

Non-chemical means to control strawberry powdery mildew

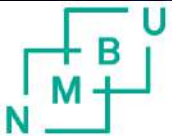
- Overhead irrigation
- Steaming of transplants
- Ultraviolet (UV) light

Arne Stensvand, Belachew Asalf, Aruppillai Suthaparan
Natalia Peres, Rodrigo Onofre, David Gadoury



NIBIO

NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH



Norwegian University
of Life Sciences



CORNELL
UNIVERSITY

Powdery mildew

Podosphaera aphanis

Great differences in
cultivar susceptibility

Symptoms may vary



Photo: A. Stensvand



Hyphae and conidial chains on a strawberry leaf

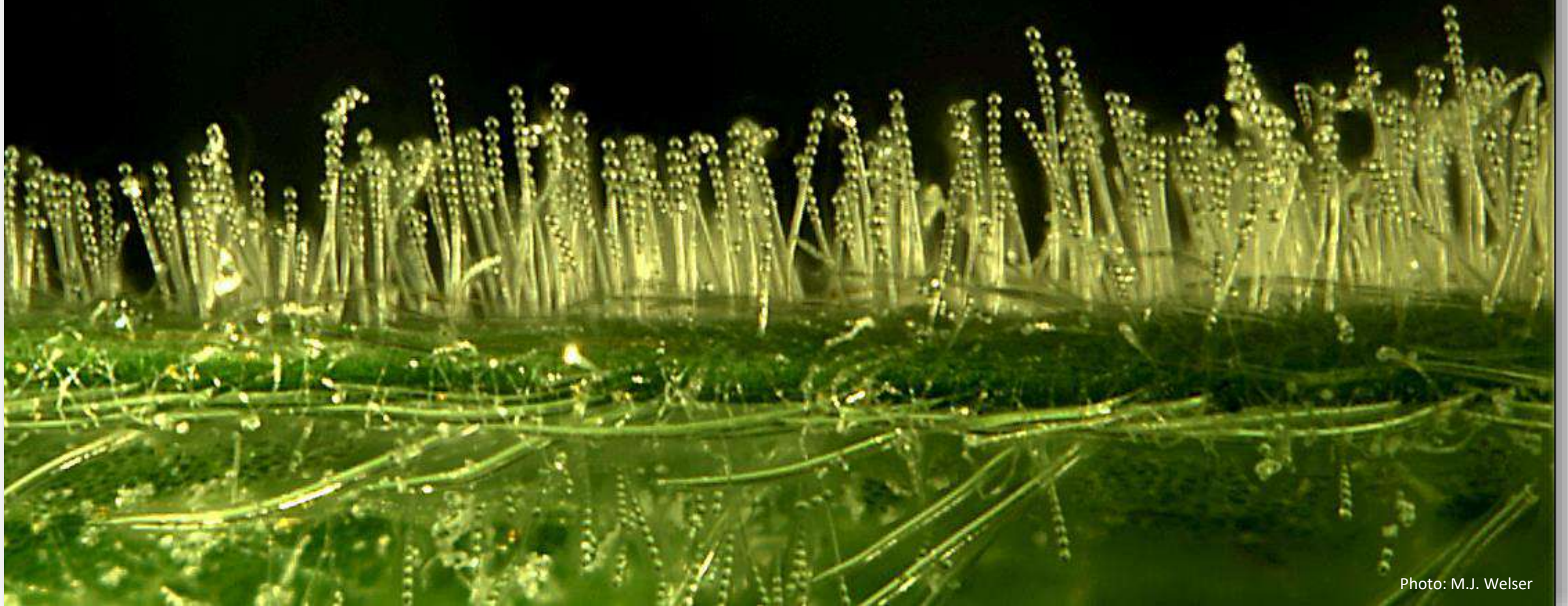


Photo: M.J. Welser

At optimal temperature (around 20°C) it takes only 4 to 5 days from a spore has infected until it forms new spores



Green overwintered leaves
infected with powdery mildew

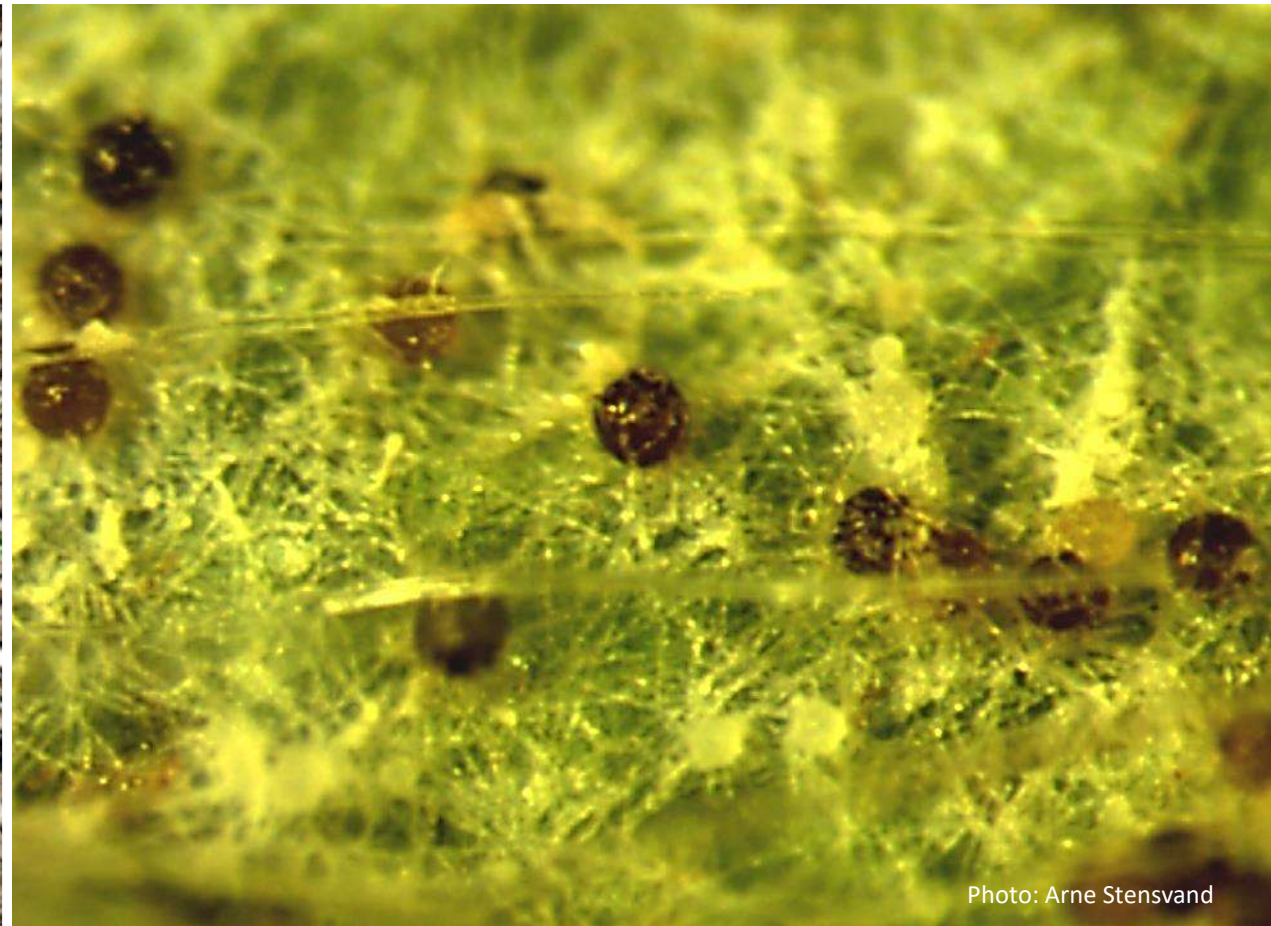
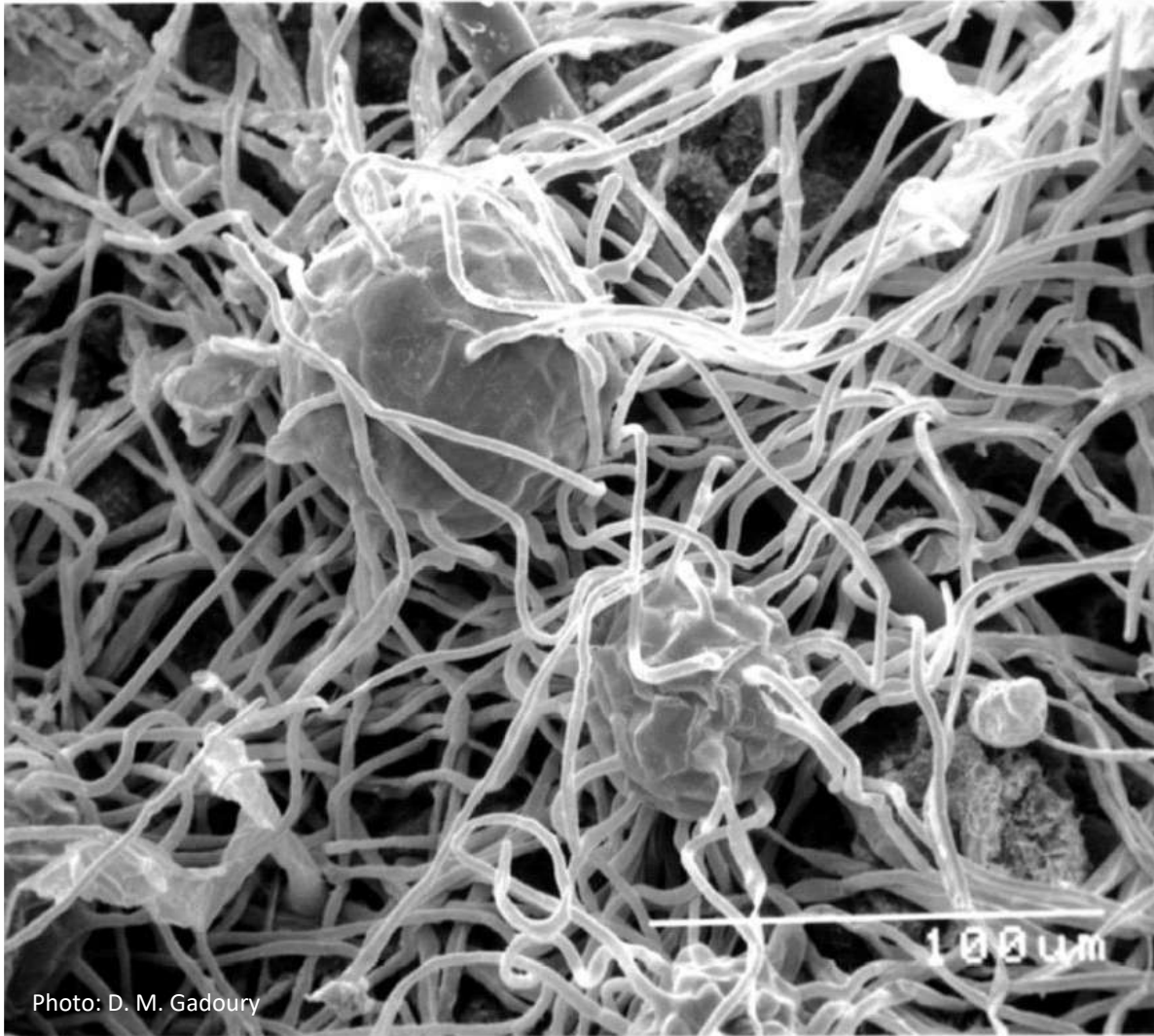


