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Modelling the interaction of white marble gravel mulch and the tomato plant in the energy balance inside a Mediterranean naturally ventilated greenhouse.

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Introduction

The use of soil mulching is an agricultural technique used for hundreds of years with the main function of reducing soil evaporation and reducing heat loss at night. The reflection of solar radiation that reaches the ground depend on the type of mulching used, affecting both energy balances in air and on plants (Jones *et al*., 2021). In winter, where what is intended is to increase the temperature of the greenhouse, black mulches are suitable while in summer white mulches are used.

The aim of this work is to analyze the effect of using a white marble gravel mulch using an energy balance model on the different heat fluxes inside a naturally ventilated solar greenhouse in Almería.

Results

As consequence, the PAR radiation was increase at the level of the tomato leaves while maintaining the same temperature of the air and the plants. In this work the different components of the energy balances of greenhouse and plants, were analysed.(Fig. 3)

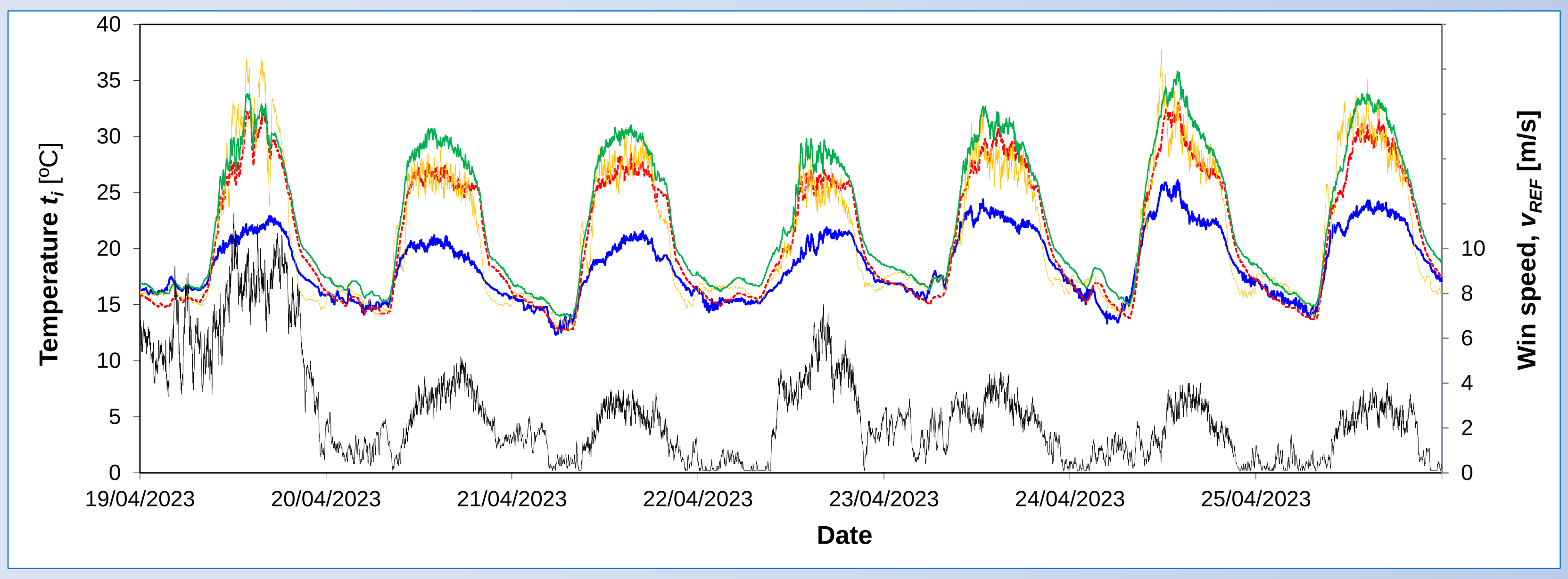

Figure 3. Inside air temperature measured (----) and calculated (---) in the sector with the gravel marble mulching, in the sector with black polypropylene mulching (---), outside the greenhouse (---) and wind speed (---).

A good correlation was obtained between temperatures simulated and measured forn the different components of the greenhouse model (Fig. 4).

