Influence of Greenhouse Different Coverings on Chemical and Physical Risk Factors

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Abstract

Crop production in greenhouses needs the use of chemicals and requires high levels of temperature and relative humidity to assure the increasing of crop production. This can cause risks for the health of the operators, especially if they are not equipped with protection devices. The risks may also vary with the type and/or size and/or shape of the protected structures.

In order to determine the influence of different coverings on type and amount of risks, chemical and physical risk factors were measured inside greenhouses with different cladding materials (glass panels and plastic films) after crop management.

In these two different greenhouses typologies, that were similar for location and crop, the same crop practices were performed.

To measure ambient temperature, relative humidity, the levels of VOC (Volatile Organic Compounds) and to process the measured data, were used two electronic systems equipped with a data logger and a photo ionisation sensor.

The results of these measurements gave useful indications about the health of the operators working inside the greenhouses in order to control the risk factors.

INTRODUCTION

Crop production in greenhouses needs the use of chemicals and requires high levels of temperature and relative humidity to assure the increasing of crop production. This can cause risks for the health of the operators, especially if they are not equipped with protection devices.

Inside the greenhouses both physical and chemical risk factors can be found. Temperature and relative humidity can be considered the most important physical risk factors, while CO_2, NO_2 and VOC (Volatile Organic Compounds) represents the most remarkable chemical risk factors. These compounds influence the health of the operators depending on their levels of concentration and permanence in the air.

Greenhouses are largely spread in Sicily due to the favourable pedoclimatic conditions, especially in the provinces of Catania and Ragusa (Eastern Sicily) and in the provinces of Palermo and Trapani (Western Sicily).

In these areas several types of greenhouses can be found. They are different for their structure (wood or steel) and their cladding materials (glass panels or plastic films). These factors cause different microclimatic conditions inside the greenhouses having different influences on the crop and the operators.

In order to evaluate the influence of different cladding systems on the type and amount of risk for the operators, a research was performed about two types of greenhouses respectively covered with glass panels and plastic films.

Temperature, relative humidity, CO_2, NO_2 and VOC were measured inside the greenhouses in the space of 24 hours. Outside temperature and relative humidity where also measured.

MATERIALS AND METHODS

The research was carried out in Partinico (in the province of Palermo, near to the boundary with the province of Trapani, Sicily).

Two types of greenhouses were chosen, 300 m far each other, having the same crop and crop management inside.

The first greenhouse (Fig. 1), named 1, had a steel frame and an elliptic roof with the minor semiaxis 2.10 m long. The walls and the roof where realized with plastic films (PE).

The second greenhouse (Fig. 2), named 2, had a steel frame and a sloping roof of 25°. The walls and the roof where realized with glass panels.

Tables 1 and 2 show the main characteristics of the greenhouses. Inside both of them there was a crop nursery (melon, tomato, courgette, aubergine plants). The plants were located in alveolate boxes placed in benchs 0.70 m tall.

As shown in tables 1 and 2, the only difference between the two greenhouses is represented by the covering material, since structure, crop, exposure, spans, area, volume and openings percent are very similar.

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. Two indoor air quality monitor (IAQRAE PGM – 5210 and MultiRae IR PGM-54) were used. They are portable instruments that 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.

During the tests the doors were always closed. The instruments were placed at a height of 1.6 m from the ground in the middle of the greenhouses. They were placed inside each greenhouse before pesticide treatment.

During the pesticide treatment all the side openings were opened in greenhouse 2 and half of them in greenhouse 1; no artificial ventilation systems worked.

The measurements were recorded in the space of 24 hours.

Outside temperature and relative humidity were recorded by means of a data logger (Babuc M) equipped with a thermohygrometer probe (BSU401) and providing real time measurements every 120 s in the space of 24 hours.

The tests were carried out in May and June, when ambiental temperature was higher than 20° C. The pesticide treatments were performed during the afternoon. The following active principles were used: indoxcarbon 30%, thiamethoxan 25%, cipro-conazolo 10% and famoxadone.

RESULTS AND DISCUSSION

Figure 3 shows the trend of outside and inside temperature in the two greenhouses. The temperature inside greenhouse 2 was higher than the temperature inside greenhouse 1 of about 10°C between 7.00 and 16.00. In greenhouse 2 a peak of 50°C was recorded between 14.00 and 16.30. Outside temperature was only just higher than 30°C.

The difference of the temperature inside the two greenhouses is exclusively due to the different cladding material. In fact both the glass and the plastic film have high transparency respect to the solar visible radiation (380-760 mμ), but the glass has higher opacity than plastic film respect to the infrared radiation that causes an increase of the inside temperature (greenhouse effect).

Figure 4 shows the trend of relative humidity outside and inside the two green-houses. Relative humidity inside the greenhouses shows a similar trend with the highest values (90 – 95%) recorded between 22:00 and 6:00. Relative humidity inside greenhouse 1 was a little higher than greenhouse 2 between 14.00 and 18.00.