Photo: Arne Stensvand

Dense mat of mycelium with
chasmothecia in early spring

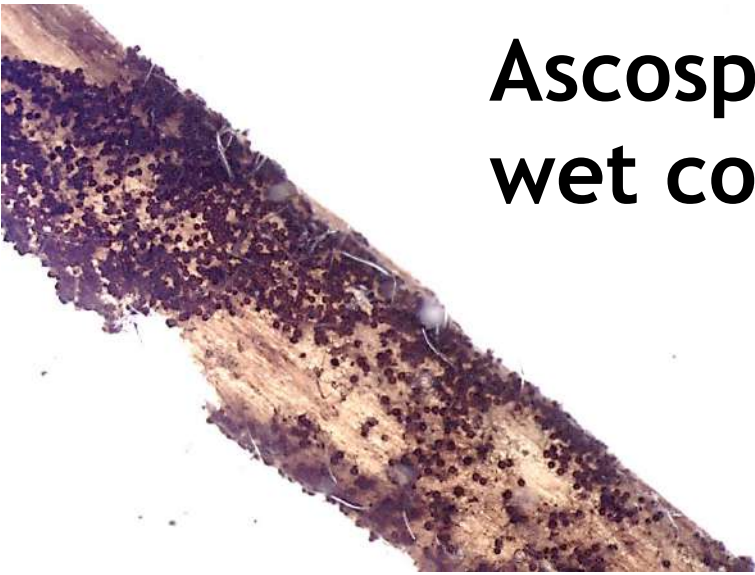


Chasmothecia also form on infected fruit; old overwintered fruit may be a source of inoculum in perennial strawberry fields

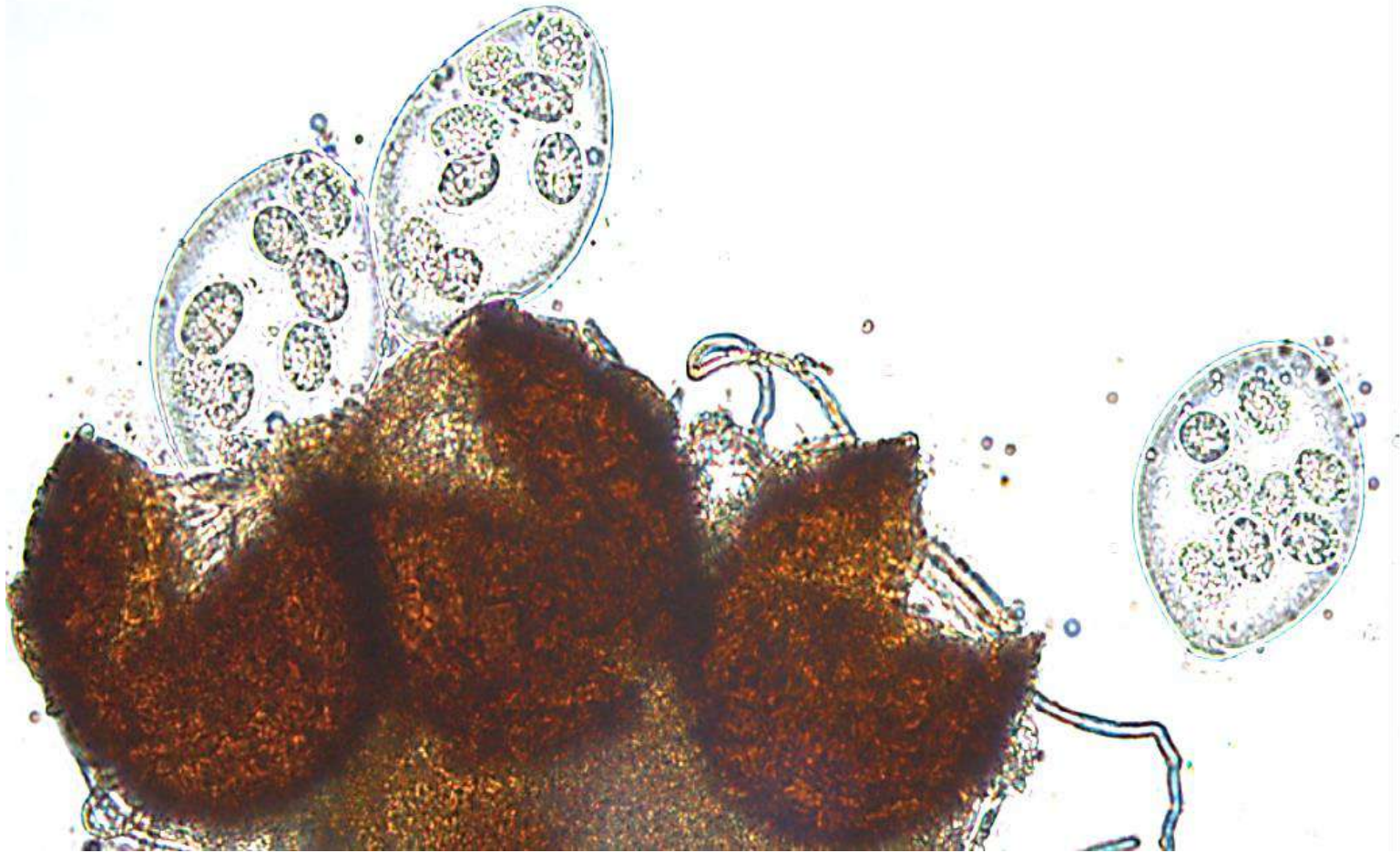


SEM-pictures of chasmothecia embedded in dense mycelial mats and fastened to the leaf surface by appendages

Ascospores spread under wet conditions in spring



Overwintered stolon and leaf with chasmothecia



One ascus with 8 ascospores in each chasmothecium

Young plant tissue
is very susceptible
to powdery mildew;
periods of rapid
growth → more
disease

Flowers and young
green fruit are also
very susceptible,
while white and red
fruit are immune

