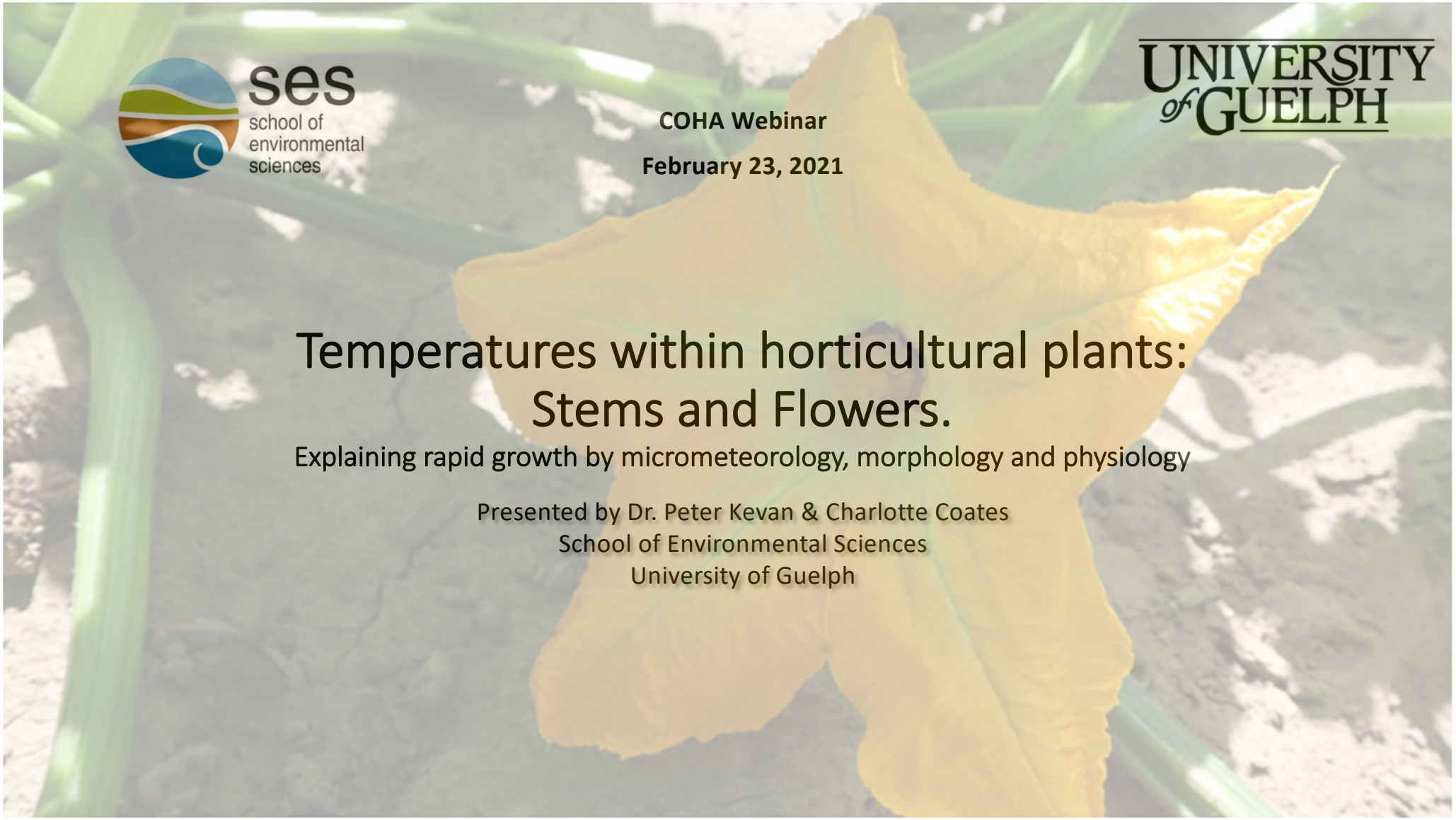


ses school of environmental sciences

UNIVERSITY of GUELPH

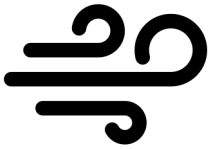
COHA Webinar

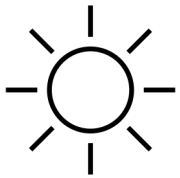
February 23, 2021

Temperatures within horticultural plants: Stems and Flowers.