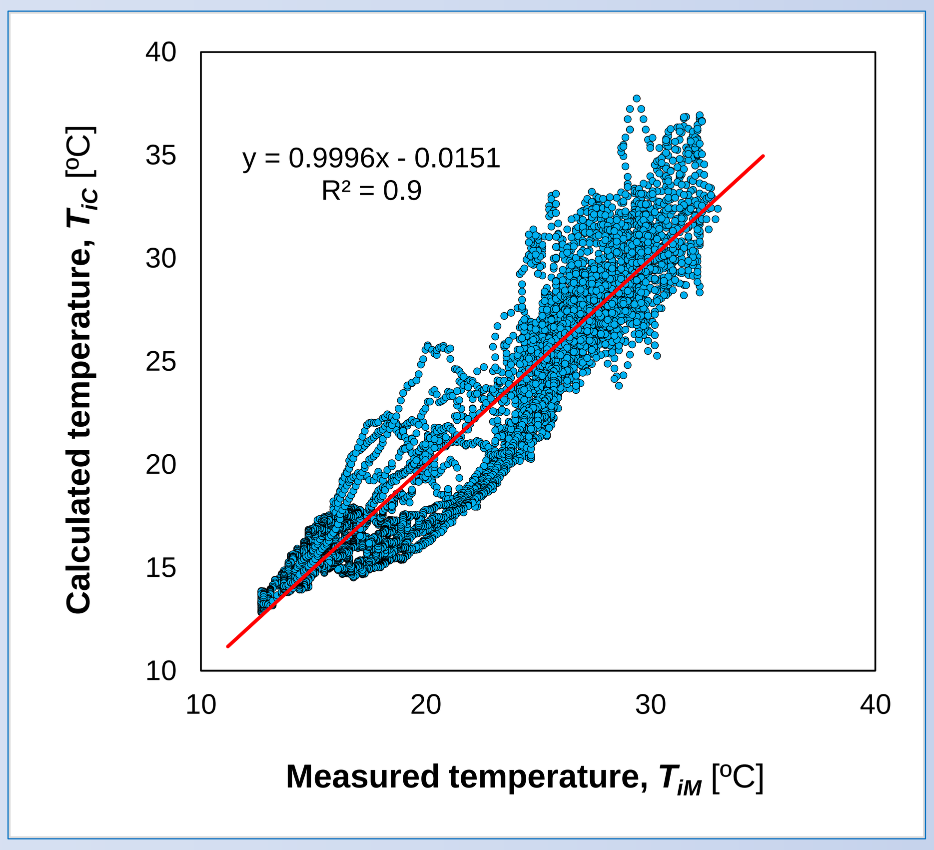

Figure 4. Adjustment of the simulated inside air T_i and crop T_C temperatures to the experimental measurements in the greenhouse.

Materials and Methods

In order to reduce the solar radiation absorbed by the soil and avoid the reflection of direct radiation, in September 2022 a white marble gravel mulch was installed in the western half of a multispan greenhouse with a tomato crop inside in Almería (Spain), increasing soil reflection coefficient ρ_s (Table 1). In the East sector, a black polypropylene plastic mulching was maintained.

Table 1. Measured reflection ρ_s from different soil mulching.

Mulching	Silica sand	White marble gravel	Blackn polypropylene
Reflection (%)	15.7	44.2	11.3

The energy (in air, soil and plants), balances inside the greenhouse (Fig. 1) have been calculated using MOCLINAL model (Molina-Aiz *et al*., 2017; Reyes-Rosas *et al*., 2017). One of the fundamental elements of the balances is ventilation flow G_C that has been modelled according to the wind conditions and the position of the greenhouse openings.

$$V_{inv}\rho_a c_{pa}\frac{dT_i}{dt} = R_n - Q_{cc} - Q_{VC} - Q_{ET} - Q_s \pm Q_g$$

$$Q_{VC} = \eta_{TC}\frac{\rho_a c_{pa} G_C (T_{ic} - T_o)}{S_c}$$

$$R_n = R_{so}(\alpha_c + \tau_c\alpha_{ps}) + \sigma\,[\alpha_{psT}(\tau_{cT}\varepsilon_{sky}T_{sky}^4 + \varepsilon_{cT}T_{ci}^4) - (f_p\alpha_{pT}T_p^4 + (1-f_p)\,\varepsilon_{sT}T_{s0}^4)]$$