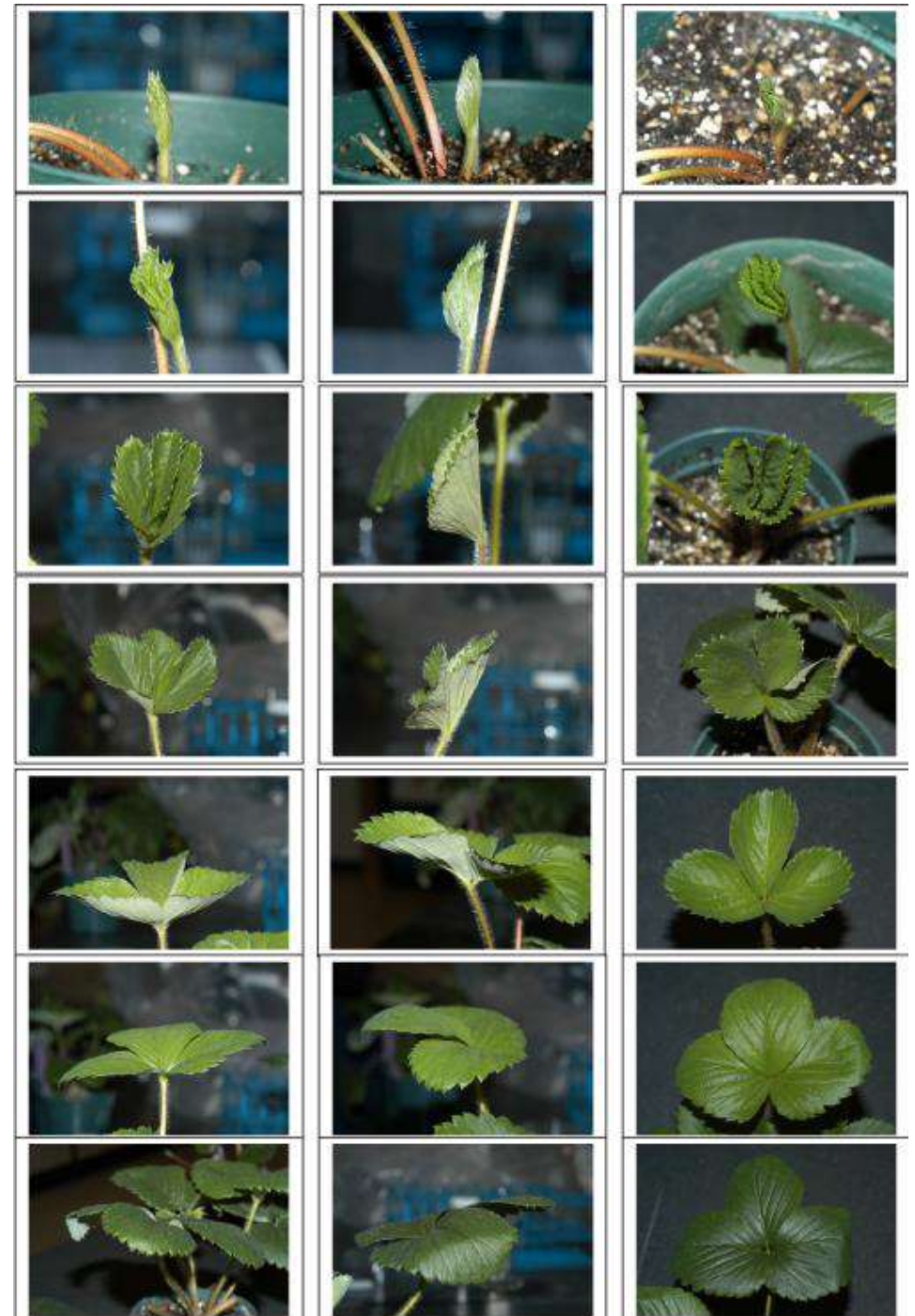
Very susceptible →

Very susceptible →

Susceptible →

Low susceptibility →

Immune →



Runners for propagation - very susceptible to powdery mildew



Chasmothecia on stolons not as strongly attached as on leaves - they can easily slide down to the base where they may stay over winter



Transplants should be clean

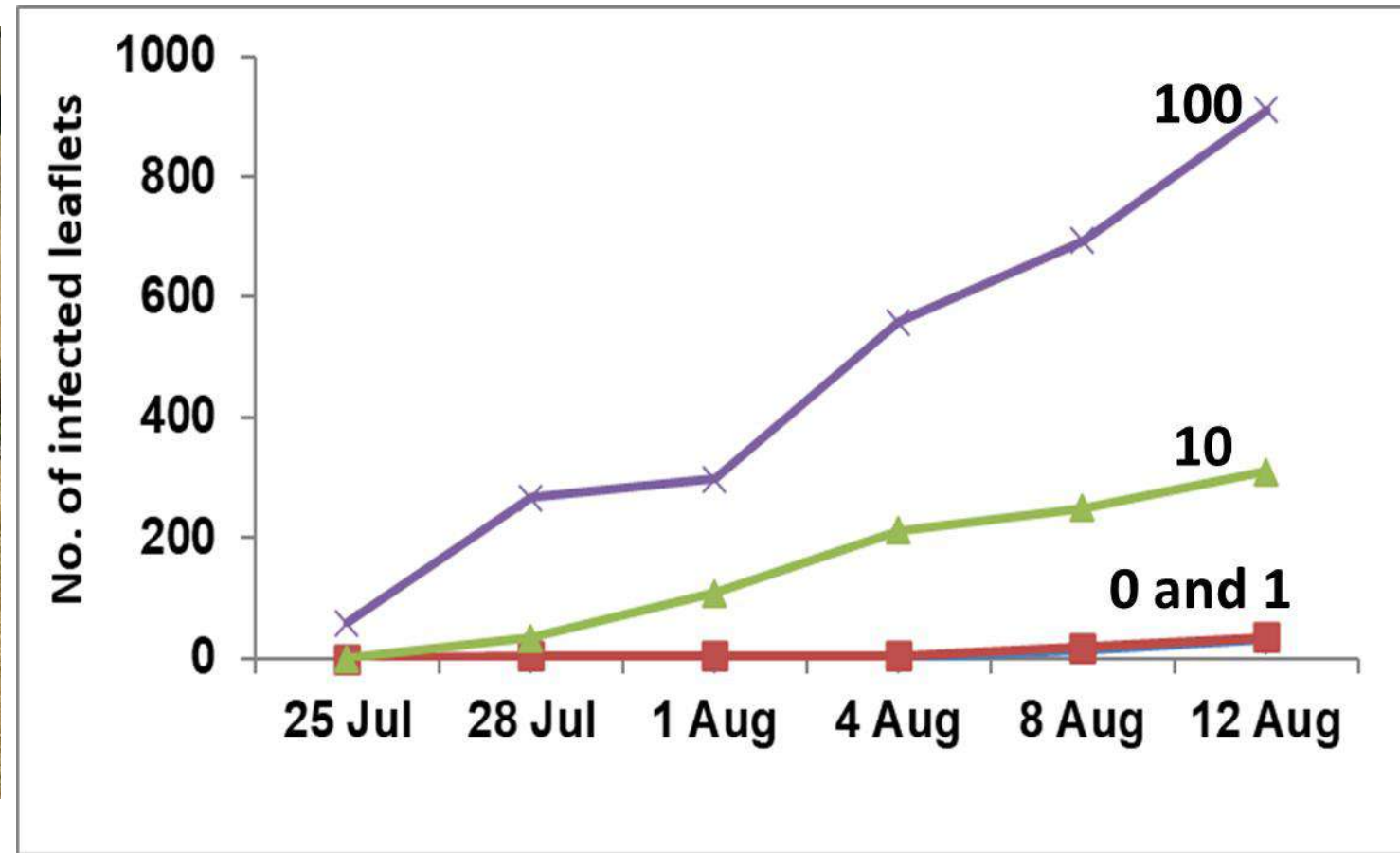


Clean strawberry transplants

Photo: A. Stensvand



Strawberry transplants heavily infected with powdery mildew



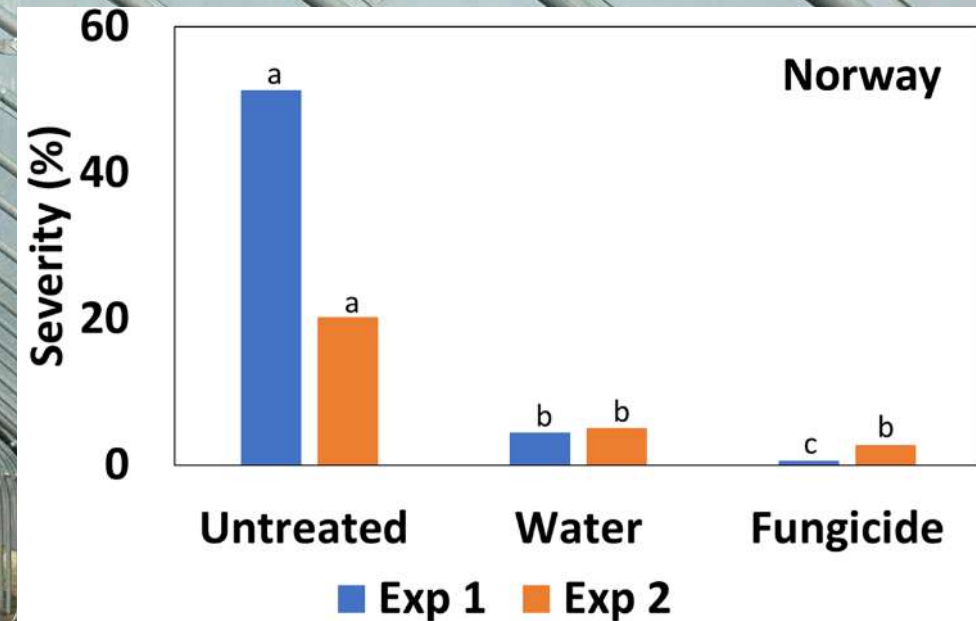
Small plots with clean strawberry plants (50 plants) in the middle of a cereal field; infected plants with either 0, 1, 10 or 100 infected leaflets placed in the middle of each plot

Overhead irrigation

Sprinklers installed in many high plastic tunnels to help plant establishment, cool the plants, and **reduce powdery mildew**



Sprinkling 1 min. 4 times per day in periods with warm, sunny weather



Two experiments in a high tunnel in Norway

- 
- Spores attach to the droplets and roll off the leaves
 - Hyphae carrying the spores will break
 - Water inhibits spore germination



Should not be used in overcast or rainy weather - it may stimulate grey mould and other diseases



Warm steam treatments of strawberry transplants in the 'Plant Sauna'



Photo: A. Stensvand



Photo: Moleda Inc.

