Energiezuinig ontvochtigen

Masterclass 26 november 2015 HAS Den Bosch
BOGO project "Klimaat en energie: nieuwe low input teeltsystem in de tuinbouw"

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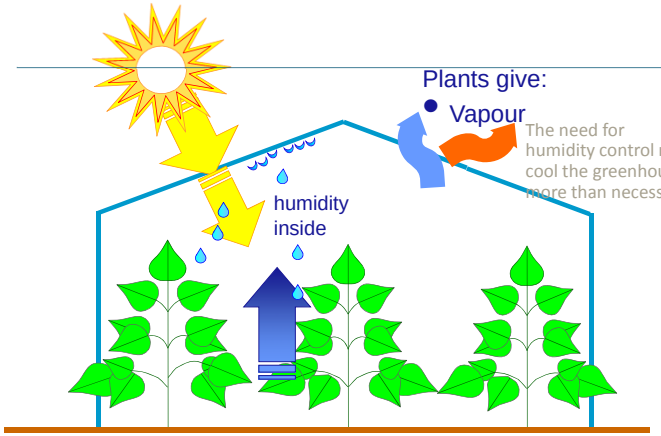
Ministerie van Economische Zaken

How does a greenhouse work: humidity



The need for humidity control may cool the greenhouse more than necessary

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Climate control, humidity

Relative Humidity or vapour deficit ?

- Absolute humidity
  ➔ amount of water in air [g/kg or g/m^3]
- For the control Absolute Humidity difference in- & out-side is most important
  - $Abshum_{in}$ >> $Abshum_{out}$ open the window
  - $Abshum_{in}$ <= $Abshum_{out}$ increase T_{inside}
- Outside air (dryer '≈always')
  - Latent and sensible heat loss
  - Minimise sensible heat loss (winter)

  ➔ ventilation

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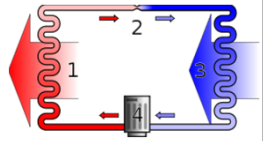
Climate control, humidity

- Cover
  - condensation → cover temperature
  - Condensation heat stays inside
- Mechanical dehumidification
  - condensation → cold surface
  - What cold source? ➔ Production costs energy
  - Temperature below dew point else no condensation at all as well loss of sensible heat (pre heat back to air temperature?)



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Climate control, humidity

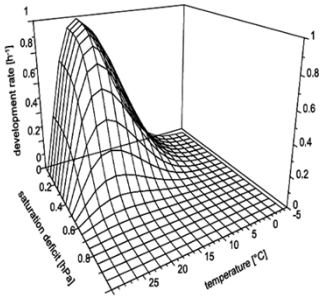
- Energy fluxes
- Transpiration needs energy
  - If warm it cools the greenhouse
  - If cold 'extra' heating energy required
- Condensation releases energy

Melting vs freezing of water

Climate control, humidity

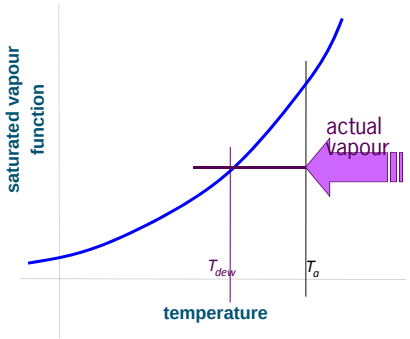
Botrytis

- Chance for Botrytis is high when crop (parts) become wet
- Wet crop caused by
  - Condensation
  - Guttatie (root pressure)
- Chance for infection increases with duration of wet crop

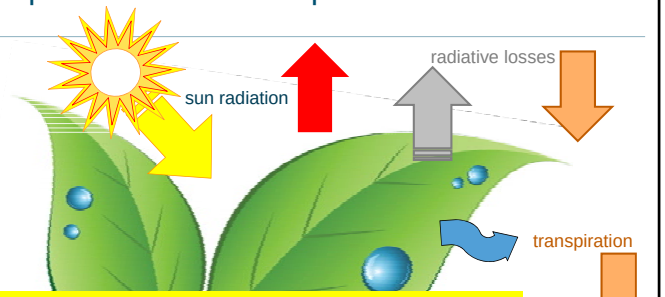


Climate control, humidity

- Vapour content in air can also be described in terms of **dew point**, that is the temperature at which air with given vapour content would be saturated



