Analysis of the Main Critical Points in Protected Crops on Risk Prevention in Sicily

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Abstract
The evaluation of the safety conditions inside the greenhouses is a matter of primary importance in order to safeguard the operators' health who are exposed to high chemical and physical risk factors.
The aim of this paper was to evaluate these risk factors for the operators inside the greenhouses through the estimation of some parameters related to the environmental quality inside the greenhouse. Temperature, relative humidity, CO_2 and VOC (Volatile Organic Compounds) were monitored inside different greenhouses before, during and after chemical treatments.
The results of these measurements gave useful indications about the risk for the operators' health.

Keywords: risk prevention, protected crops, greenhouse

Introduction
In the last decade the vegetable crop production in greenhouses has highly increased. Enlarging the harvesting period of tomato, pepper, melon, aubergine, courgette, strawberry, etc. gives, in fact, the chance to obtain higher prices and, therefore, the growing of the profit of the farmer.
Unfortunately, crop production in greenhouses needs the use of chemicals and requires high levels of temperature and relative humidity. This can cause risks for the health of the operators, especially if they are not equipped with protection devices.
The aim of this paper is to evaluate the risks for the operators through the estimation of some parameters related to the environmental quality inside the greenhouse.

Materials and methods
The tests were carried out in April-June 2009 in some farms located in Western Sicily in the neighbouring of Balestrate, Marsala and Mazara del Vallo. The outdoor temperature in the daytime was higher than 20°C. The pesticide treatments were performed during the afternoon; the following active principles were used: indoxcarbon 30%, thiamethoxan 25%, ciproconazolo 10% and famoxadone.
The investigated greenhouses were different in type of the structure, covering materials and crop production (table 1).
Temperature, relative humidity, VOC (Volatile Organic Compounds), NO_2 and CO_2 were measured by means of an electronic system equipped with a data logger and a photo ionisation sensor.
High temperatures, above 41°C, associated with high humidity levels (above 70%) and lack of ventilation, can produce to man hyperthermia (heat stroke). The man, in fact, is an omeotermic with a normal body temperature of about 36.7°C.

Regarding carbon dioxide, concentrations between 8% and 15% by volume in air may give headaches, nausea and vomiting. Concentrations higher than the last threshold, can cause heart failure also with fatal results. The maximum permissible concentration for exposures of 8 hours per day for 5 days per week is 5,000 ppm by volume in air.

Table 1. Characteristics of the investigated greenhouses.

Test site	Town	Structure	Covering	Span [n]	Shape of the roof	Exposure	Crop
A1	Balestrate	Steel	Plastic film	3	Ellipse	East-West	Plant nursery
A2		Steel	Glass	3	Sloping	East-West	Plant nursery
B1	Marsala	Wood	Plastic film	1	Sloping	North-South	Strawberry
B2		Wood	Plastic film	1	Sloping	North-South	Tomato
C1	Mazara del Vallo	Steel	Plastic film	3	Ellipse	East-West	Tomato
C2		Steel	Glass	3	Sloping	East-West	Tomato

The oxides of nitrogen is a very toxic compound. The maximum allowable concentration in the mixture with air, for exposures of 8 hours per day for 5 days a week, is 3 ppm by volume.
It 's a strong irritant of the airways: a moderate concentration causes acute coughing, chest pain, convulsions and circulatory failure. The attack to the pulmonary apparatus may cause irreversible damages whose most serious injuries may occur many months after the attack.
With the designation of volatile organic compounds (VOC) the vapors arising from complex mixtures are indicated
The compounds that fall into this category are more than 300; among the best known there are the aliphatic hydrocarbons (n-hexane, n-hexadecane and metilesani), terpenes, aromatic hydrocarbons (benzene and derivatives, toluene, o-xylene, styrene), chlorinated hydrocarbons (chloroform, dichloromethane, chlorobenzenes), alcohols (ethanol, propanol, butanol, and derivatives), esters, ketones, and aldehydes (formaldehyde).
In confined spaces where agriculture is performed, sources of VOC are found in pesticides. Exposure to VOC can cause both acute and chronic effects based on concentrations; the acute effects may include irritation to eyes, nose, throat headache, nausea, dizziness and asthma. Chronic effects may include cancer, damage to kidneys, liver and central nervous system. To reduce exposure to VOCs is advisable to make a proper room ventilation during and after treatment and keep the humidity between 40 and 60%.
Two indoor air quality monitor (IAQRAE PGM – 5210 and MultiRae IR PGM-54) were used during the tests. These portable instruments provide real time measurements every 120 s and activate alarm signals when exposure exceeds preset limits. The recorded data were downloaded to a personal computer through the software ProRAE-Suite. The range of the measurements were: 0° - 50°C for temperature, 0 – 100% for relative humidity, 0 – 200 ppm for VOC, 0 – 20 ppm for NO_2 and 0 – 20.000 ppm for CO_2.