Steaming kills or strongly reduces

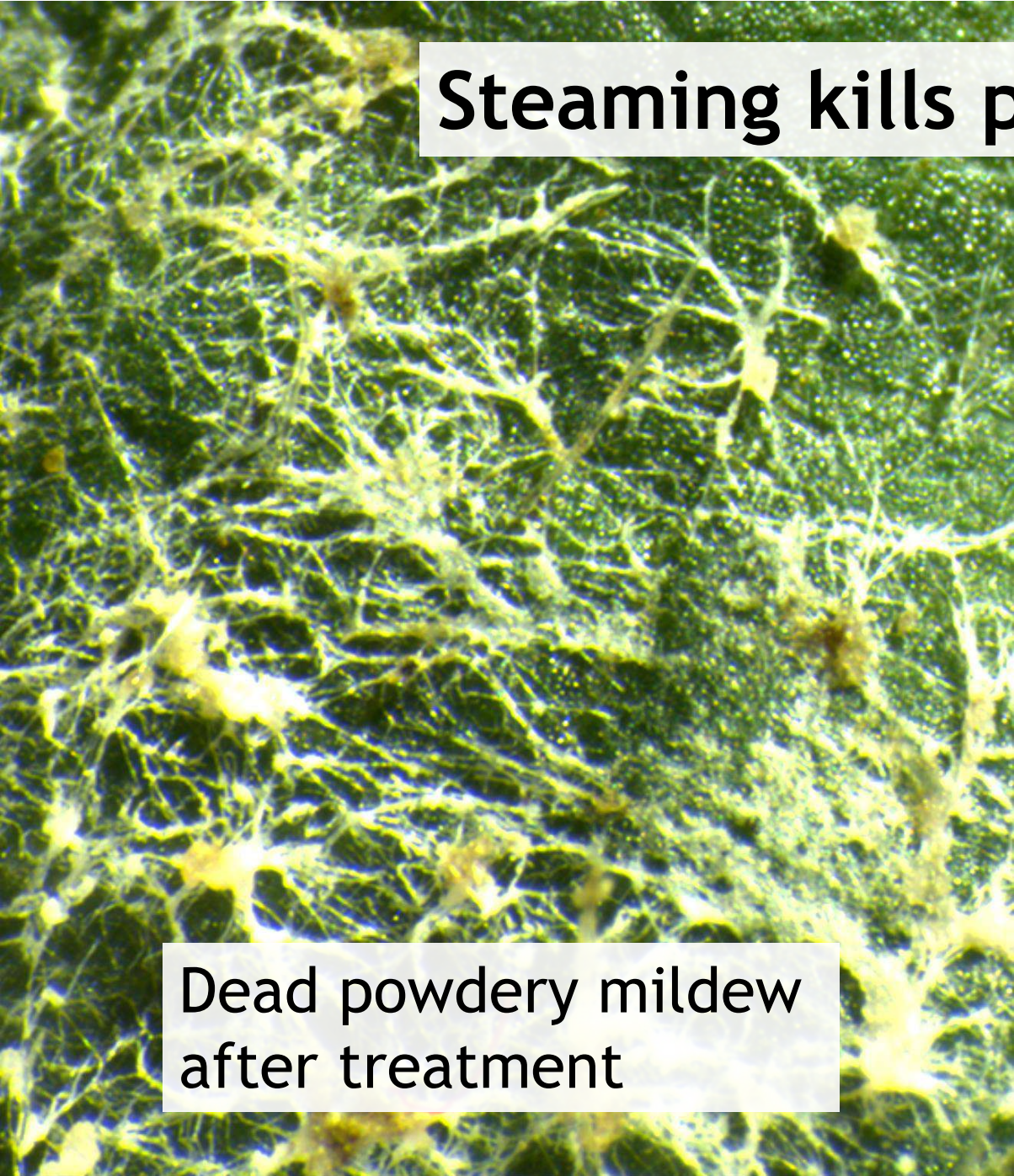
- Angular leaf spot
- Anthracnose
- Grey mould
- Phytophthora crown rot
- Powdery mildew
- Strawberry mite
- Leaf nematodes
- Etc.

Standard treatment:

1 h at 37° C, 1 h at 20-25° C, 4 h at 44° C

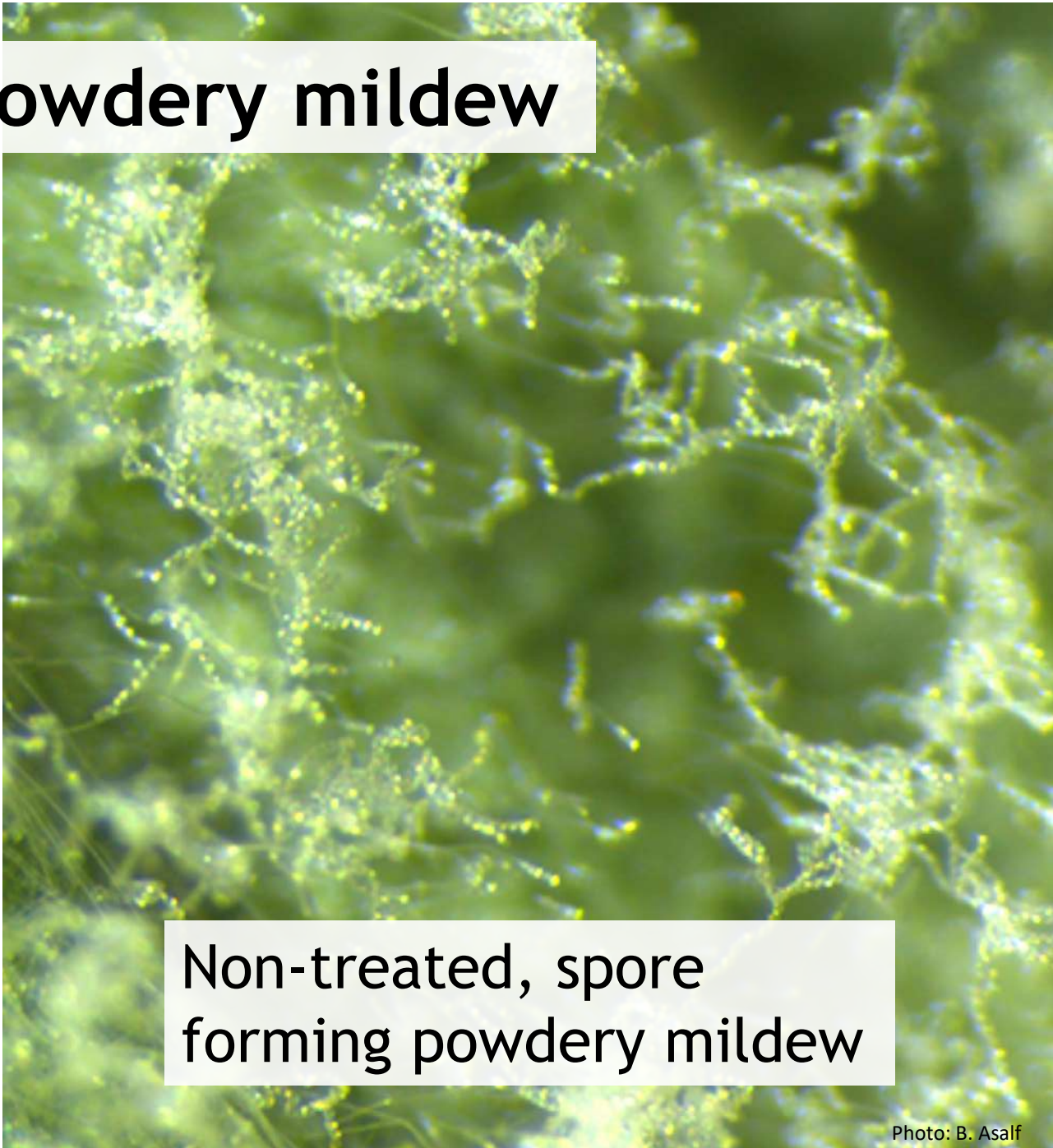
(Turechek et al. 2021)

