed for several days in post-harvest storage. Ground cover with white clover was shown to limit water availability in the soil after heavy rainfall compared to bare soil, probably limiting peach growth variations, well-known as a possible source of detrimental micro-cracks at the fruit surface. This suggests that under our conditions appropriate cultural practices, water deprivation and a clover crop cover in the tree row possibly decrease peach disease sensitivity, which might lead to the reduced use of pesticide sprays to control brown rot in the orchard.

1. Introduction

Brown rot, mainly caused by *Monilinia fructicola* (G. Wint.) and *Monilinia laxa* (Aderh. and Ruhl.) in Europe (Rungjindamai et al., 2014), is the main stone fruit disease in the South of France (Mercier et al., 2003). Weather conditions favorable for brown rot lead to considerable economic losses in the peach sector (Fan et al., 2010). Some microorganisms have been identified as antagonists of *Monilinia* species and proposed as possible active ingredients for the development of biocontrol fungicides (Mari et al., 2012). Nevertheless, brown rot is still mainly controlled by chemical fungicide spray programs in the field, and alternative methods have still not actually been assessed, with the exception of rain protection cover in sweet cherry (Borve et al., 2007).

An important challenge now exists for fruit growers concerning the reduced use of pesticides in peach orchard, in compliance with Integrated Pest Management rules. More generally, guidelines concerning sustainable agricultural systems recommend the reduction of inputs (irrigation water, pesticides, etc.). Cultural practices in peach orchards can be adapted to contribute to these aims, and irrigation scheduling and soil management in the tree row appear to be of particular interest (Faci et al., 2014; Wan et al., 2014).

When applied throughout the entire peach growing period, including that of rapid fruit growth (Stage III), mild water restrictions in orchards, according to the RDI (Regulated Deficit

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Irrigation) concept (Girona et al., 2005), were shown to be decisive in terms of increasing peach quality, slightly reducing peach fruit yield (around −10%, according to Miras-Avalos et al., 2013). Crisosto et al. (1994) also detected a decrease in peach water loss with restrictive irrigation due to the formation of a thicker fruit cuticle. Miller et al. (1997) corroborated this finding in kiwifruit, adding that microcracking of the fruit epidermis might be reduced with limited water supply. Given that fruit cracks are assumed to be the preferential pathway of pathogen invasion (Kamamoto et al., 1990; Gibert et al., 2005), water restrictions in peach orchards have been reported to reduce peach sensitivity to brown rot (Li et al., 1989b; Gibert et al., 2007).

Alternative cultural practices to herbicides strips centered along the tree line in modern orchards have led some fruit growers to sow grass species in the fruit tree row, particularly legumes that combine a limited competition with fruit trees for nutrient uptake and an increasing biodiversity in the orchard soil (Parveaud et al., 2012). But frost damage in orchard was reported to increase under ground cover due to the induced microclimate modification (Sharatt et al., 1989). Nevertheless, damage due to *Monilinia* spp. fungi might be reduced when peach tree row was covered with white clover (Gomez and Mercier, 2008).

In order to compare the effects of water deprivation before harvest and a white clover cover crop in the tree row on the incidence of peach brown rot to that of conventional irrigation and herbicide use, different combinations of irrigation and soil management on the tree row were studied over a four-year period in a young (three-year-old at the beginning of the study) peach tree orchard planted with the cultivar 'Ruby Bright' in Middle Rhone Valley conditions. In addition to assess irrigation and soil management effects on brown rot incidence in the peach orchard, the challenge of this experiment is to promote a more environmentally-friendly orchard by proposing alternatives to two cultural inputs, water irrigation and herbicides, the use of which have to be significantly limited by fruit growers in the near future because of scarcity and toxicity problems, respectively.

2. Materials and methods

2.1. Orchard description

This study was carried out in a peach tree orchard planted in 2008 at INRA's Gotheron Experimental Station near Valence in the Middle Rhone Valley in France (45.0°N; 4.9°E, 190 m altitude). The soil was stony alluvial with 15% clay, 30% silt and 54% sand, pH of 7.0 and 1.5% organic matter.