Crop cooler than dew point of the air

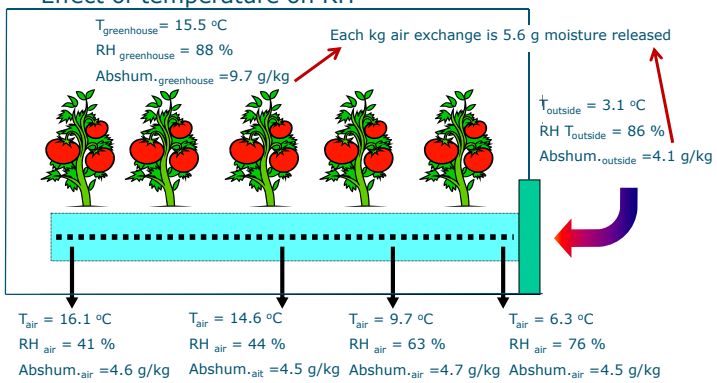


The crop at night is cooler than the air, but it should be warmer than dew point…

Crop temperature ~ air temperature, but…

Climate control, humidity

Effect of temperature on RH



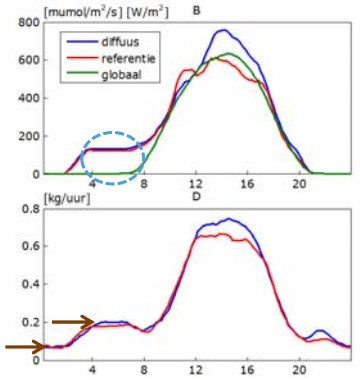
Climate control, humidity

Transpiration how much we have?

Effect of artificial lighting (180 µmol/m²/s) on transpiration.

Mainly related to:

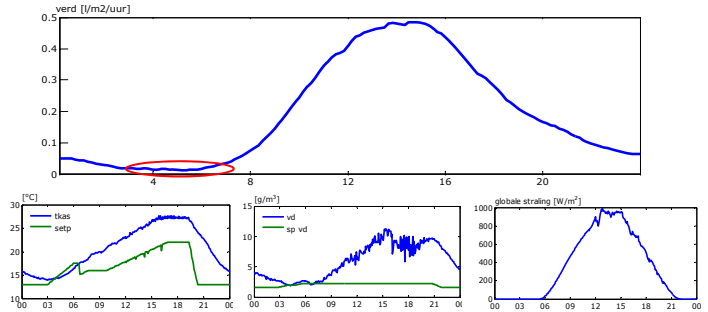
- Radiation
- Humidity
- LAI
- CO_2



Climate control, humidity

Transpiration: full grown tomato crop

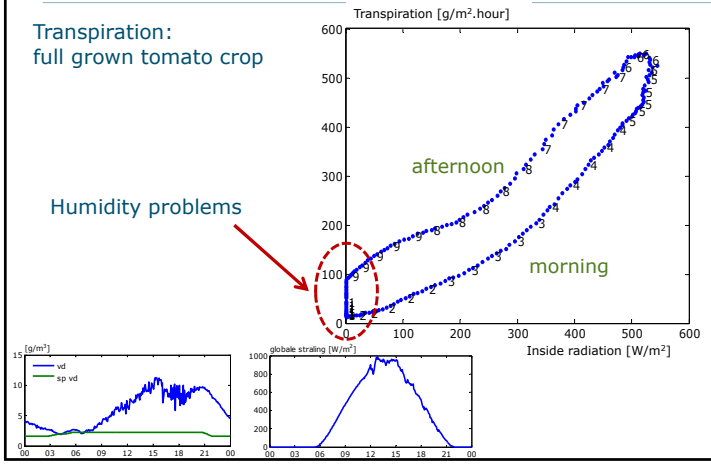
20 a 30 gram/m²/uur at the lower side is not eq min transpiration