$$\rho_s$$

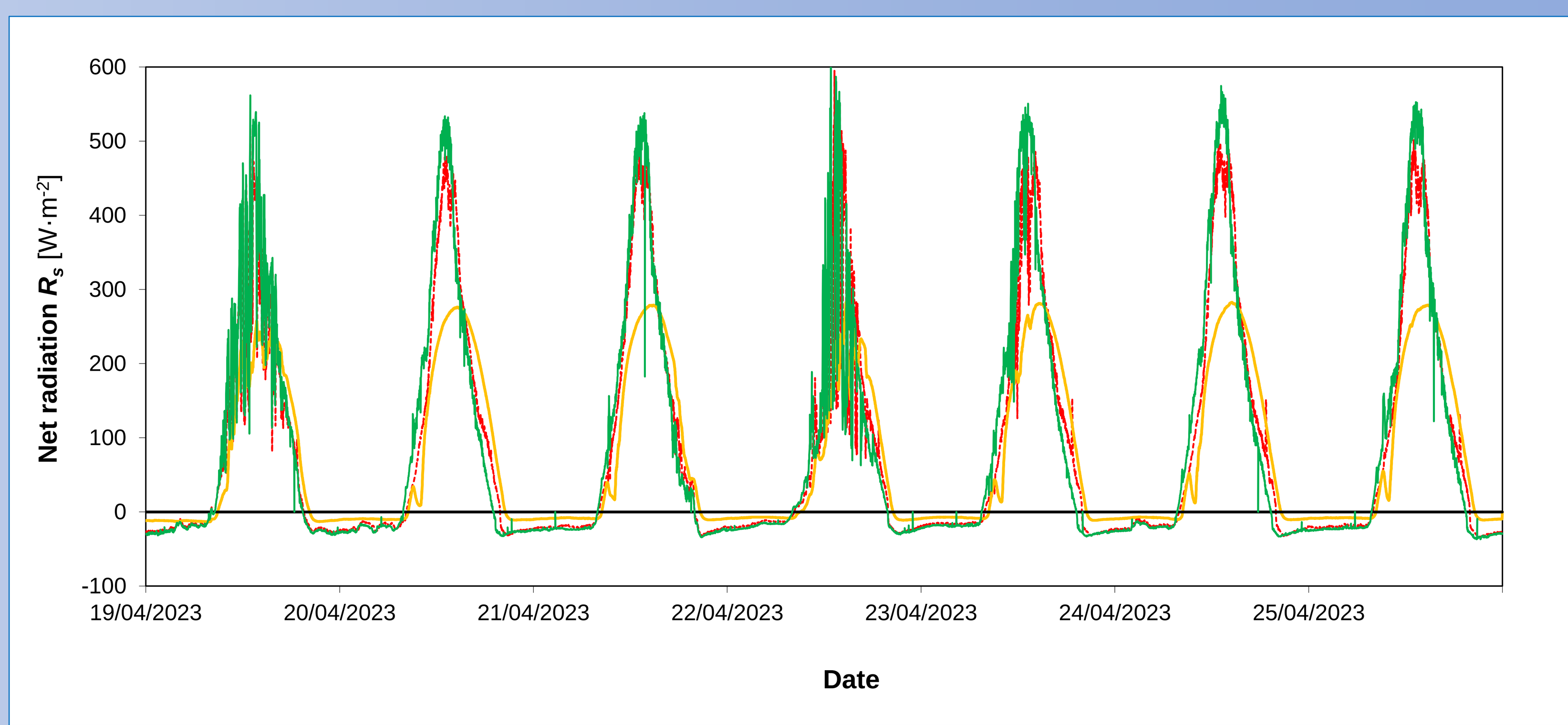

Figure 3. Net radiation measured (----) and calculated (---) in the sector with the gravel marble mulching and measured in the sector with black polypropylene mulching (---).

Conclusions

- White marble gravel mulching together with larger side vent openings reduce the maximum air temperature by –2.1-4.5°C and increase the relative humidity by 5-10%.
- The MOCLINAL energy balance model allows to predict accurately the air, crop and soil temperatures, taking into account the effect of the increase in soil surface reflection coefficient produced by the gravel marble mulching.

References: Jones *et al*. (2021). *Solar Energy*, **214**, 457–470; Molina-Aiz *et al*. (2017). *Acta Hortic*. **1170**, 209-218; Reyes-Rosas *et al*. (2017). *Computers and Electronics in Agriculture* **142**, 9–28; Verdouw *et al.* (2021). *Agricultural Systems*, **189**, 103046.

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