CLIMATE CHANGE EFFECTS ON OLIVE SYSTEMS IN SARDINIA: ANALYSIS OF THE ALGHERO CLIMATE SCENARIO

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Abstract

The need for agroecosystem analysis has increased due to additional complexity brought about by climate change. In this paper, a multi-trophic system model is applied to the analysis of olive systems in Sardinia (Italy) using a 105-year climate scenario for the Alghero location. This scenario includes 50 years (1951-2000) of observed weather and 55 years (2001-2055) of weather projected according to the observed 1951-2000 trend. General physiologically based demographic models that apply to all species at all trophic levels, are used to simulate the effects on olive system dynamics of observed and projected weather included in the Alghero climate scenario.

Introduction

To fully understand the effects of weather on species dynamics requires that we describe the dynamic processes of growth, development and behaviour of species as driven by weather and other species and by abiotic factors in a general way. Physiologically based demographic models (PBDM) of species have been developed that capture these processes (Gutierrez, 1996; Gutierrez *et al.*, 2005; Gutierrez *et al.*, 2006).

In this paper, a multi-trophic PBDM of the olive system (Gutierrez *et al.*, 2008) is used to simulate the dynamics of olive, *Olea europaea* L., and olive fly, *Bactrocera oleae* (Gmelin), based on observed and projected weather included in a 1951-2055 climate scenario for Alghero (Sardinia, Italy).

Materials and methods

General PBDM that apply to all species at all trophic levels (Gutierrez *et al.*, 1975; Gutierrez and Baumgärtner, 1984; Gutierrez, 1992, 1996) are used to simulate olive system dynamics using the Alghero climate scenario. Specifically, we concentrate on olive, *Olea europaea*, and olive fly, *Bactrocera oleae* (Gmelin).

The climate scenario includes observed, homogenized weather for the years 1951-2000 and weather for the period 2001-2055 projected according to the observed 1951-2000 trend (Cossu *et al.*, 2004). For details on the climate scenario, see Werner and Gerstengarbe (1997).

Tab.1 – Average warming between first and last decade of the 105-year climate scenario for Alghero, Italy.

Average parameter (°C)	T_{max}	T_{min}
Decade		
First (1951-1960)	20.12	11.59
Last (2046-2055)	21.02	13.15
First to last decade increase	0.90	1.56

The Alghero climate scenario shows small warming (table 1) and slightly decreasing rainfall (figure 1); the latter is confirmed by field studies (Cossu and Bodini, 2007).

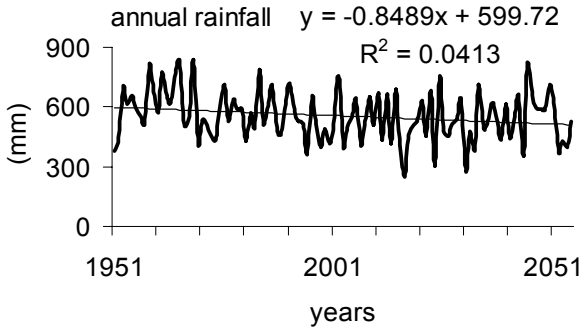

Fig. 1 – Annual rainfall (mm) in the 105-year climate scenario for Alghero, Italy.

Results

Degree days (*dd*) for olive increased considerably (1.81 *dd* year^{-1} on average); note that the lower variability of projected vs. observed weather is intrinsic to the statistical procedures underlying the climate scenario (figure 2).

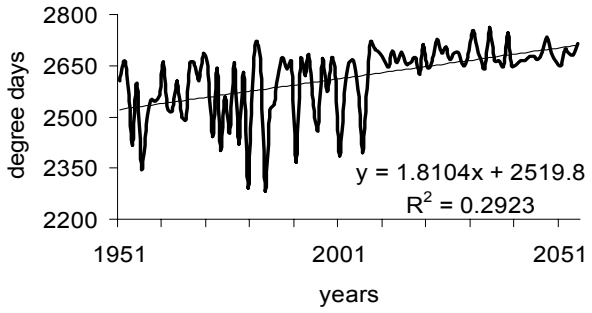

Fig. 2 – Simulation of season length for olive in degree days using 105 years of climate scenario for Alghero, Italy.

Date of bloom (range 100-154 days) declined at an average rate of 0.22 days yr^{-1} from an initial average value of 145.11 days (figure 3); an overall decline of 23 days in 105 years.