Explaining rapid growth by micrometeorology, morphology and physiology

Presented by Dr. Peter Kevan & Charlotte Coates
School of Environmental Sciences
University of Guelph





Introduction to *Endo*micrometeorology in Plants

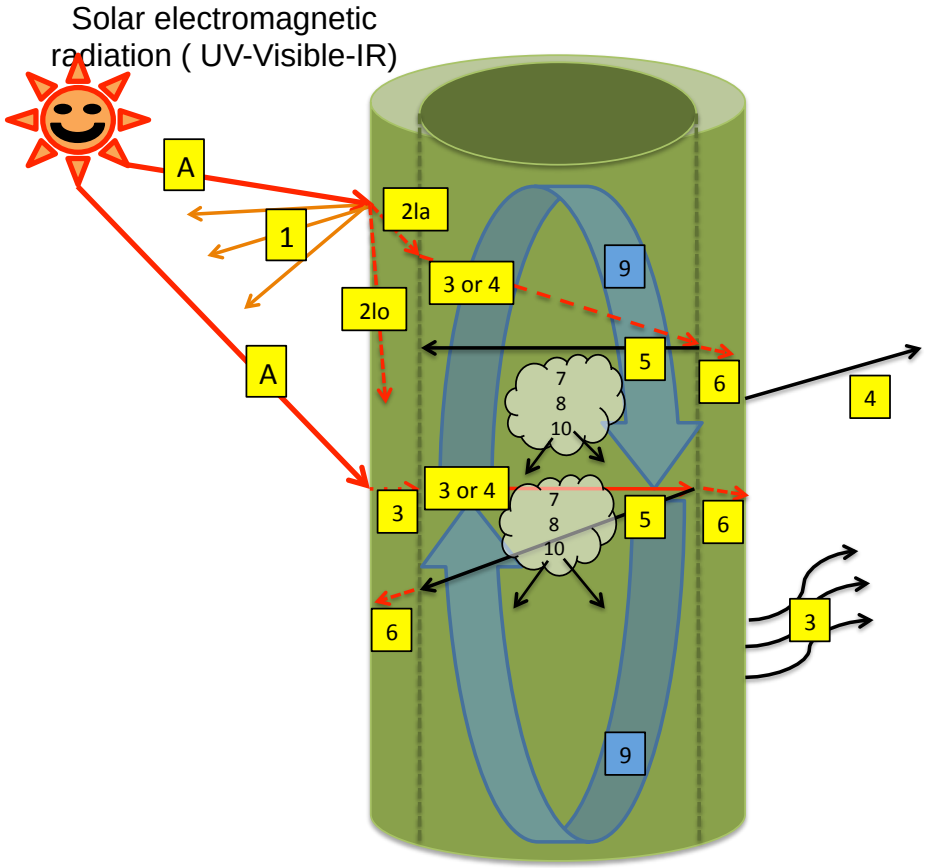
- Micrometeorology = Climate near the ground
- Micrometeorology around plants is well studied
  - atmospheric movements (wind, convection, etc.)
  - light conditions & radiation
  - temperature & heat
  - humidity (moisture) & precipitation

What micrometeorological conditions exist within plant parts?

What micrometeorological conditions exist *within* plant parts?

- **Unknown: Atmospheric conditions** within plant parts (flowers, stems, fruits, galls) little studied
  - plant parts enclose air, especially **hollow structures**
- **Known: Transpiration** in leaves causes evaporation which leads to cooling of plant tissue
- **Known: Metabolic heating**

Complex Mechanisms of Microgreenhouse Heating



From: Kevan et al. 2018. *International J. Biometeorology*

Solar radiation (UV-Visible-IR) (A):

Some Reflected (1),

Some Absorbed (2),

Some Transmitted (3) (translucence).

Absorbed radiation Conducted (2la; 2lo).

Some lost (radiation (3)/conduction (4)) in/out of (lumen) stem.

