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BEST PRACTICES

Environmental control in greenhouses in Mediterranean area

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Summary

Explain your case in one or two sentences

This text aims to propose active and passive methods that could be applied to control climate and CO_2 levels inside a Mediterranean greenhouse, without affecting the yield amount and quality. The main greenhouse environmental control systems are heating, dehumidification, ventilation, shading, and cooling systems.

Background information: How was the situation previous to your actions?

The lack of climate control in many greenhouses in Mediterranean countries results in an inadequate microclimate that negatively affects yield components and input-use efficiency. A better control of the greenhouse aerial environment can improve marketable yield and quality, and extend the growing season.

What were the needs you identified?

Temperature and humidity are the most important variables of the greenhouse climate that need to be controlled. Plants have to be grown within the sub- and supra-optimal temperature and relative humidity values. Additionally, CO_2 concentration has to remain at the optimum levels to enhance

crop photosynthesis. All these variables are strongly related to the energy consumed for greenhouse operation.

What solution you found to cover those needs?

Reduction of the heat load is the major concern for greenhouse climate management under hot climate conditions. This can be achieved by reducing incoming solar radiation, removing the extra heat through air exchange, and increasing the fraction of energy partitioned into latent heat. Shade screens and whitewash are the major methods used to reduce the incoming solar radiation. Ventilation is an effective way to remove the extra heat through air exchange between inside and outside when outside air temperature is lower. Evaporative cooling is the common technique to reduce sensible heat load by increasing the latent heat fraction of dissipated energy.

What actions did you take to reach the solution?

- Calculation of the ventilation rate considering outside solar radiation, greenhouse's dimensions, air- exchange and required difference between outside and inside temperature.
- For effective ventilation, ventilators should, if possible, be located at the ridge, on the side walls and the gable.
- Total ventilator area equivalent to 15 – 30% of floor area is recommended for natural ventilation. Above 30%, the effect of additional ventilation area on the temperature difference is very small.
- The entry of unwanted radiation (or light) during sunny summer days can be controlled by the use of shading or reflection.
- Greenhouse whitening has many advantages compared to other shading methods.
- Evaporative cooling allows simultaneous lowering of temperature and vapour pressure deficit and can lead to greenhouse air temperatures lower than outside air temperature. Its efficiency is higher in dry environments.
- Fog systems, especially the high pressure systems, have many advantages compared to other cooling methods.
- The nozzles of the fog system should be located at the highest possible position inside the greenhouse to allow water evaporation before the water drops to crop or the ground.
- During the operation of a fog system, a ventilation opening of 20% of the maximum aperture should be maintained.
- Calculation of greenhouse's heating needs based on concrete steps considering factors like dimensions and other characteristic features of the greenhouse, desired temperature difference, and heat losses.
- Use of water to store heat (a simple passive solar heating system), use of barrels or plastic tubes filled with water inside the greenhouse to capture the sun's heat.
- Use of greenhouse fans to circulate the heat from greenhouse ceiling to floor.
- Continuous monitor of indoor and outdoor climate conditions.
- Keep and follow a heating checklist.

- CO_2 depletion could be avoided by increasing the ventilation rate through forced air, improving the management of the ventilation system, or providing CO_2 enrichment.
- The ventilation scheme of the greenhouse has to ensure the inflow of CO_2 and the maintenance of an adequate temperature in the greenhouse simultaneously, particularly during sunny days
- Reduce humidity to 70 – 80% as night falls to prevent condensation.
- Reduce humidity to prevent condensation and start transpiration as the sun rises.
- Remove any excess sources of water from the greenhouse.
- Use of indoor thermal screens to balance the ambient temperature of the greenhouse and reduce heating costs. They can be opened or closed voluntarily depending on the external weather conditions and the crop. They offer a certain level of shade during the day reflecting outward unwanted solar energy and when opened during night, limit radiative cooling and losses of heat.
- Use cover materials with special properties such us internal films for anti-dripping effect for the control of condensation and humidity and disease management.
- Placement of radiant heat sources near the crop to keep plant's surfaces slightly warmer than air.

If any, which partners or other organisations did you involve during the process?

- Institute for Bio-Economy and Agri-Technology, Greece
- Wageningen UR Greenhouse Horticulture, The Netherlands

What were the main problems or difficulties you had to face?

- Forced ventilation by fans is the most effective way to ventilate a greenhouse, but it consumes electricity.
- Natural or forced ventilation is generally not sufficient for extracting the excess energy during sunny summer days.
- Before installing an evaporative cooling system, the required water flow rates have to be calculated.
- The orientation and insulation of the greenhouse affects positively or negatively the heating losses and therefore the heating strategy and costs.
- The poor efficiency of ventilation systems of the low-cost greenhouses in Mediterranean countries, coupled with the use of insect proof nets, results in relatively high CO_2 depletion.
- Establishing optimal CO_2 set points is a complex procedure as they depend on several factors like photosynthesis rate, indoor CO_2 balance affected by ventilation, economic issues, etc.
- Condensation can be a major problem and unfortunately, at least at certain times of the year, it can't be avoided entirely.

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What is the situation now, after your actions?

Improvements have been achieved regarding the environmental control inside the greenhouse. Efficient measures have been applied to control temperature, humidity, and CO_2 levels through adjustments of ventilation, shading, cooling, heating, and dehumidification.

Main lessons learned along the way? *

Clearly there are numerous technologies for greenhouse systems which can be adopted by the farmers enabling better, more efficient, and sustainable environmental control. However, many obstacles and constraints remain to be solved that are related to the application of the existing technology and know-how to greenhouses in Mediterranean area, to the high technology cost compared to the modest investment capacity of Mediterranean farmers, to the adaptation of technology to the problems that are encountered in Mediterranean greenhouses.

Sources:

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