Steaming kills powdery mildew



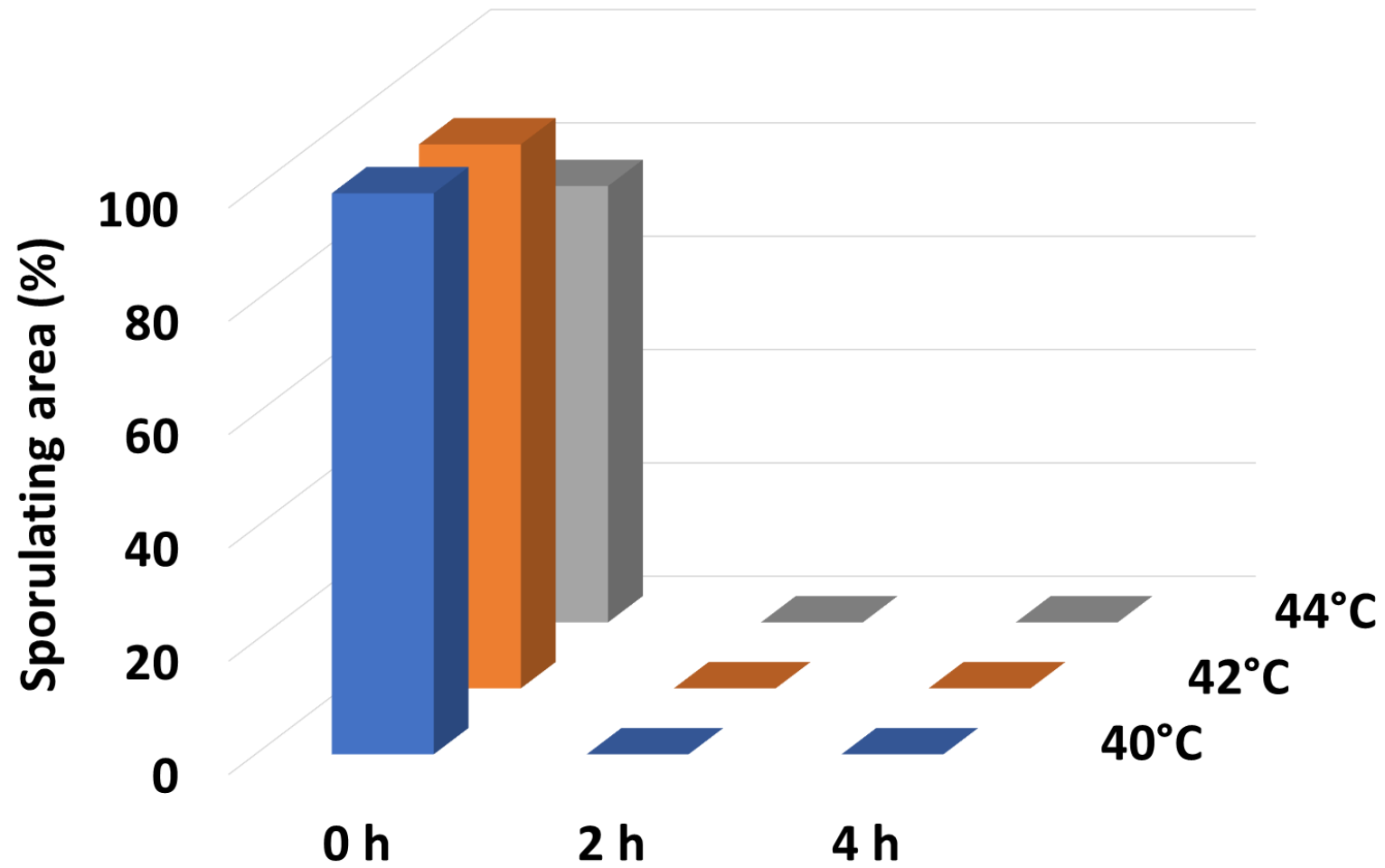
Dead powdery mildew
after treatment

This image shows a microscopic view of dead powdery mildew after treatment. The fungal hyphae are fragmented and appear as a dense, tangled mass of yellowish-brown structures against a dark green background.

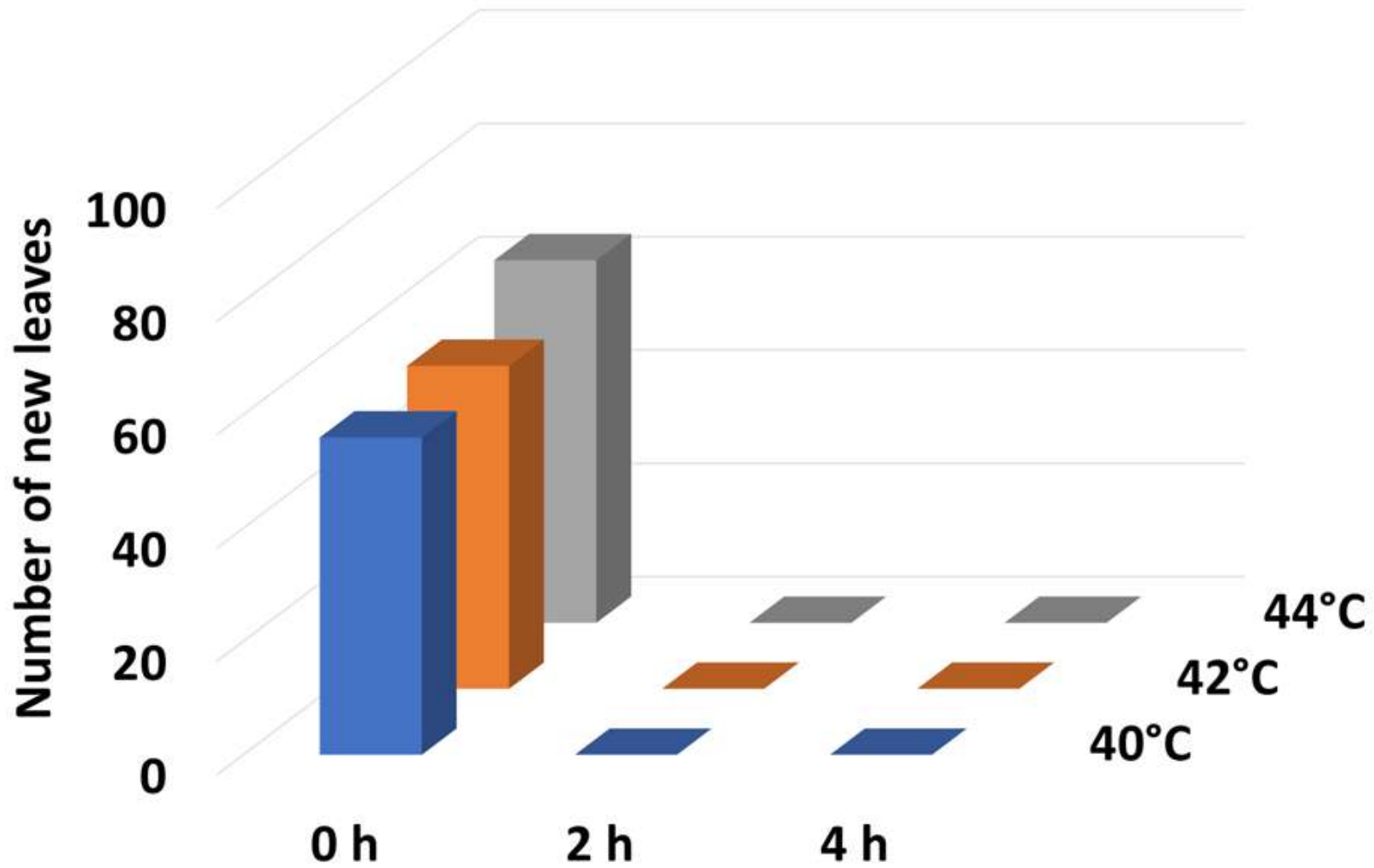


Non-treated, spore
forming powdery mildew

This image shows a microscopic view of non-treated, spore-forming powdery mildew. The fungal hyphae are more organized and form a dense, interconnected network of yellowish-brown structures against a dark green background.



Powdery mildew lesions
dead after treatments



No new infections with powdery mildew on treated plants



No negative effects on growth and yield of several cultivars of tray-plants in Norway or bare root plants in Florida

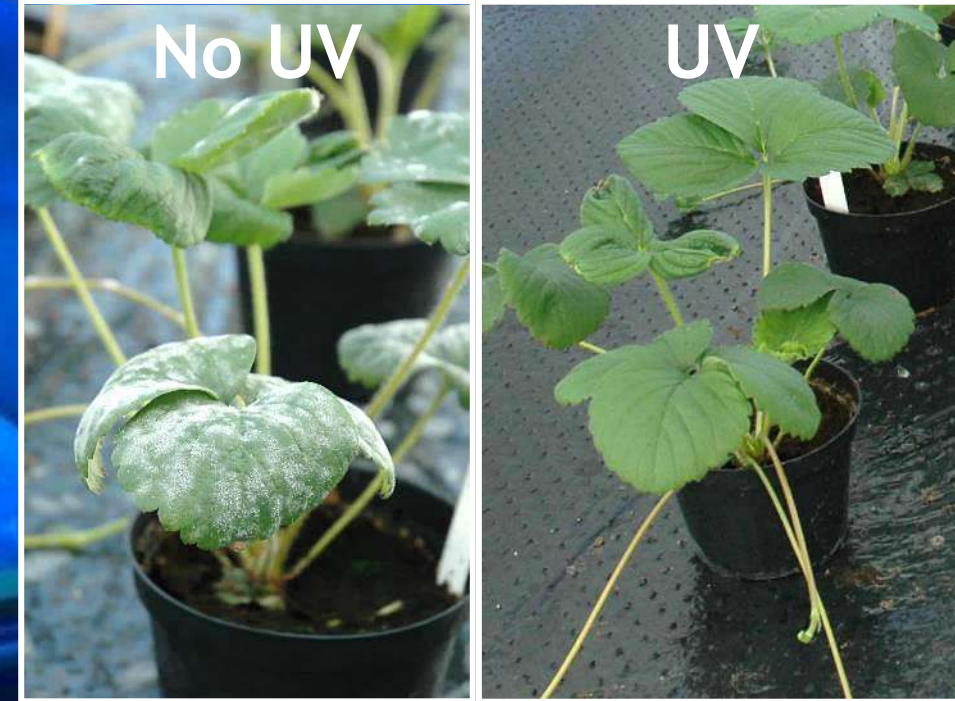
Upscaling of the Plant Sauna?