Transmitted (3)/conducted (4) heat adds energy to the lumen.

Within, radiant energy (3), can be a) reflected (5), b) absorbed (6),

and also

Absorbed by atmosphere in lumen (7), then exchange by Conduction (8) , Convection (9) and Reradiation (10).

= Greenhouse Effect

Heat in stems liberated by radiation (Emissivity; 3) & conduction (4) to environment. Some conducted away by phloem & xylem; 2lo). Some is used in photosynthesis, and metabolism (not shown).

Model organisms:

Gerbera jamesonii

and

Cucurbita pepo

Gerbera daisies at Van Geest Brothers Ltd., Grimsby, ON

Pumpkins at Strom's Farm, Guelph, ON

Methods & Mechanisms of Heating in Enclosed Flowers, Fruits & Stems

- **Temperature measurements** (thermocouples)- Work analyzing long-term data on **elevated temperature of up to 13 degress C** in *Gerbera, Cucurbita,* Milkweed, *Amaryllis,* Daffodil, *Physallis*, Japanese Knotweed continues.
- **Shape & Form Measurements**
  - Physical dimensions – *Over 500 plant specimens catalogued*
  - Growth rate measurements on model organisms
  - Reflectance & Absorbance spectrophotometry (including IR) – *Began spectrophotometry work January 2020 in Amaryllis*
  - Histology (morphology cellular & subcellular)
- **Light & Electron microscopy** (cell & cellular morphology)
- **IR thermography (Heat)** Use of thermal camera in horticulture methods for improved accuracy of plant surface temperature presented in Byerlay et al. 2020
- **Thermal Conductance** stem flow meter purchased, experiments on hold due to COVID-19 restrictions

Accurate quantification of plant surface temperature

Byerlay et al. 2020 presents an in situ calibration **method for thermal cameras to reduce error and improve accuracies** for the observed surface temperatures of plant material

Method:

- FLIR E6 uncooled thermal camera was calibrated **in situ** Van Geest Brother's Ltd. Greenhouse in Grimsby, ON
- 5 varieties of *Gerbera jamesonii*
- Data collected January & February, 2020