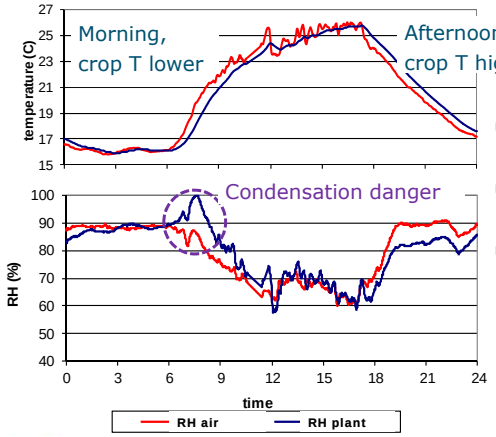
Climate control, humidity

Transpiration:
full grown tomato crop

Humidity problems



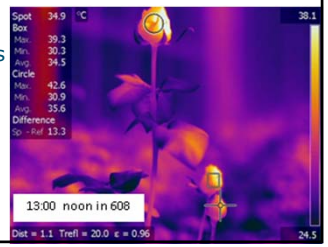
Climate control, humidity



- RH air is controlled
- RH plant shows problem
- Good plant temperature measurement is difficult

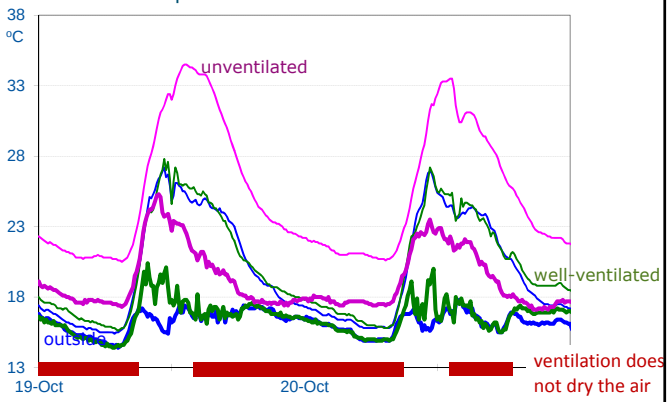
Climate control, humidity

- Plant, where to condensate?
- Plant temperature
  - Cover temperature & screen control
  - Radiative heat losses (night)
    - Effect of cover material (glass / plastic, τ_{ir})
    - Plant shape (gerbera)
  - Plant health
  - Plant type (pot plants versus tomato)
  - Plant part (leave or flower bud)



Climate control, humidity

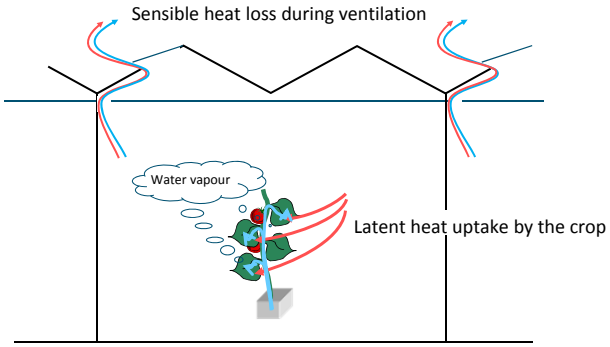
Ventilation and temperature



Climate control, humidity

- Effect of low humidity on crop
  - Small leaves
  - Blossom end rot
  - Delayed growth
  - Smaller buds
  - Smaller fruits (better taste)
  - Less fungi
  - Loss of production
  - Generative growth
- Effect of high humidity is in general positive for crop production unless diseases become a problem

