Assessing the impacts of extreme high temperatures on the productivity of olive orchards through a modelling approach

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Introduction

- Global warming is expected to increase the frequency and intensity of such extreme events, threatening the sustainability of many agricultural systems.
- To date, most of the research in this field has focused on the main annual crops, whereas little attention has been paid to perennials.
- Assessing the responses of perennial crops to extreme weather events adds further complexity as the impacts of extreme events might have consequences beyond the season in which they take place.
- This study explores this issue the particular case of olive trees, for which conditions of very high temperature are known to affect fruit set and, therefore, productivity (Kobouris et al., 2009).
- We hypothesize that the perennial nature of olive trees has implications on the long-term impact of extreme heat stress events on the productivity of this crop.

Fig. 1

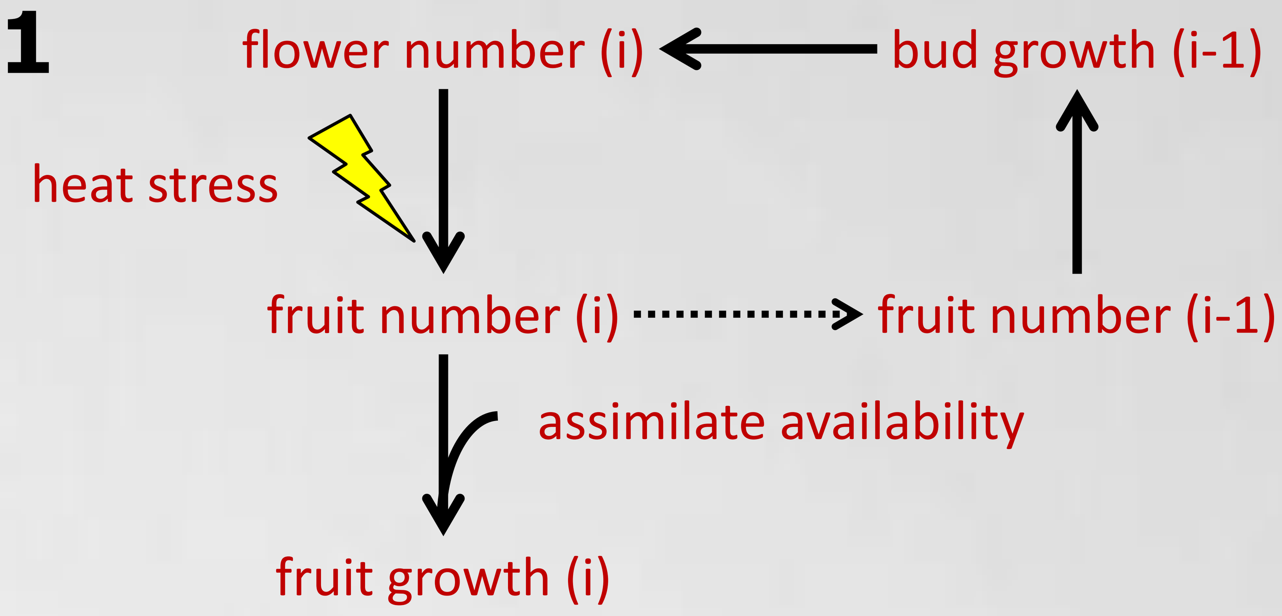
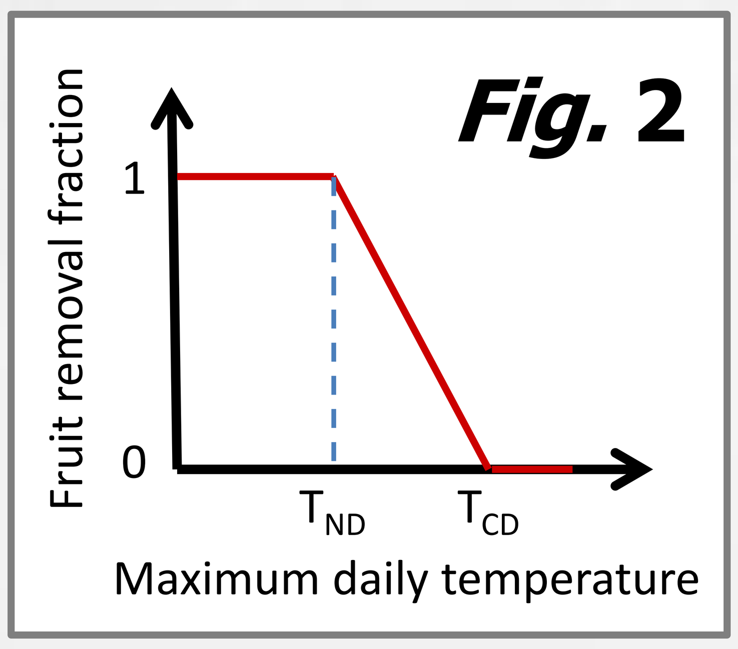