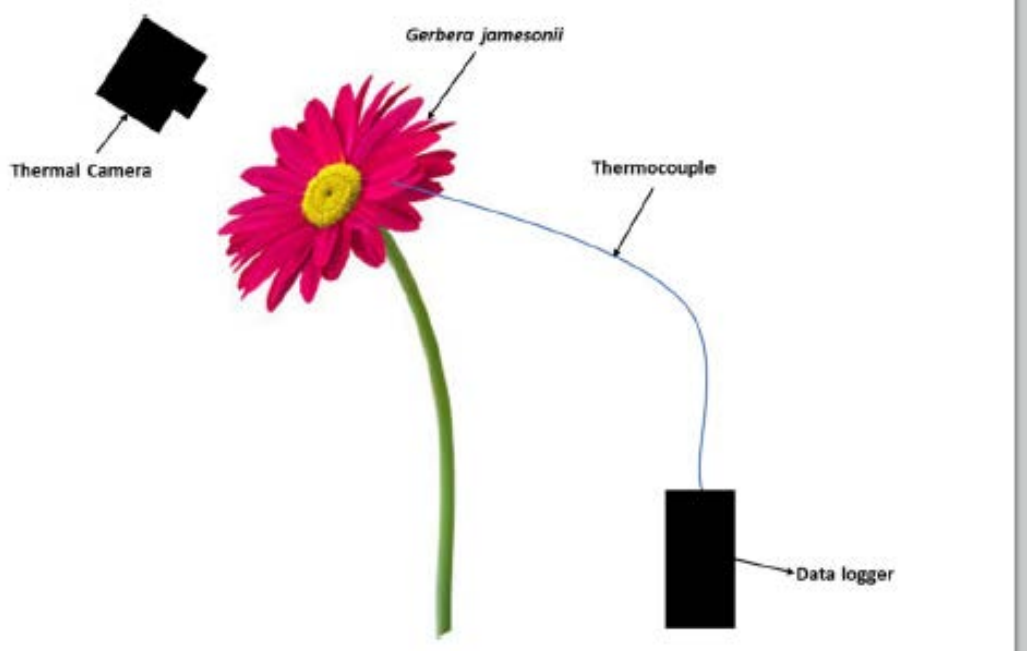
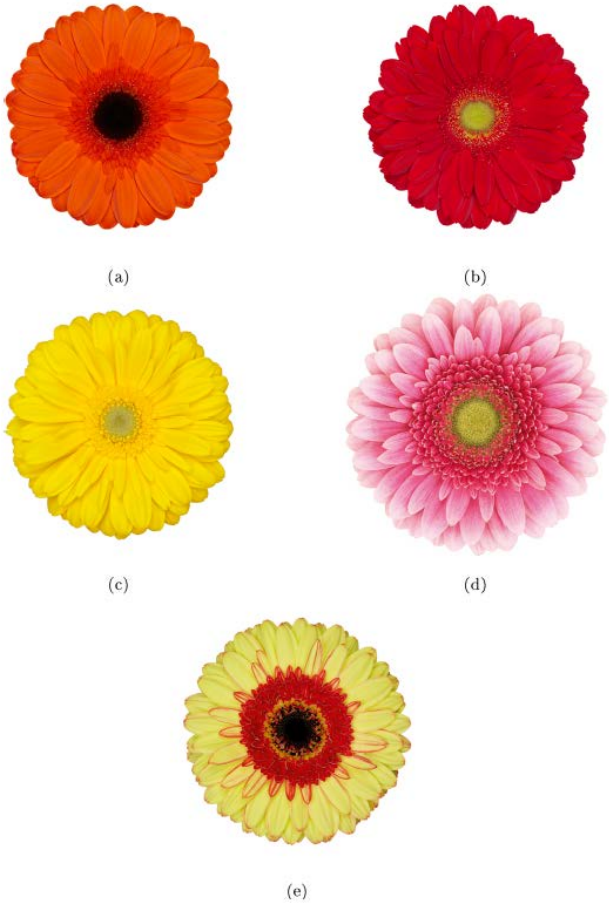
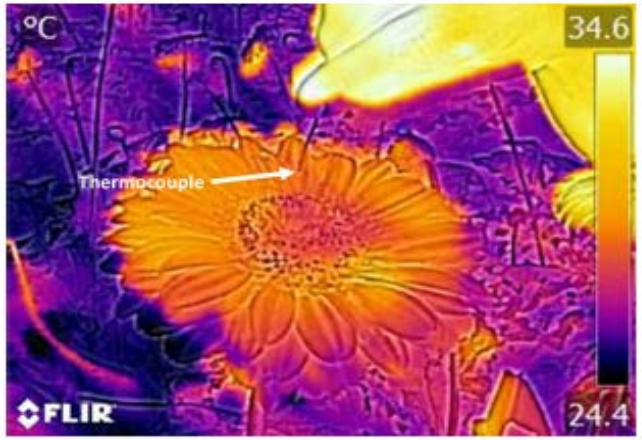


Diagram of experimental set-up in greenhouse.



Gerbera varieties recorded by the thermal camera (a) Prestige, (b) Brunello, (c) Panama, (d) Rendez-Vous, and (e) Toast. Source: Van Geest Bros. Limited.



(a)

(b)

Thermal image of Prestige flower recorded on January 24

How thermal cameras measure temperature

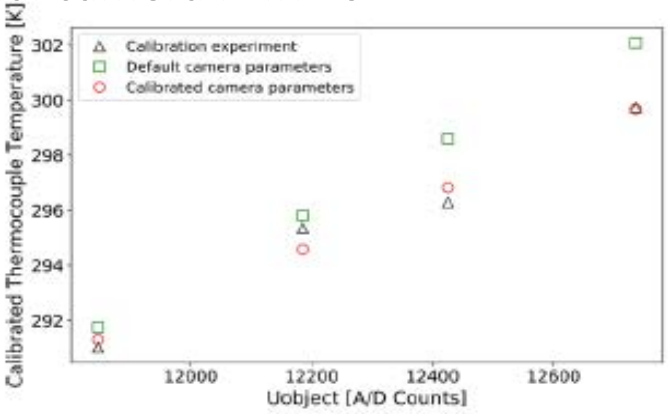
- **New calibration constant parameters intrinsic to the thermal camera were derived** for both flowers and stems for each *Gerbera* daisy variety.