For treatment of
larger volumes



Ultraviolet light (UV)



UV < 300 nm reduces powdery mildew
Treatment at night

R&D on UV

Numerous research groups working with UV against berry diseases

Several companies produce UV units, e.g., **Octinion** in Belgium

Xenion

Robotic UV-unit (Saga Robotics) in Florida



Photo: R. Onofre



Photo: Saga Robotics

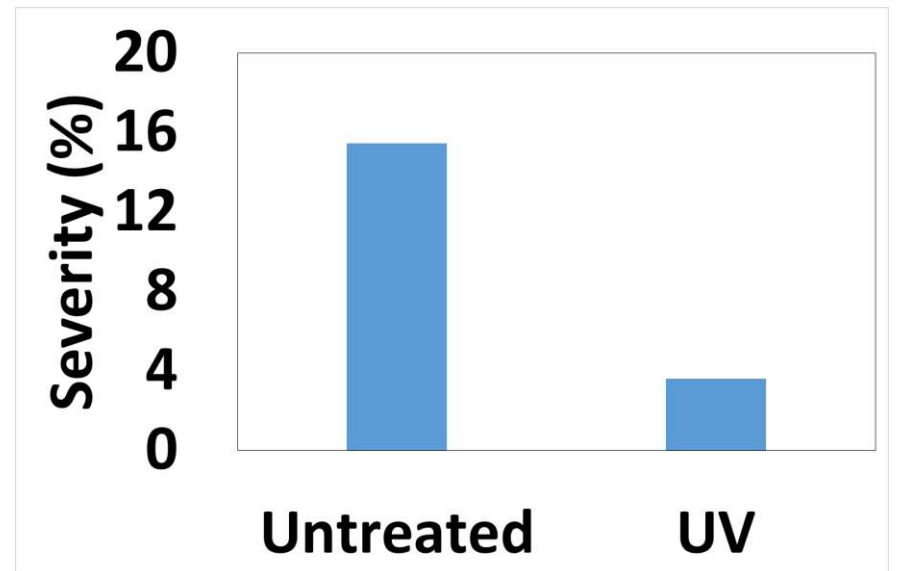
Saga Robotics unit in an 11 ha high tunnel strawberry farm in Norway



Photo: A. Stensvand

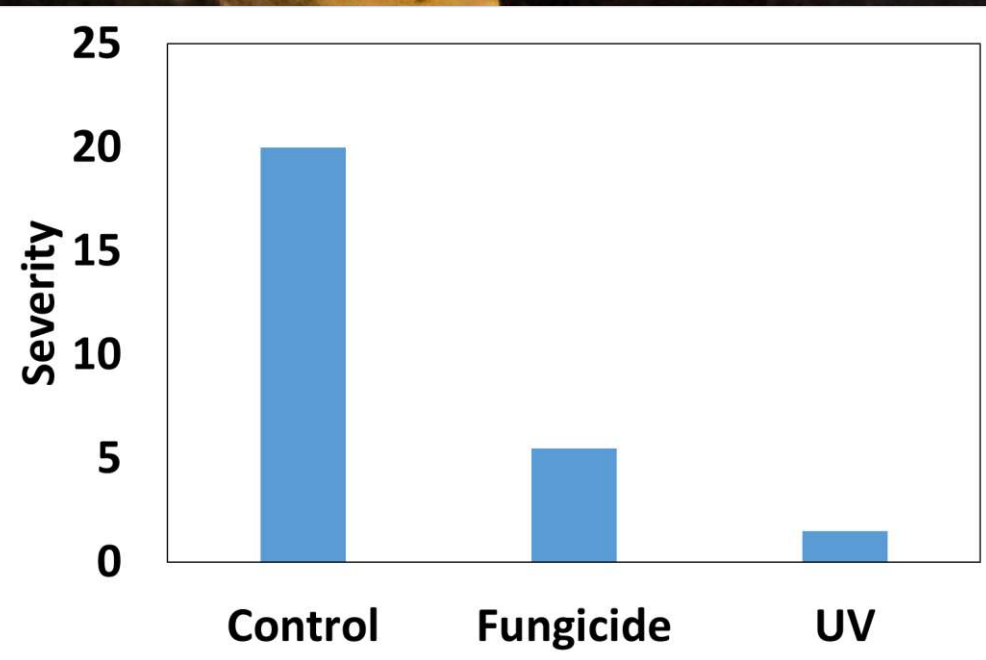


UV-units charged during day

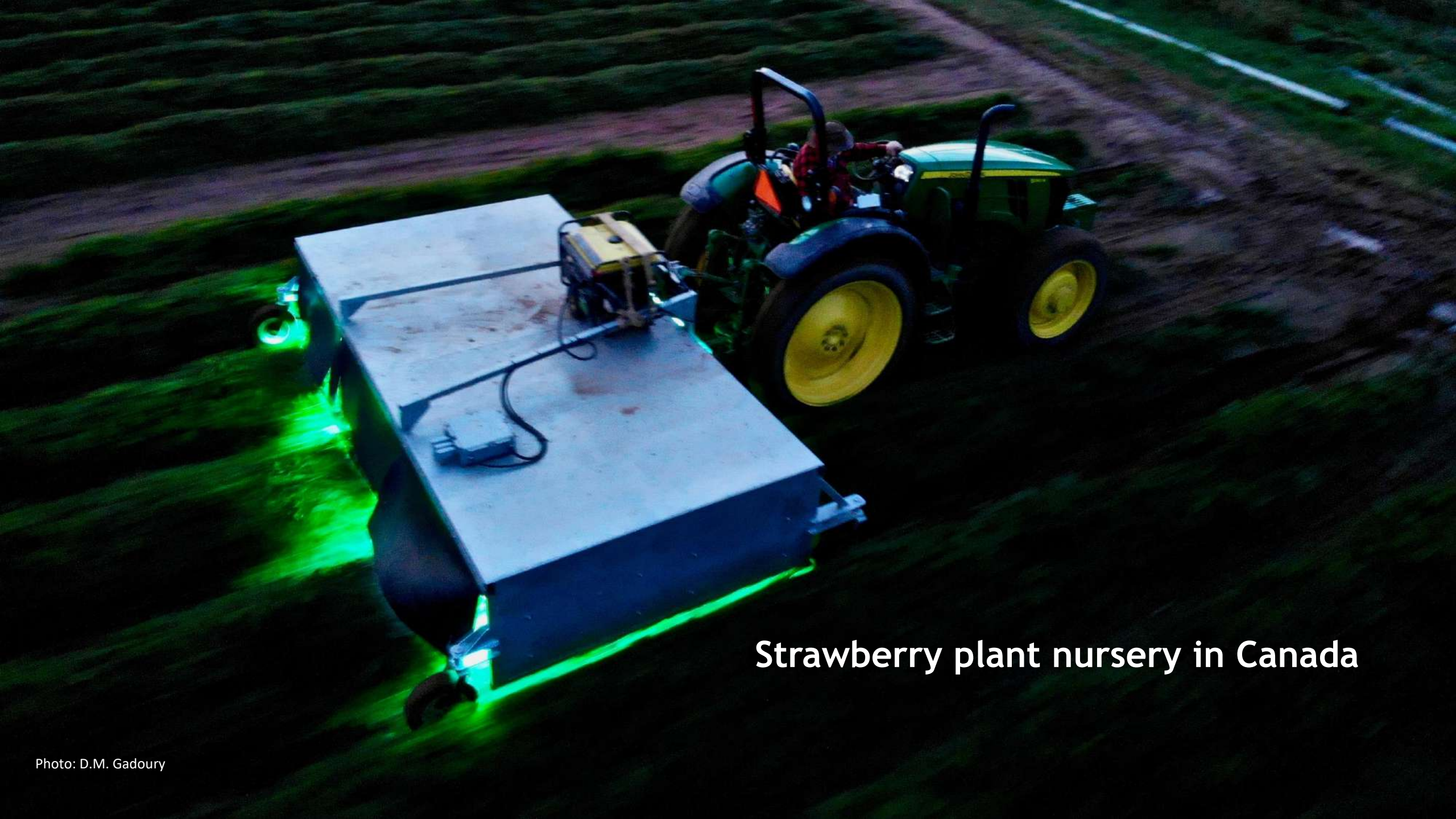


Tractor-drawn UV units

Onofre et al (2022):