Dehumidification costs energy - because

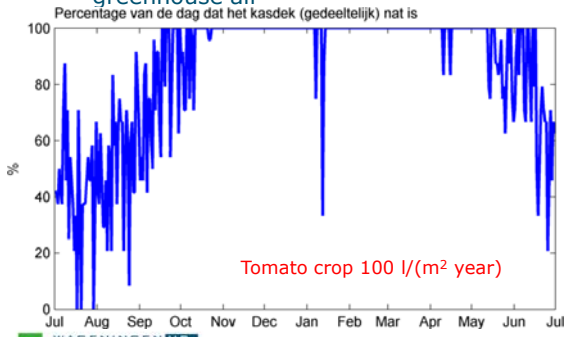


Dehumidification

- 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

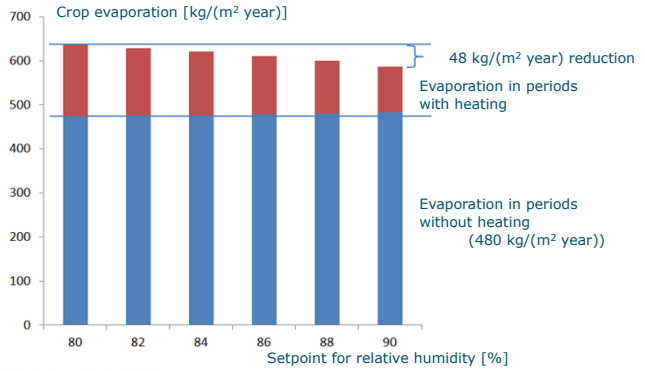
Condensation

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

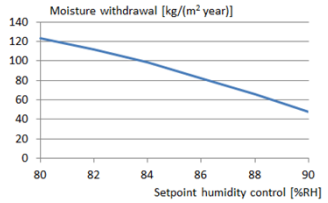


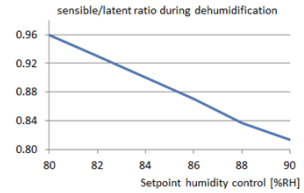
Saving on energy for dehumidification

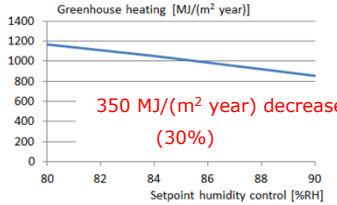
→ control on a higher setpoint



Saving on energy for dehumidification

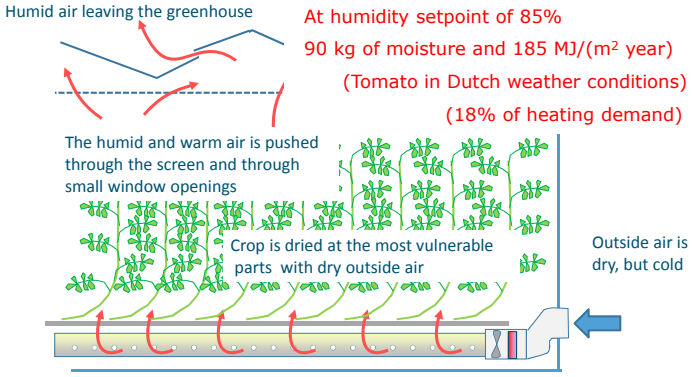




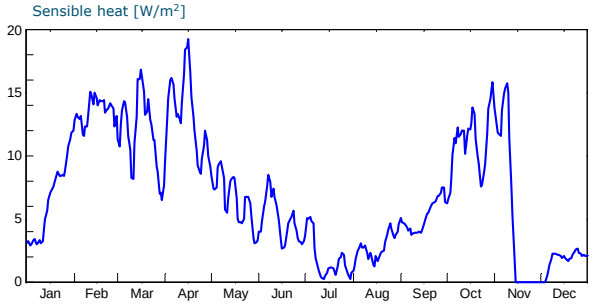


350 MJ/(m² year) decrease (30%)

Accurate humidity control



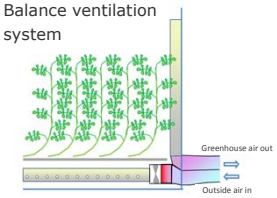
Sensible heat loss due to dehumidification



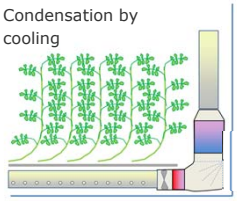
185 MJ/(m² year)

