

Efficient cooling of strawberries during glasshouse production for managing harvest time

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Typical greenhouse strawberry crop in The Netherlands

- Starts late in August to avoid high temperatures and early harvest
- Use of heating for humidity control and air movement around the plant
- Typical energy use $17 \text{ m}^3_{\text{gas}}/\text{m}^2$ per year



Hypothesis: an earlier transplanting would:

- Give enough assimilates for production and an early start of bud development
- Synchronize end of autumn harvest and flower bud development for spring crop cycle
- Night-time cooling (August/September) would spread production and increase fruit weight

➡ Problem: Increase efficiency of night-time cooling



Research questions:

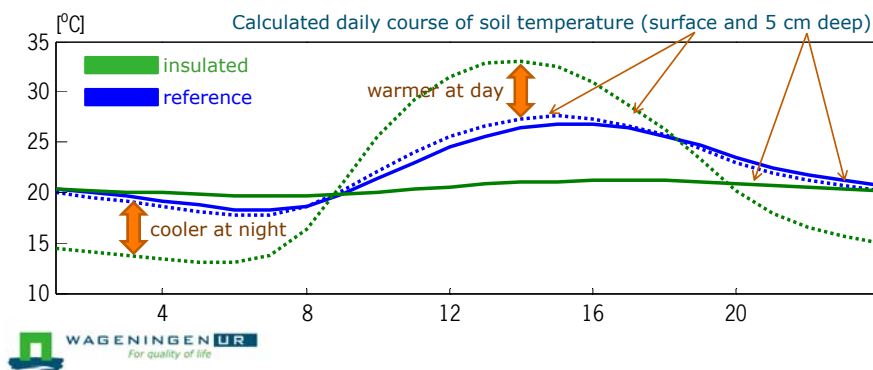
Experts' advice

- Ensure "ideal" daily mean temperature: 13.4°C with an increase of 0.2°C for each 100 J/cm² daily total
- Maintain [at least] crop production and quality
- Reduction of energy consumption by at least 20%



Model simulations to select most promising option(s)

- Misting
- Mechanical cooling
- Forced ventilation on side-wall
- Floor insulation



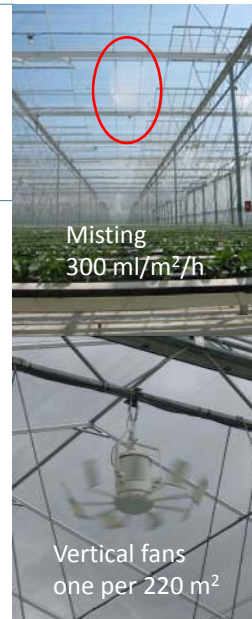
Vertical fans and energy saving



Experimental set-up

1 Ha commercial greenhouse with daytime misting and vertical fans

1.	2.
<ul style="list-style-type: none"> reference joint steering of heating and roof ventilation 	<ul style="list-style-type: none"> night-time misting side-wall fans
3.	4.
<ul style="list-style-type: none"> mechanical cooling joint steering of heating, cooling and roof ventilation floor insulation 	<ul style="list-style-type: none"> mechanical cooling



Capacities and investments

- Misting 6 €/m²
- Vertical fans 3 €/m²
- Mechanical cooling 20 €/m²
 - nominal capacity 200 W/m²
- Side wall fans 2 €/m²
 - capacity 14.6 m³/m²·h
- Insulation 4 €/m²
 - 4 cm polystyrene R=1.15m²K/W



Elsanta planted on August 10 and 11th

Three periods:

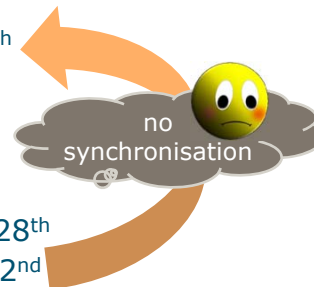
- August 10 - January 5th and 10th
- 3 – 4 weeks cold
- January 28th – June 13th

■ Autumn

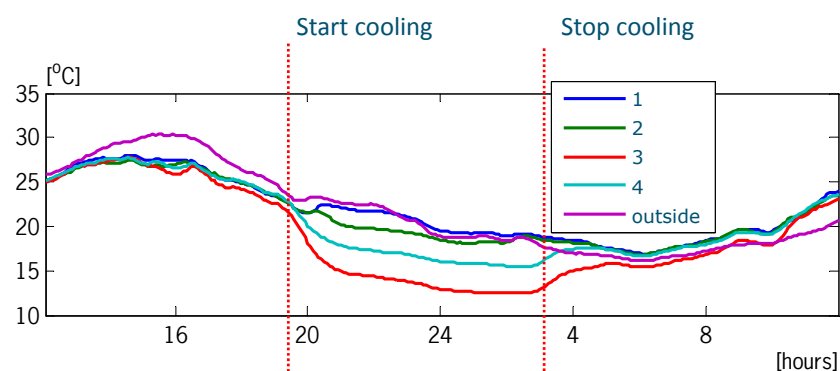
- first harvest September 22nd – 28th
- Last harvest December 15th – 22nd

■ Spring

- Harvest April 5th – June 13th



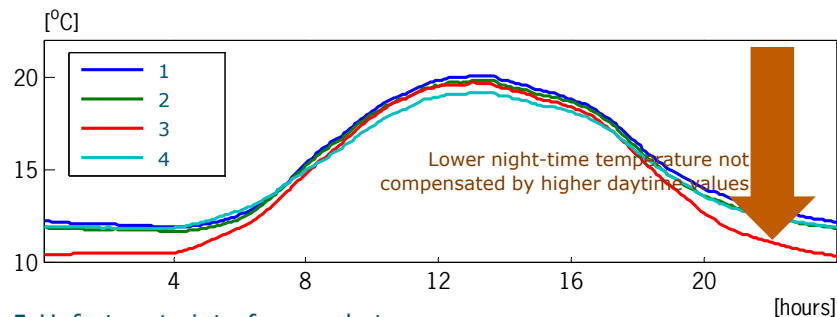
Effect of cooling on air temperature



August 24th 12:00 to August 25th 12:00



Mean daily air temperature course August – December



- Unfortunate interference between treatments and joint climate control
- Failure to reach desired degree days in the cooled compartments



1. reference	2. night-time misting side-wall fans
3. mechanical cooling floor insulation	4. mechanical cooling

Crop and yield

- Over the whole crop cycle no significant differences in
 - crop growth,
 - average fruit weight,
 - yield (5.2-5.4 + 9.2-9.6) kg/m²
- In cooled sections in autumn:
 - lower plant load
 - higher mean fruit weight
 - lower weekly yield
- We did succeed in spreading yield



Conclusions

- Humidity control accounting for vertical fans reduced energy use by 20 %
- The most efficient daytime cooling is by misting
- The most efficient night-time cooling is by floor insulation
- However, floor insulation increases energy consumption when night-time heating is required
- Failure to compensate night-time cooling with higher daytime temperature required heating after end of autumn harvest (5% of yearly energy use)
- Planting date should have been at least one week earlier



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