Experimental field in Florida



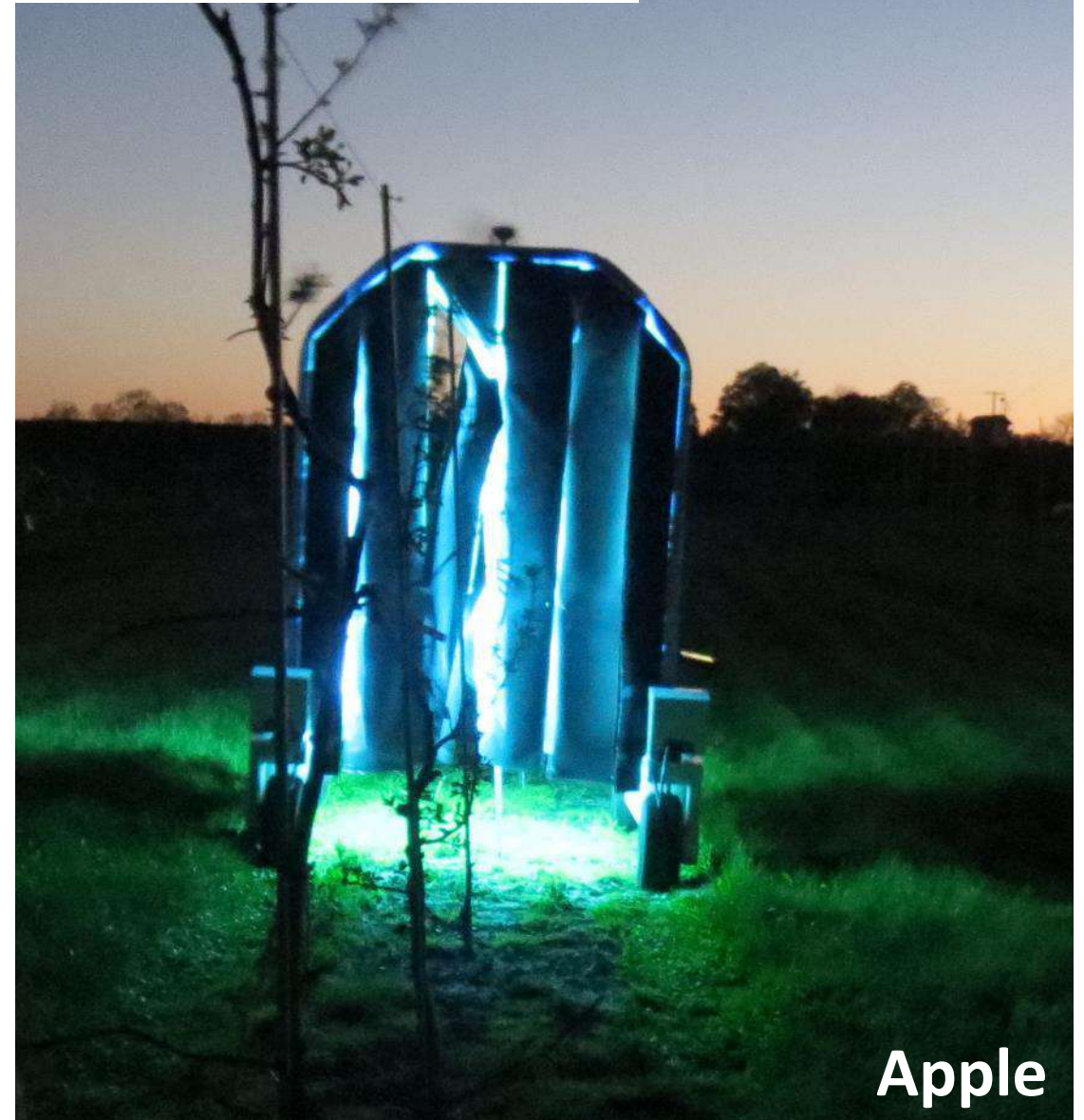
Strawberry plant nursery in Canada

UV boom

Prototype of a UV-boom
in northern Norway



UV treatments in other crops





**Polyethylene removes UV
→ more mildew**

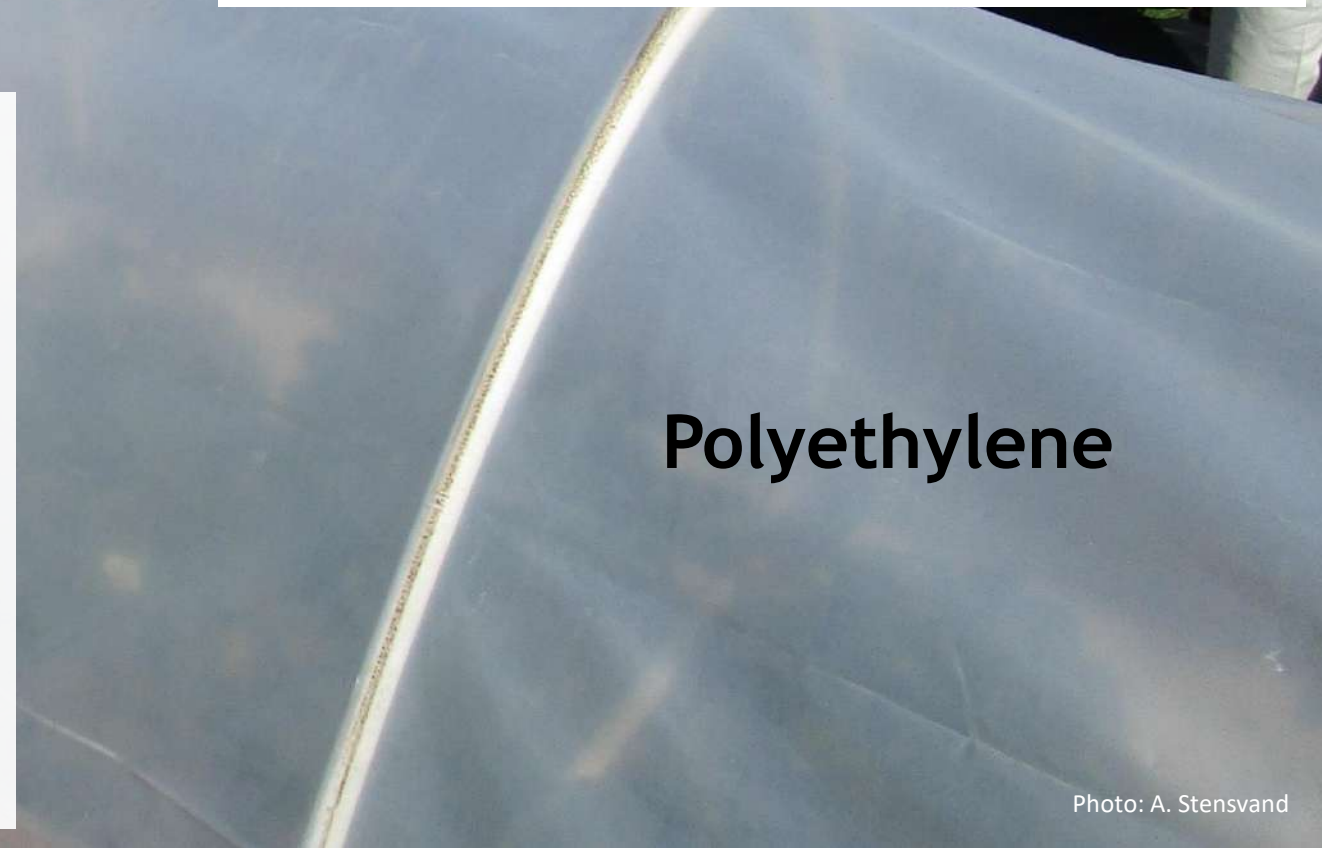
**F-Clean transmits UV
→ less mildew**

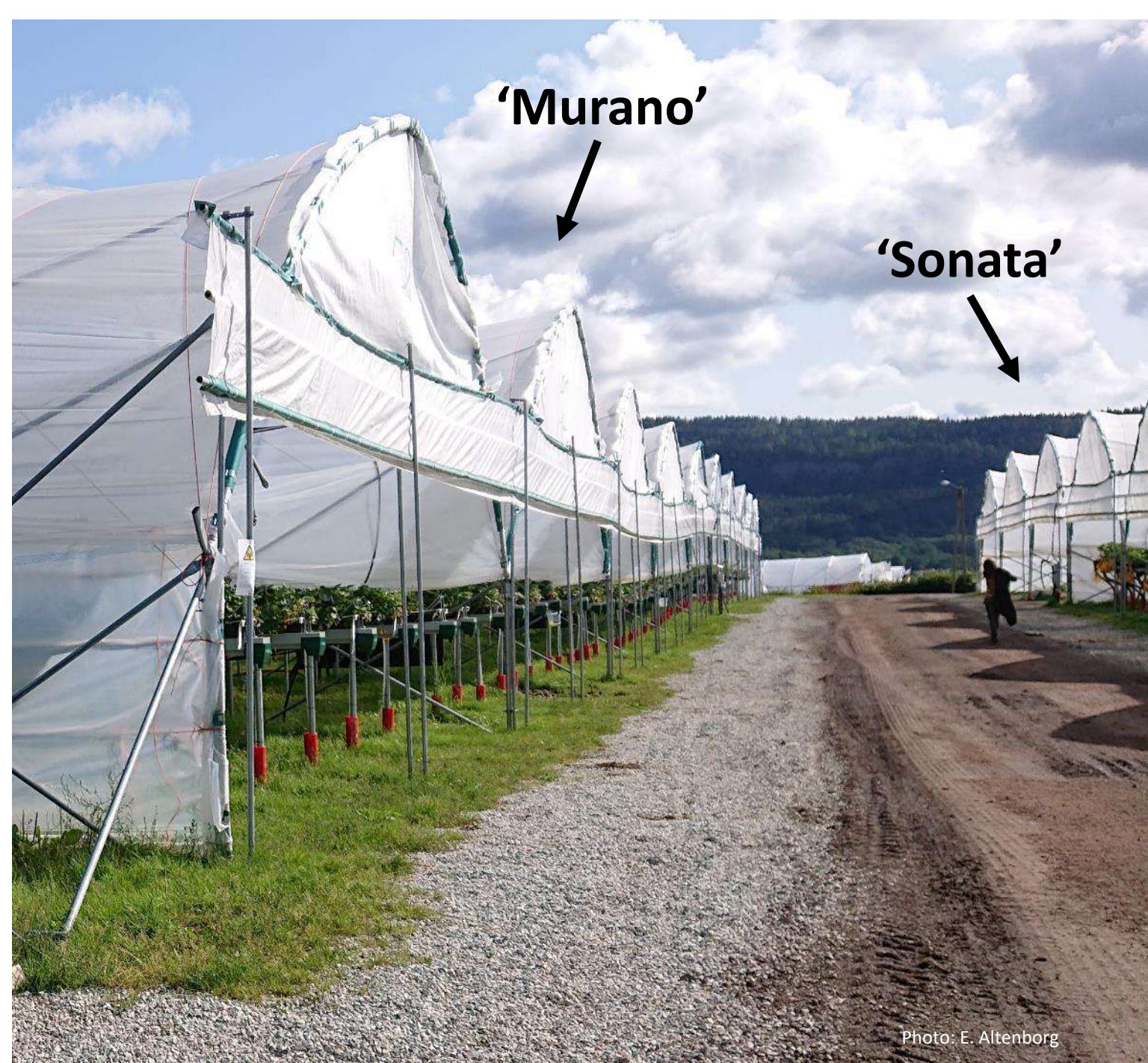
Two years of experiments in Florida:

F-Clean: 28-35% less powdery mildew
than under the polytunnel

Open field: 45-67% less powdery mildew
than under the polytunnel

Differences in temp and RH not the only
explanation of more powdery mildew in
tunnels vs. open field

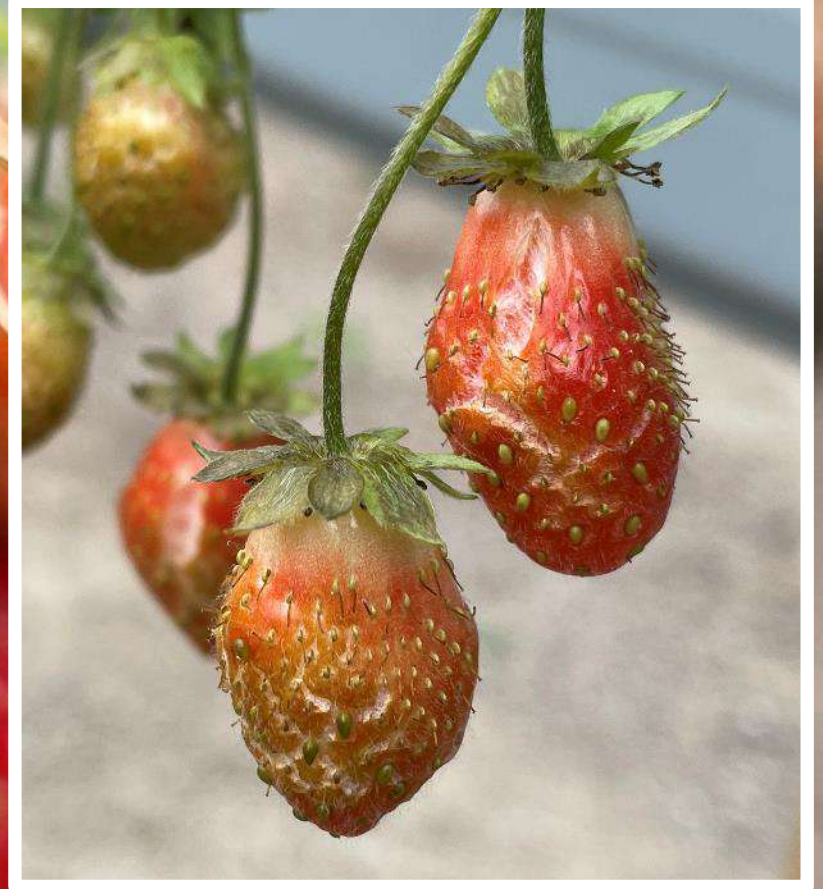




2019: 'Murano' was UV treated - no powdery mildew; 'Sonata' was sprayed numerous times with fungicides - had to give up production one month ahead of normal time because of powdery mildew

2020-2024: No fungicides used and only biological control of mites and insects

**UV has some effect
against grey mould**

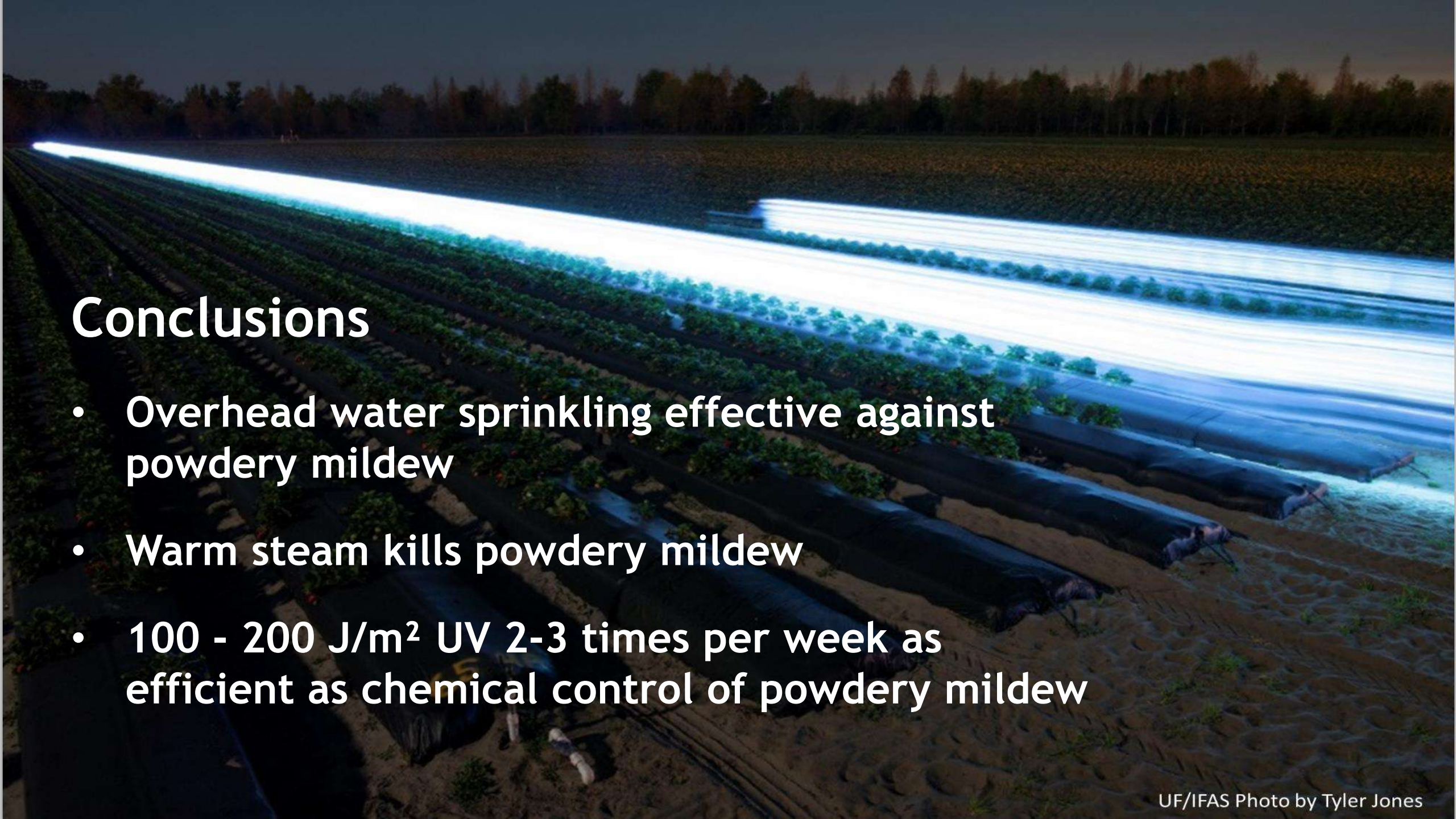


**To be efficient, doses
must be higher - may
result in phytotoxicity**

UV effective against two-spotted spider mite (*Tetranychus urticae*)

Direct exposure to UV:

- No effect against adults
- Kills > 99% of larvae and nymphs
- Kills 100% of eggs



Conclusions

- Overhead water sprinkling effective against powdery mildew
- Warm steam kills powdery mildew
- 100 - 200 J/m² UV 2-3 times per week as efficient as chemical control of powdery mildew



Thanks!

Funding: Research Council of Norway, Norwegian Agriculture Agency, H2020 - EU (GoodBerry), USDA OREI/SCRI, Poland - Norway grants (QualityBerry)

Photo: E. Fløistad

Collaborators: NIBIO, NMBU, Cornell Univ, Univ of Florida, USDA, RPI Lighting Research Center, Myhre AS, Moleda Inc., Sagaplant AS, Ushio America, OSRAM Americas