Figure 5 shows the trend of CO_2 in the two greenhouses. The highest concentra-tion was recorded in greenhouse 1 in the night (270 – 310 ppm between 22.00 and 6.00). Inside greenhouse 2 the concentration of CO_2 between 11.00 and 19.30 was at least 50 ppm higher than the values recorded in greenhouse 2 in the same period.

In Figure 6 the trend of the concentration of VOC is shown. The graphics show a peak, respectively, of 4.05 ppm in greenhouse 2 and 3.1 ppm in greenhouse 1. The VOC concentration increases, both in the two greenhouses, immediately after the pesticide treatment; they decrease to zero 90 minutes after the treatment.

CONCLUSIONS

The results of the research can be summarized as follows:

- In the greenhouse covered with glass panels the values of the temperature were higher than the values obtained in the greenhouse covered with plastic films. The limit value that causes hyperthermia and heatstroke on man (41°C) was exceeded only in greenhouse 2 between 10.00 and 17.00, when crop management is performed.
- The relative humidity critical values (>70%) were recorded during the night both in the two greenhouses, when no operators were inside.
- The highest CO_2 values were recorded both in the two greenhouses during the night; they were lower than the limit value for the health of the operator (5000 ppm).
- The concentration of VOC after the pesticide treatments persist both in the two greenhouses until 90 minutes after the treatment (between 16.30 and 18.00 in greenhouse 1 and between 19.00 and 20.30 in greenhouse 2). In the same period relative humidity increases. These values are lower than the critical value for the health of the operator (5.00 ppm).
- NO_2 values were always equal to zero.

ACKNOWLEDGEMENTS

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Literature Cited

Castellano, S. and Scarascia Mugnozza, G. 2003. The influence of the structural design in the greenhouse quality management. In: XXX CIOSTA – CIGRV Congress, Turin.

EN 13031-1. 2001. Greenhouses: Design and construction – Part 1: Commercial production greenhouses.

Monarca, D., Cecchini, M., Marucci, A. and Porceddu, P.R. 2003. Microclimate risk for workers in greenhouses. In: XXX CIOSTA – CIGRV Congress, Turin.

Romero, A., Garcia, J.L., Benavente, R.M., Luna, L. and Parames, E. 2002. Effect of side and roof opening area on greenhouse temperature conditions. In: EurAgEng, Budapest.

Russo, G. and Anifantis, C. 2003. Safety at work for greenhouse agricultural production: structural, equipment and environmental aspects. In: XXX CIOSTA – CIGRV Congress, Turin.

UNI EN 13206. 2002. Film termoplastici di copertura per uso in agricoltura ed orticoltura.

Kittas, C., Bartzanas, T. and Boulard, T. 2002. Influence of the heating system on greenhouse microclimate during night time. In: EurAgEng, Budapest.

Tables

Table 1. Main characteristics of the greenhouses.

Greenhouse	Cladding material	Structure	Crop	Exposure	Span [n]
1	Plastic Film	Steel	Plant nursery	East-Western	3
2	Glass	Steel	Plant nursery	East-Western	3

Table 2. Main characteristics of the greenhouses.

Greenhouse	Shape of the roof	Area [m²]	Volume [m³]	Side openings [%]	Roof openings [%]	Doors [m²]
1	Ellipse	2.500,00	11.750,00	8,10	0,00	4,99
2	Sloping	2.500,00	11.125,00	4,50	4,70	13,31

Figures

Fig. 1. Greenhouse 1.

Fig. 2. Greenhouse 2.

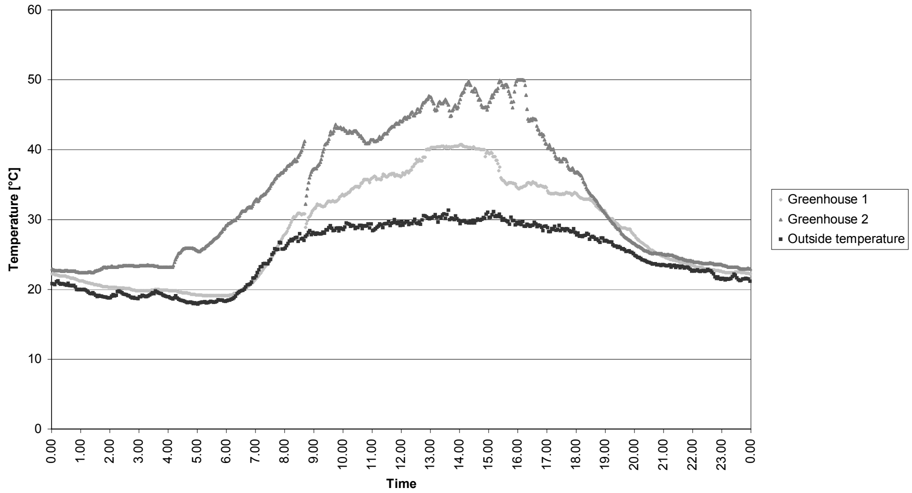

Fig. 3. Temperature inside and outside the greenhouses.