Three ways to reduce this heat loss

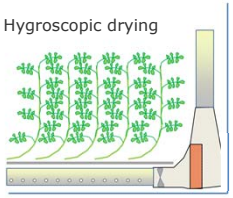
Balance ventilation system



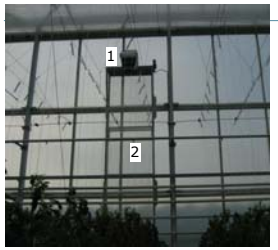
Condensation by cooling

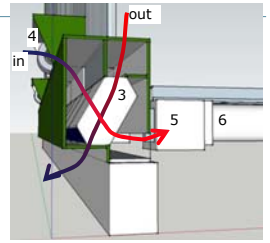


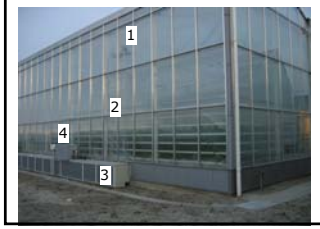
Hygroscopic drying



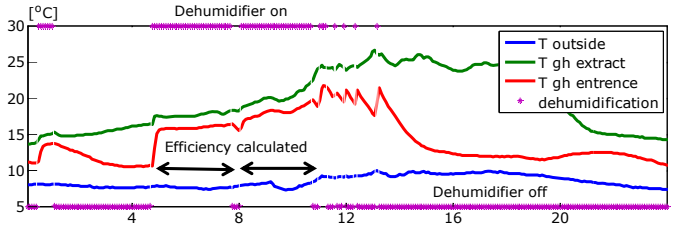
Regain







Efficiency van de regain unit



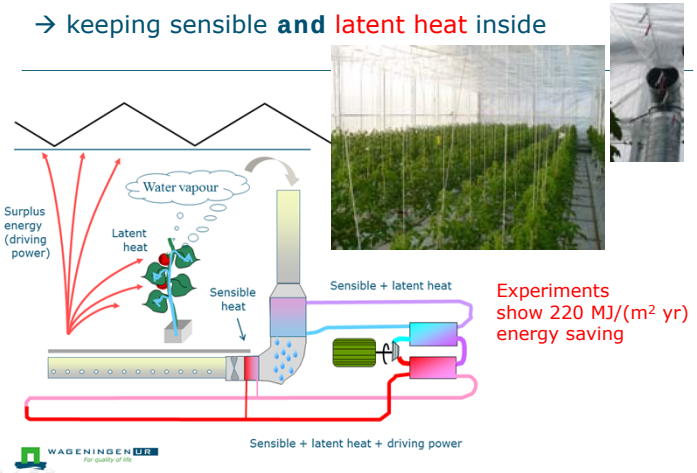
- Efficiency of this regain unit is about 82% (sensible heat)
- Switching on /of reduces the efficiency (vary the fan speed)