During the tests the instruments were placed inside each greenhouse at 1.6 m from the ground in the middle of the room (fig. 1) before pesticide treatment; the measurements were recorded along 24 hours.
Outside temperature and relative humidity were recorded by means of a data logger (Babuc M) equipped with a thermo hygrometer probe (BSU401) and providing real time measurements every 120 s along 24 hours.

Fig. 1. Instruments inside the greenhouses.

Results
Figure 2 shows the results obtained in the test sites named A1 and A2; temperature obtained in A2 are higher than A1; there are no differences in relative humidity between test site A1 and A2; in the daytime CO_2 was always under 100 ppm; the VOC concentration increases, both in A1 and in A2, immediately after the pesticide treatment.

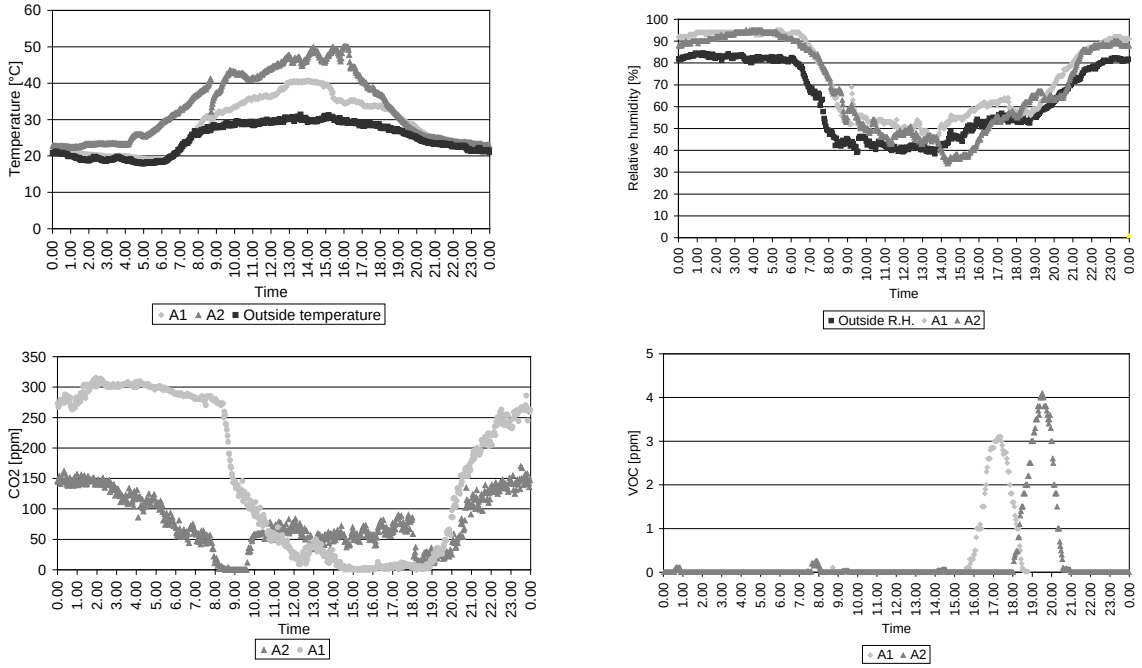

Fig. 2. Test sites A1 and A2 – Temperature, relative humidity, CO_2, VOC measured.

In figure 3 the results of test sites B1 and B2 are shown; the highest temperatures were obtained in test site B2; relative humidity values are similar for test sites B1 and B2; CO_2 values obtained in B2 are higher than B1 due to the presence of tomato that is characterized by an higher growth of the crop; the VOC concentration increases, both in B1 and in B2, immediately after the pesticide treatment.

