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MISURE DEI PARAMETRI METEOROLOGICI IN COLTURA PROTETTA INFLUENTI SULLA VARIABILITÀ DI POMODORO

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Abstract

The amount of solar radiation, when operating in protected environment, undergo to modifications that depend on the type of cover used. This can affect the characteristics of plant growth and trigger a variety of physiological responses. Currently, measurements of meteorological parameters in protected cultivation lack of measurement uncertainties evaluation that could be translated in uncertainty of the product variability.

An experimental site for these measurements and the evaluation of the variability of a table tomato cultivar is presented. The site was equipped with cultivation structures (tunnel type) and calibrated sensors traceable to SI. The microclimate conditions were monitored by sensors for solar radiation, air temperature and relative humidity; inside and outside the tunnel with different covering materials having opposite filtering properties with respect to UV-B radiation. High temperatures recorded (over 40 °C) changed the transmissive feature of the films and consequently affected the growth, anthesis, leaf area index and fruit setting of tomatoes.

Keywords

Meteorological parameters, protected cultivation, calibration, uncertainty, tomato

Parole chiave

Parametri meteorologici, coltivazione protetta, taratura, incertezza, pomodoro

Introduction

Light is a factor of paramount importance for plants since, in addition to providing the radiant energy for photosynthesis, it modulates growth and development in response to the environmental conditions. When operating in protected cultivation the amount and the spectral distribution of solar radiation (SR) inside the cultivation undergo modifications that depend on the type of the cover used. The productivity of a protected crop is highly correlated to the amount of electromagnetic radiation received (Krizek, 2004). On the other hand, instruments that measure SR need constant maintenance and calibration, to obtain UV measurements of required quality (Hülsen and Gröbner, 2007). Schaepman (1998) shown that the introduction of the measurement uncertainty for ground based spectroradiometric measurements increases significantly the reliability of measured data.

On the basis of the experience acquired in metrology for agrometeorology (Sanna *et al.*, 2014; 2018), an experimental site equipped with cultivation structures and calibrated sensors for the measurements of meteorological parameters was assembled.

Materials and Methods

The research activities concerned the quality of table tomatoes (*Lycopersicon esculentum*, var. Saint Pierre) grown in protected environment. The following aspects were evaluated:

- Microclimate conditions: air temperature (T) range (-10 – 40) °C, relative humidity (RH) range (10 – 98) %rh with a target uncertainties of 0.3 °C and 5 %rh, respectively; SR in the spectral distribution from 290 nm to 2800 nm;
- Morphological observations of the crops in response to the type of plastic film adopted.
- Monitoring of the ageing and radiometric properties of the films used as covering material due to their exposure to the sun and their deterioration.

The following structure and instruments were installed:

- No. 2 adjacent high-tunnels (called IN-C and IN-B) of equal size with different covering material. The first was a diffusive type and filtering the UV-B radiation, the second one of transmissive type.
- No. 2 Automatic Weather Stations (AWS), one per tunnel, including sensors for the detection of: air T and RH, SR for UV-B, and PAR;
- No. 1 AWS outside the tunnels (called OUT), including sensors for the detection of: air T and RH, SR for UV-B, global radiation.

The meteorological instrumentations were calibrated by means of procedures defined *ad hoc*. The air T and RH sensors were calibrated using the "EDIE – Earth Dynamics Investigation Experiment" facility, developed under the European ENV07 MeteoMet project (Merlone *et al.,* 2015).

Results and Discussion

The meteorological sensors for the measurement of microclimate conditions were recalibrated and evaluated for the dynamic and stability. In order to cover the whole calibration range for atmospheric measurements, the