- **Bias** and **root mean square error (RMSE)** of the surface temperatures using **the default manufacturer camera and the new calibrated camera parameters were calculated and compared.**

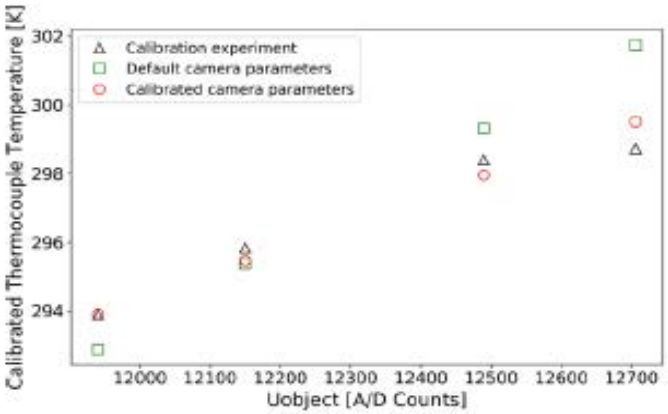
Linear calibration: Thermocouple vs. Thermal camera FLIR E6

- Thermocouple temperature compared to radiometric image
- Green squares: default mfg camera parameters
- Red circles: calibrated camera .
- A/D counts : pixel excitation in the camera
- **Significance:** Linear relationship between calibrated camera and thermocouple temperatures

The calibrated camera parameters were used to quantify the calibrated temperatures.