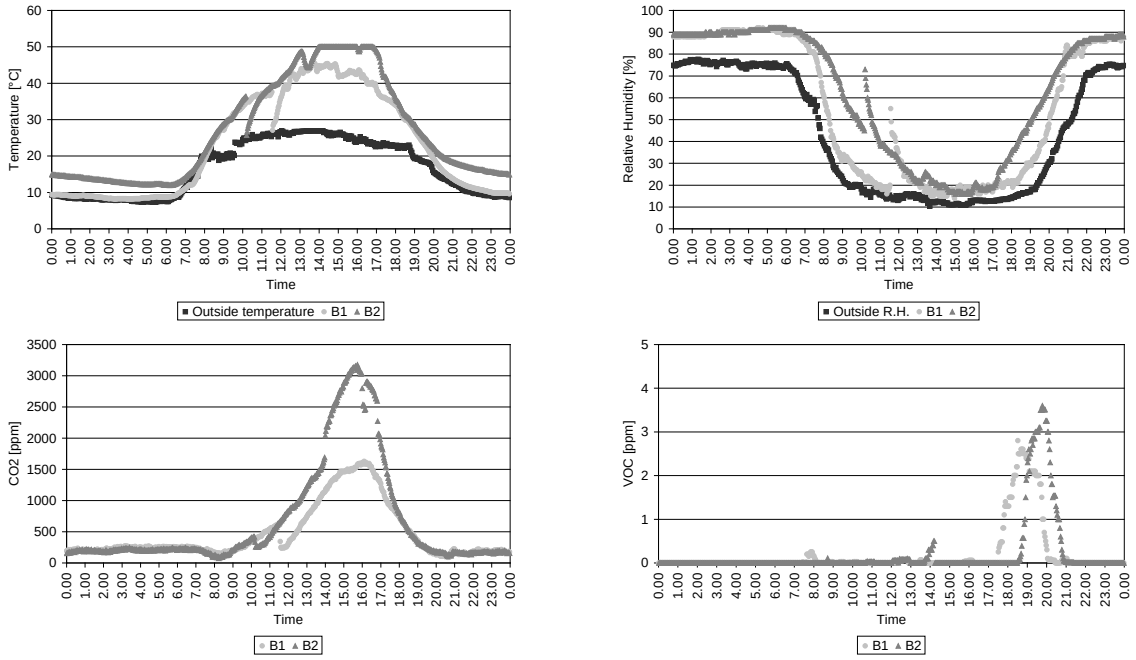

Fig. 3. Test sites B1 and B2 – Temperature, relative humidity, CO_2, VOC measured.

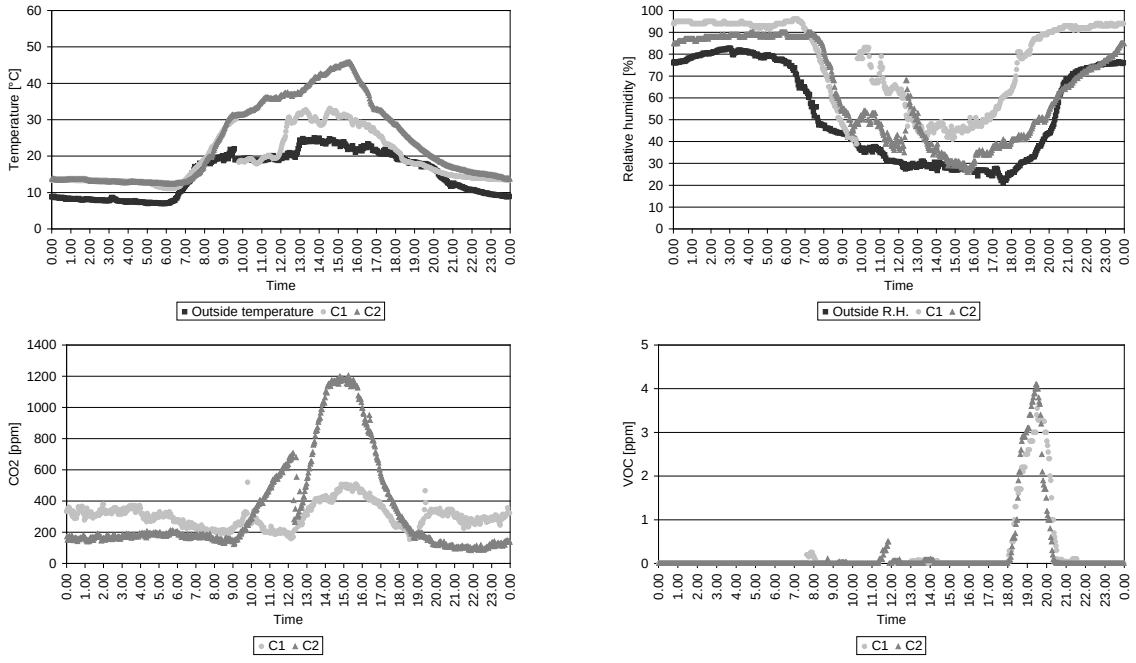

Fig. 4. Test sites C1 and C2 – Temperature, relative humidity, CO_2, VOC measured.

In figure 4 the results of test sites C1 and C2 are reported; the highest temperatures were obtained in test site C2 while relative humidity in C1 was higher than C2; CO_2 concentration shows a peak (1200 ppm) between 14.00 and 16.00 in test site C2; the VOC concentration increases, both in C1 and in C2, immediately after the pesticide treatment.

Conclusions

Some interesting conclusions can be drawn from the results of the investigation.
In the greenhouses covered with glass panels, temperature data have proved to be higher than the corresponding values obtained in greenhouses with plastic cover exceeding the limit temperature (41 °C) beyond which there may be phenomena of hyperthermia (heat stroke man), in the period from 10.00 to 17.00 in which farming operations are usually carried out.
The critical values of relative humidity (higher than 70%) were always recorded during the night, when no operator was inside the greenhouses.
The highest CO_2 values were recorded during the night, always lower than the minimum danger threshold for man (5000 ppm).
The concentration of VOC, as a result of pesticide treatments, had a permanence of about 90 minutes from time when treatment was performed, 18:00 to 19:30 hours; in this period relative humidity takes increasing values in all the greenhouses. The obtained values are close to the threshold of danger for man (5.00 ppm).
Finally, NO_2 values were always equal to zero.

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