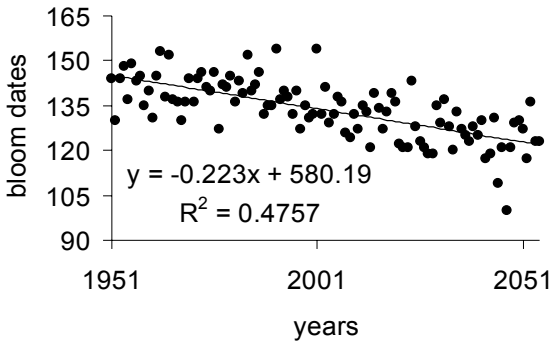

Fig. 3 – Simulation of olive bloom date (days after 1 January) using 105 years of climate scenario for Alghero, Italy.

Yield expressed as dry matter $tree^{-1}$ (range 1157-9956 g) decreased at an average rate of 0.95 g yr^{-1} (figure 4) due to increased respiration with climate warming. Future yields tend to be more variable, probably reflecting increased damage by low temperatures in spring due to earlier bloom dates. Specifically, two crop failure events were predicted in 2028 and 2049 (see arrows in figure 4).

Olive fly infestations as measured by the season-long sum of all daily counts of larvae (figure 5a) and adults (figure 5b) decreased due to declining fruit mass and increasingly adverse high temperatures near the fly's upper thermal threshold, with subsequent decreased fecundity and increased mortality (figure 5). Note that the two major population contractions correspond to the crop failures.

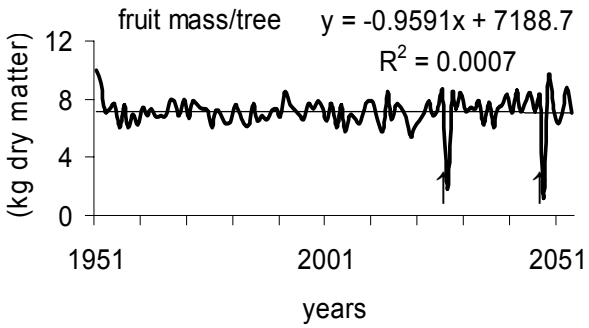

Fig. 4 – Simulation of olive fruit mass(kg of dry matter $tree^{-1}$) in the absence of olive fly infestations using 105 years of climate scenario for Alghero, Italy.

Conclusions

Even though climate warming in the Alghero scenario appeared to be small (table 1), an effect on day degrees, olive bloom date, yield, and olive fly was evident. The reason for this is that short term adverse conditions are critical during certain periods, e.g. crop failure due to earlier booming in presence of low spring temperatures. Furthermore, olive has a much wider temperature range than olive fly, which is why effects on the fly are more evident.

The physiologically based weather driven approach of the models used in this analysis was key in dynamically detecting important phenological aspects even under current trends of low climate warming present in the Alghero scenario. This may be considered an implicit validation of the PBDM capacity to assess the impact of climate change on agro-ecosystems.

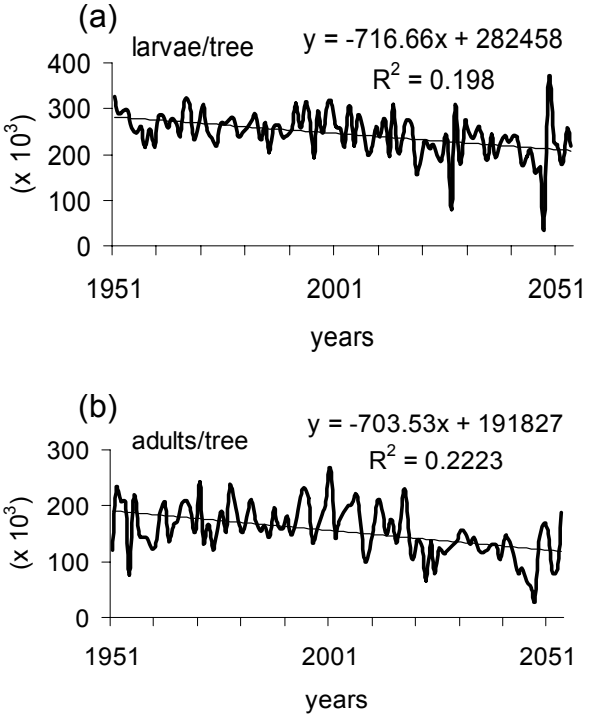

Fig. 5 – Simulation of cumulative daily counts of olive fly larvae (a) and adults (b) $tree^{-1}$ y^{-1} using 105 years of projected weather for Alghero, Italy.

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