The area of the experimental orchard was 0.45 ha 'Ruby Bright', a mid-season maturing nectarine (*Prunus persica* (L.) Batsch) reported to be rather sensitive to brown rot (http://www.freepatentsonline.com/PP11952.pdf), was grafted on GF305 rootstock and planted in an open vase training system (4 × 5 m). In this area, flowering, the beginning of Stages II and III, and harvest usually occur on March 25, June 1 (65 d after full bloom, DAFB), June 25 (90 DAFB) and July 20 (115 DAFB), respectively. Routine horticultural care in terms of fertilization was provided (Huguet, 1978). Hand-thinning was carried out in May to leave 10–15 cm between fruits along the fruiting shoots in order to ensure commercial fruit size (Mitcham, 1980). Peaches were harvested in three or more commercial pickings as required by fruit maturity. Crop phytoprotection was managed according to the Integrated Pest Management system (ACTA, 1979). Cankers and mummies were removed from the entire orchard every winter in order to limit brown rot inoculum among the different treatments. Further phytoprotection measures were undertaken, except in 2010. From 2011 to 2013, a single application of fungicide spray (tebuconazol, 100 g ha^{-1}) was performed against brown rot around three weeks before harvest in all treatments (see Fig. 1). Furthermore, in summer, pathogens were isolated from infected fruits and incubated on agar in Petri dishes at 25 °C, with 12 h dark/12 h light cycles for 10 days (Mercier et al., 2005). *Monilinia fructicola* and *Monilinia laxa* were visually identified, their relative importance fluctuated greatly from year to year; overall, they were rather similarly represented.

A microjet irrigation system was installed with two emitters per

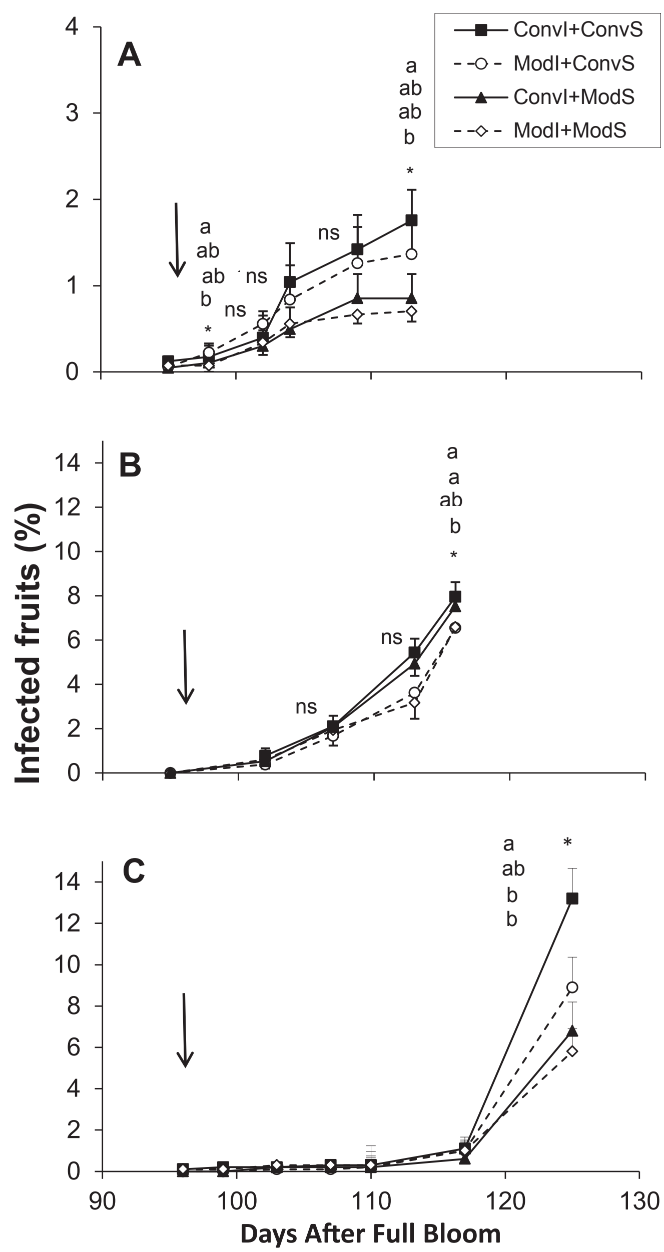

Fig. 1. Time-course of cumulative brown rot incidence in 2011 (A), 2012 (B) and 2013 (C) according to irrigation and soil management in the tree row treatments. ConvI+ConvS: conventional irrigation and soil management; ModI+ConvS: water deprivation and conventional soil management; ConvI+ModS: conventional irrigation and modified soil management; ModI+ModS: water deprivation and modified soil management. Brown rot incidence was assessed twice a week from around three weeks before fruit maturity until one day before harvest (at least five measurements). Fungicide spraying before harvest is represented by an arrow. Vertical bars denote positive or negative standard errors of the averaged cumulative percentage of infected fruits in each treatment. Different letters indicate statistical difference at P ≤ 0.05 using the Fisher test (LSD); ns, non-significant.