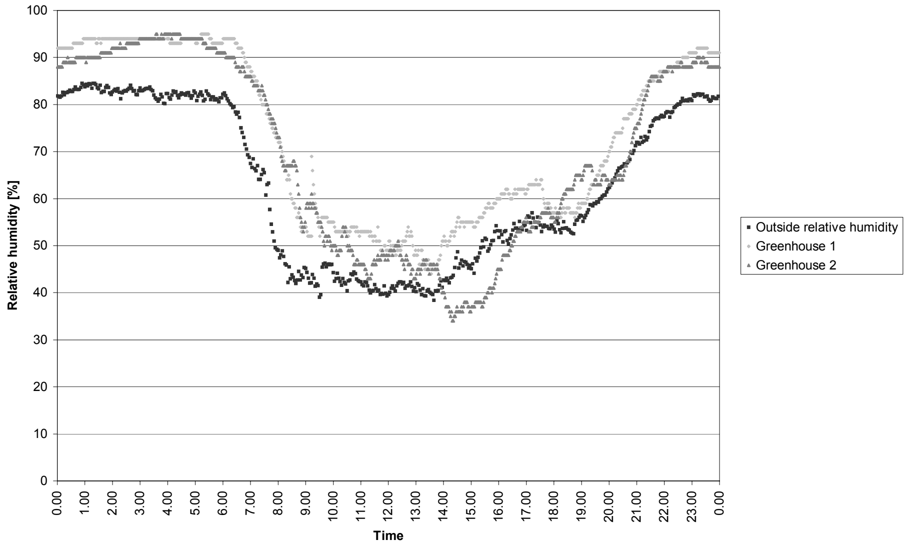

Fig. 4. Relative humidity inside and outside the greenhouses.

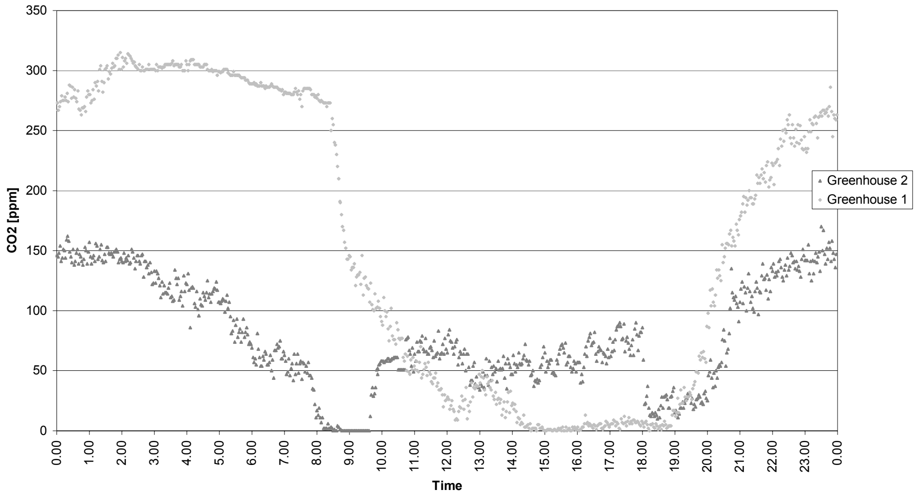

Fig. 5. CO_2 inside the greenhouses.

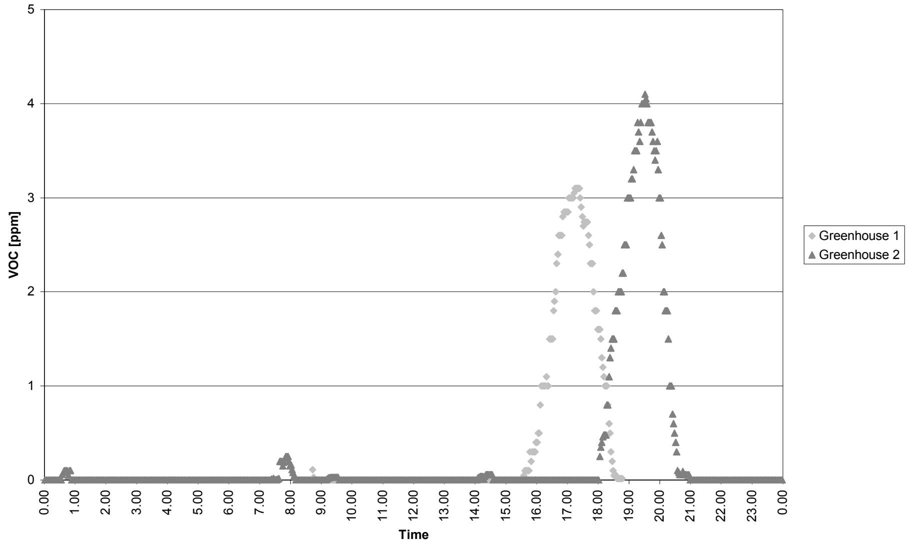

Fig. 6. VOC inside the greenhouses.