Heating and dehumidification in production greenhouses at northern latitudes: energy use

Dehumidification

F. Kempkes, Wageningen UR Glastuinbouw
Energy saving & Humidity

- Energy saving matters taken:
  - Decrease of temperature setpoints
  - Increase of humidity setpoint
  - Increase of insulation
  - **all matters will increase humidity**

- Humidity control:
  - The aim of humidity control is to **PREVENT CONDENSATION ON THE PLANT**

- Condensation causes:
  - Increased risk of diseases
  - And risk increases with longer wet periods
Humidity control: condensation

How does condensation happen?

The temperature of the plant surface is lower than the dew point temperature of the greenhouse air. Thus the difference between the plant temperature and dew point ('humidity deficit') must be increased.

How to do this:
1. Increase crop temperature
2. Decrease dew point temperature
Humidity control: condensation

How to do this:
1. Increase crop temperature
2. Decrease dew point temperature

- Solar radiation (no shading)
- Energy screen (closed at night)
- Heating pipes on
- Air movement
  (to bring $T_{\text{crop}}$ closer to $T_{\text{air}}$)
- Artificial light

- Ventilation with dry outside air
- Condensation on cover
  (Avoid dripping on plants!)
- Active dehumidification
Humidity control: take the right matters, example

Ventilation and temperature

Temperature range allowed by ventilation management
Humidity control: take the right matters, example

Ventilation and temperature

- Ventilation does not dry the air
- Outside temperature trend
- Well-ventilated temperature trend
- Unventilated temperature trend
Dehumidification costs energy - because

Sensible heat loss during ventilation

Water vapour

Latent heat uptake by the crop
Dehumidification

- How to reduce losses
  - Reducing the transpiration rate during heating periods
  - Reduce the Sensible/Latent ratio of the ventilation air
  - Both measures imply growing at higher humidities
- OR
  - Make use of the cold roof top (condensation)
  - Energy efficient system
Condensation

- Condensation on inner side of roof
  - Glass temperature < dew point temperature of greenhouse air

Percentage of the day the cover is (partially) wet

Tomato crop 100 l/(m² year)
Saving on energy for dehumidification

→ control on a higher setpoint

Crop evaporation [kg/(m² year)]

Evaporation in periods with heating

Evaporation in periods without heating
(480 kg/(m² year))

48 kg/(m² year) reduction
Accurate humidity control

Humid air leaving the greenhouse

The humid and warm air is pushed through the screen and through small window openings

Crop is dried at the most vulnerable parts with dry outside air

Outside air is dry, but cold

Preheating in the air treatment unit

Outside air is dry, but cold

Accurate humidity control

Humid air leaving the greenhouse

The humid and warm air is pushed through the screen and through small window openings

Crop is dried at the most vulnerable parts with dry outside air

Outside air is dry, but cold

Preheating in the air treatment unit
Air exchange from above the screen

- Vents can be opened to reduce dew point temp. cover
Ventilation jets: (local system)
Three ways to reduce this heat loss

- Balance ventilation system
- Condensation by cooling
- Hygroscopic drying
Comparison of capacity

Dehumidification capacity \([\text{gr}/(\text{m}^2 \text{ hr})]\) @RH = 85%

- Do we know transpiration rate crop & soil
- @lower temperatures brine in advantage
- Capacity (balance) ventilation system depends on Abshum difference in-outside
Conclusions:

Allowing high humidities is a first step to save on dehumidification costs. A proper system to safely enable a high humidity control saves around 200 MJ/(m² yr).

The simplest system to further decrease energy costs for dehumidification retains sensible heat and saves around 130 MJ/(m² year).

When using a cooling system to condense the moisture excess sensible and latent heat can be recovered, saving 220 MJ/(m² year).

When using a hygroscopic dehumidification system sensible and latent heat can be recovered more effectively → expected saving of 250 MJ/(m² year).

holding for tomato in NL weather 1100 MJ/(m² yr)
Questions?

Thank you for your attention