Balance ventilation
→ 60 to 80% regain of sensible heat

185 * 70% = 130 MJ/(m^2 yr) energy saving

Condensation on cold surface

→ keeping sensible **and** latent heat inside

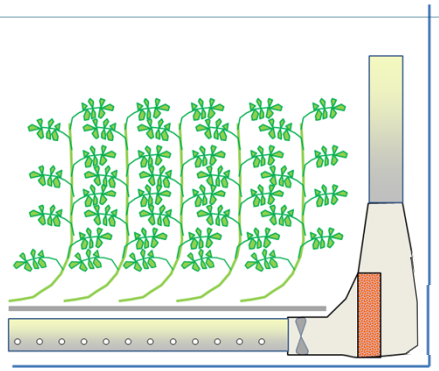


Experiments show 220 MJ/(m² yr) energy saving

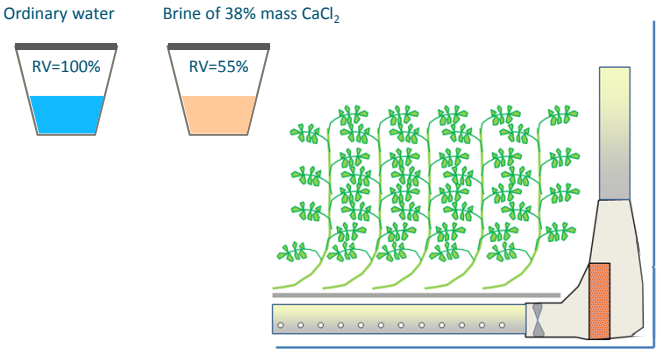
Greenhouse is closed in winter

Hygroscopic dehumidification

→ keeping sensible **and** latent heat inside



Hygroscopic dehumidification principle

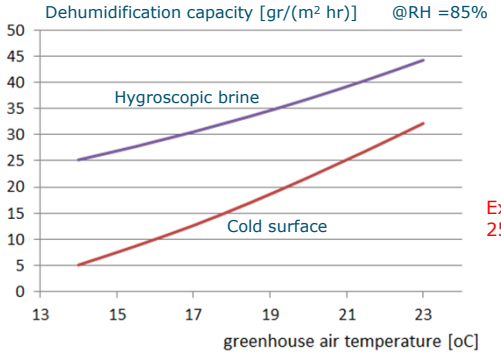


Hygroscopic dehumidification

→ orienting experiments

Comparison of capacity

air circulation rate: 10 $m^3/(m^2\ hr)$



Expected savings: 250 $MJ/(m^2\ yr)$

- @lower temperatures brine in advantage

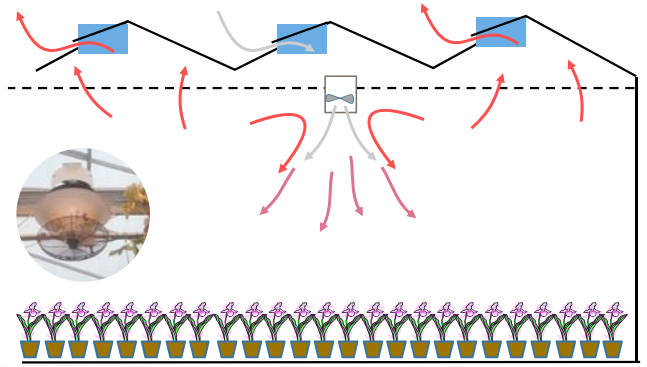
Conclusions:

(holding for tomato in NL weather)

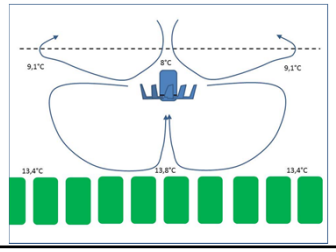
- Allowing high humidities is a first step to save on dehumidification costs. A proper system to safely enable a high humidity control saves around 200 $MJ/(m^2\ yr)$
- The simplest system to further decrease energy costs for dehumidification retains sensible heat and saves around 130 $MJ/(m^2\ year)$
- When using a cooling system to condens the moisture excess sensible and latent heat can be recovered, saving 220 $MJ/(m^2\ year)$
- When using a hygroscopic dehumidification system sensible and latent heat can be recovered more effectively → expected saving of 250 $MJ/(m^2\ year)$

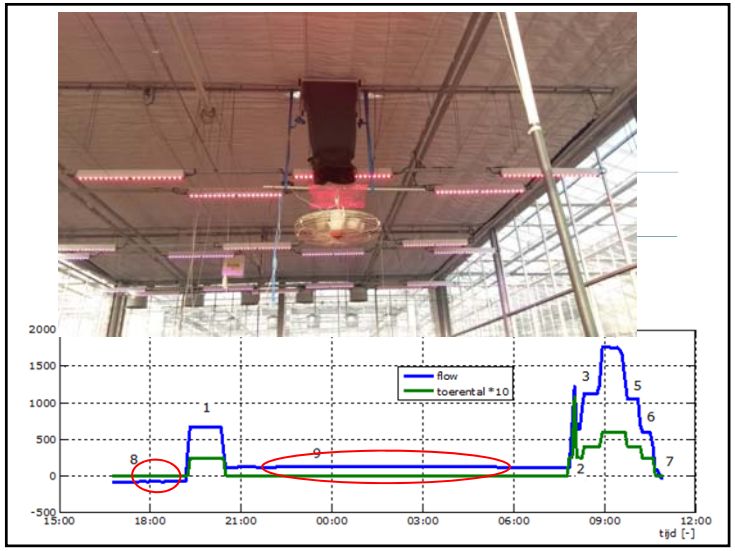
Or exchange air from above the screen

- Vents can be opened to reduce dew point temp. cover



Ventilation jets: (local system)





Dehumidification & Air circulation

- Dehumidification else than by vents means forced air movement (distributed or free
- Air circulation lowers ALWAYS the difference between crop and air temperature
  - It cools if crop is warmer
  - It warms if crop is cooler
- Thus it certainly may help when there is risk of condensation

Climate control, humidity

- Systems for dehumidification
  - Air distribution /central system

Climate control, humidity

- Systems for dehumidification
  - Air distribution /central system

Climate control,

- Air distribution
  - Air takes way of less resistance
  - Solution of poor distribution is in general not to circulate more m^3
  - High air speeds increases the transpiration

Climate control,

- Vertical temperature distribution
  - Be aware mechanical systems can change natural air flows in greenhouse systems
  - Dehumidification systems are not for cooling (too low capacity)
  - Cold air is heavy (stays at bottom)
  - For natural air mixing bring cold air in above the crop
  - Bringing in cold air from below (in case dry air is not preheated up to greenhouse air temperature) can change (negatively) the vertical temperature distribution (cold feet / warm head) and can create a "dead" climate

Questions?