selected set points were: −20 °C, −10 °C, 0 °C, 10 °C, 25 °C, and 45 °C for T sensors; 30 %rh, 60 %rh, 75 %rh, 90 %rh and a second point at 60 %rh for the evaluation of the hysteresis for RH sensors. The values of their calibration uncertainty were 0.390 °C; 0.386 °C and 0.391 °C for T and 3.988 %; 4.405 % and 4.398 % for RH for sensors A/IN-C, B/IN-B, C/OUT respectively.
During the three weeks after transplanting, the tomatoes plants in IN-B had a mean growth higher than the plants grown in IN-A, then to have a trend reversal. Plants grown in OUT had a lower growth than IN-A and IN-B. In percentage, anthesis in IN-B proceeded slowly compared to IN-C and OUT, but with a constant increasing rate, while for IN-C there was a gradual and progressive increase during the first two weeks. The fruit setting was observed primary in OUT rather than IN-B. The trend of IN-B followed the one in IN-C. The trend of IN-C was more uniform but, in percentage, lower than the other two plots. A higher mean LAI for plants grown in IN-B compared to IN-C was observed, with a turnaround on 20 June. The mean LAI of plants cultivated in OUT seemed to follow the trend of the plants in IN-B.
Data obtained from thermo-hygrometers sensors (IN-B, IN-C and OUT), calibrated and non-calibrated, were compared. In general, the air T values gathered from data in which the calibration curve were applied were higher than the ones gathered from the same data without application of the calibration curve. vice versa for RH values..
Statistical analysis were carried out regarding the parameters recorded in IN-C. General Linear Model was used to compare the growth, the anthesis, the fruit setting and the LAI values in combination with UV-B values respect to RH and T values.

Tab 1. General Linear Model including Standard Error (SE) and coefficient of determination (R^2), for morphological parameters compared to RH and T values calibrated and UV-B in IN-C.
Tab 1. Modello Generale Linearizzato comprendente analisi dell'Errore Standard (SE) e il coefficiente di determinazione (R^2) per i parametri morfologici comparati con i valori di RH e T tarati e gli UV-B in IN-C.
p-*values: '***' = 0.001; '**' = 0.01; '*' = 0.05.*

GLM	SE	R^2	p-value
Growth + UVB_INC ~			
RH IN-C Cal	11.94	0.839	0.003 **
T IN-C Cal	2.867	0.9872	6.2e-06 ***
Anthesis + UVB_INC ~			
RH IN-C Cal	NA	0.9895	< 2.2e-16 ***
T IN-C Cal	NA	0.9217	1.186e-13 ***
Fruit set + UVB_INC ~			
RH IN-C Cal	93.551	0.2141	0.040 *
T IN-C Cal	223.96	0.1957	0.0573
LAI + UVB_INC ~			
RH IN-C Cal	0.2536	0.4871	0.017 *
T IN-C Cal	0.2027	0.7974	0.0002 ***

The analysis included Standard Error (SE) and coefficient of determination (R^2). As listed in table 1, all the results were statistically significant (p-values < 0.001) except for fruits set compared to T values.
The thermo-optic coefficient for polymers is temperature and humidity-dependent and, as the temperature changes, the refractive index of polymeric films changes. A temperature comparison was performed in order to evaluate potential damages of the covering material. For all the studied period, the UV-B values recorded in IN-B were 0 W/m^2. In IN-C, the values recorded were in the range from 0 W/m^2 to 7.08 W/m2 until the 10th of July, then, with a reversal trend, reached 0 W/m^2 after few weeks (figure 1).

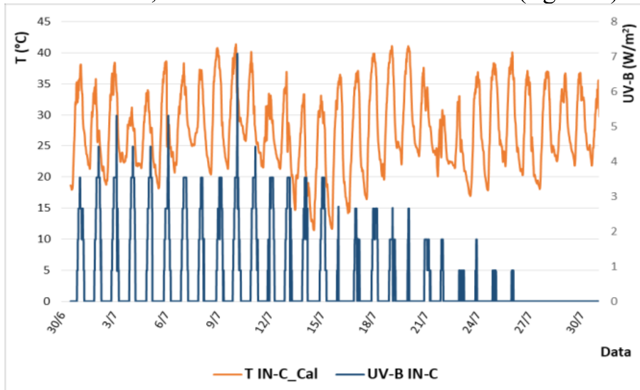

Fig.1 - Temperature (calibrated values) and UV-B measurement comparison in IN-C; daily values..
Fig.1 – Comparazione dei valori giornalieri tarati della temperatura dell'aria e gli UV-B misurati in IN-C.

Conclusions
The absence of UV-B SR (IN-B) affected growth and LAI but, at the same time, the presence of UV-B SR affected T and RH inside the tunnel. The high temperature recorded in the last ten-days of June and in first ten-days of July, over than 40 °C, changed the transmissive feature of the covering material installed in IN-C. Consequently, the phenological characteristics of tomatoes changed their growth, anthesis, LAI and fruit setting trends.

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