Fig. 2



Materials and methods

- A virtual experiment was performed with the simulation model OliveCan
- Yield is calculated as a function of the number of fruits, which is determined from the number of fruits and leaves produced in the precedent year. In doing so, the model accounts for the characteristic alternate bearing behaviour of olive trees (Figure 1)
- An additional simple sub-model is developed to reduce the number of fruits when extreme high temperatures occur around flowering (Figure 2)
- The extreme sub-model is coupled to the existing version of OliveCan (EMS) creating a modified modelling solution (MMS)
- Both modelling solutions are run for a 50 year weather dataset recorded by an automated weather station in Córdoba, Spain. For the simulations, an intensive olive cv. 'Arbequina' orchard growing on a sandy-loam soil of 1.5 m depth is considered. Both full-irrigated and rainfed scenarios are simulated.
- Yield outputs by EMS and MMS are compared to assess the impact of extremely high temperatures around flowering

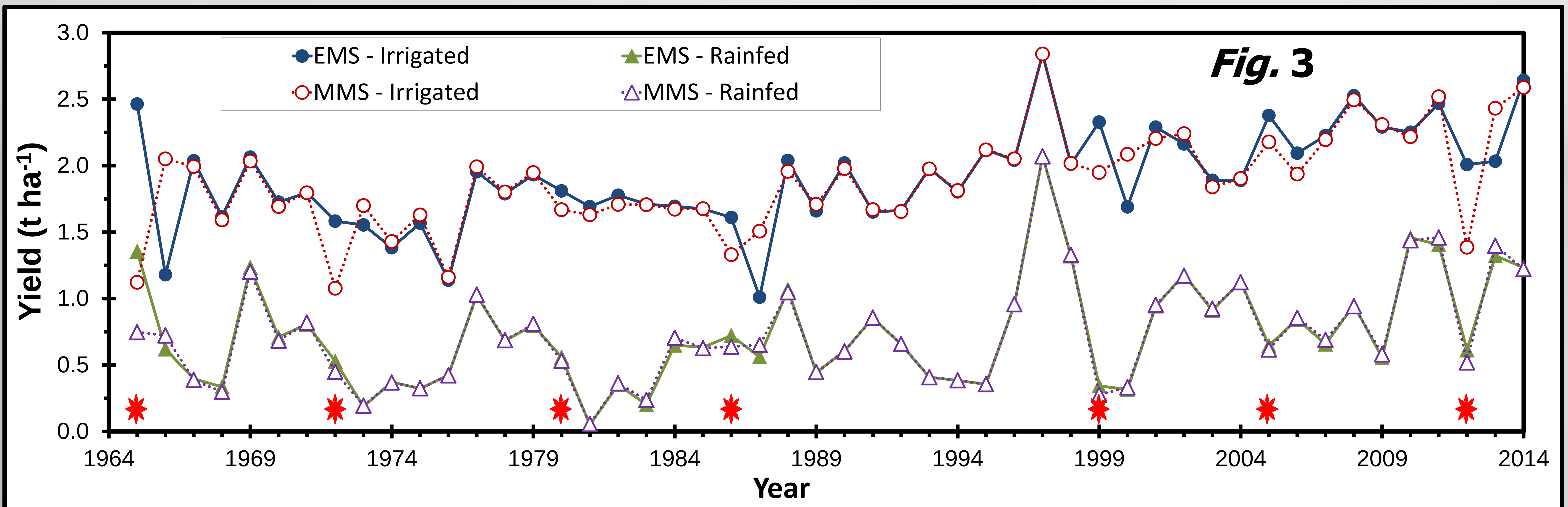
Results and discussion

- Extreme heat stress events (red stars in Figure 3) lead to appreciable differences in fruit number and yield between modelling solutions, particularly in the irrigated scenario
- Higher yields were predicted for the MMS in the years following the extreme events (Figure 3) as a result of the interactions between simulated fruit numbers in consecutive seasons (Figure 1)
- Overall, scarce differences were found between modelling solutions in the average simulated yields and their coefficients of variation (Table)
- In the rainfed scenario, fruit growth was generally source-limited, which explain the small differences found between modelling solutions (Figure 3, Table)

Table 1: Average yields and coefficient of variation in relation to modelling solution and management scenario

Modelling solution	Management scenario	Average dry yield (t ha^{-1})	Coefficient of variation (%)
EMS	Irrigation	1.915	19.5
MMS	Irrigation	1.884	19.7
EMS	Rainfed	0.743	54.2
MMS	Rainfed	0.731	54.4

Key message: the impacts of extreme heat stress events on olive productivity might be partly alleviated by the alternate bearing behaviour of this species



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