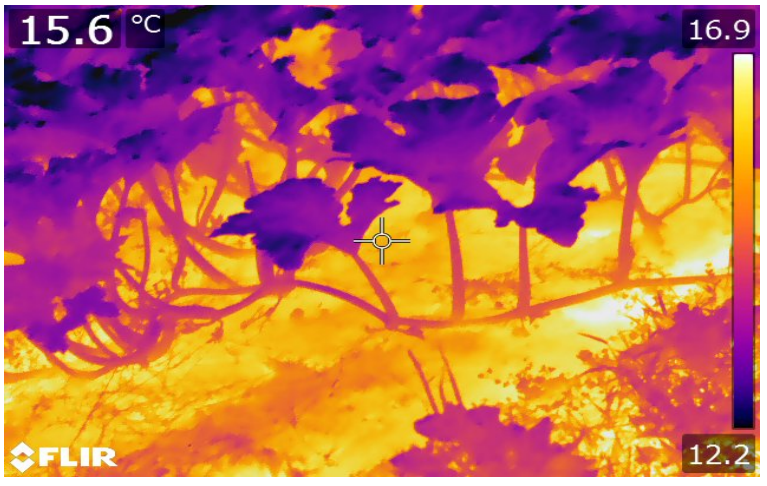
(c) Brunello

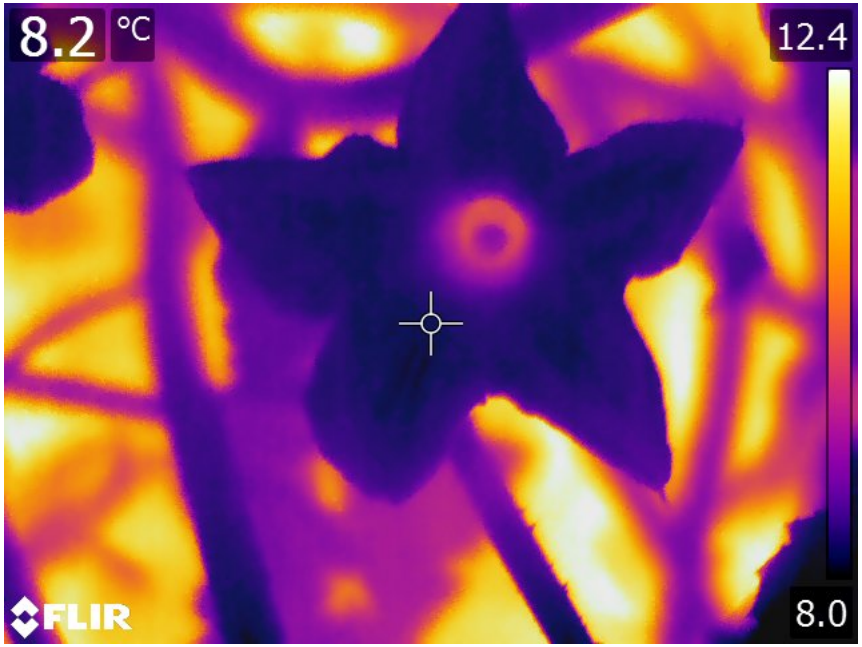


(e) Rendez-Vous

Results and further studies

- For plant organs, the **calibrated camera bias and error values were reduced by at least 89.1%** vs. default camera bias and error values.
- Most research has not used calibrated cameras in horticultural temperature studies or have calibrated elsewhere than the data collection site.
- Our results show in situ calibration improves accuracy of results
- **Further studies with higher resolution camera** and longer-term data collected are in analysis





Pumpkin flowers (*Cucurbita pepo*)

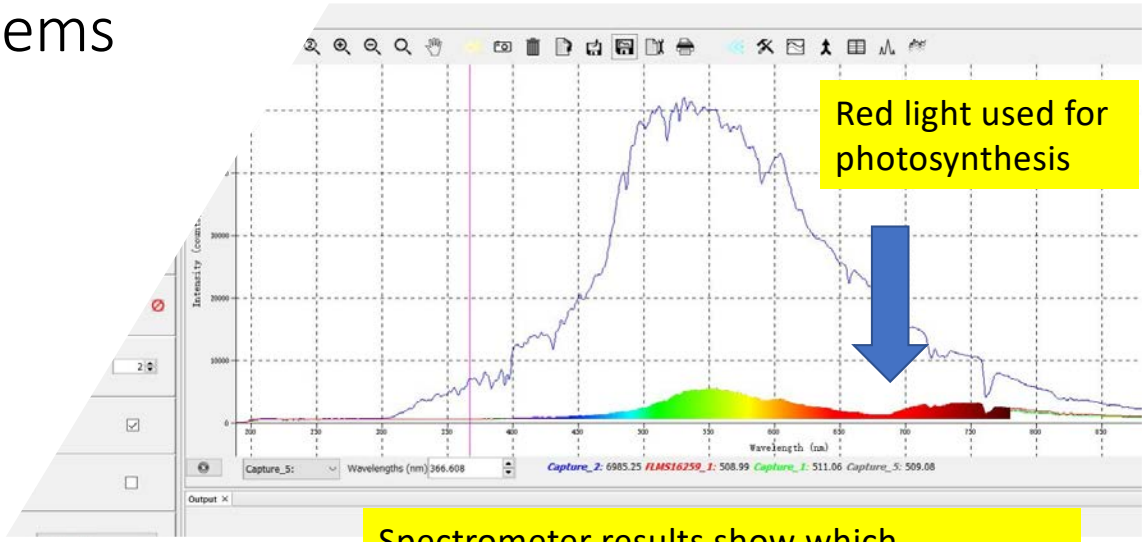
- FLIR photos of 5 male & 5 female flowers, 3 per hour for a 24 hour period.
- Nectary about 3˚C warmer than petals during nectar production
- Pumpkin flowers have a humidity gradient starting after the flowers opened until they close.
- Female squash flowers have on average, higher difference between the floral and ambient RH.

Pumpkin *(Cucurbita pepo)* stems

- Varieties: Large vs. Small pumpkins
- Plots: Sun vs. Shade, 2 plants per plot
- Recorded internal & ambient air temperature from June-August
- Collected plant growth data daily

Results:

- **Spectrometer results in analysis**
- **Stems reached 10 C warmer temperatures than air temperatures**
- **Highest temperature differences occur during 10AM -2PM**



Spectrometer results show which wavelengths of light are present inside the stem

Modelling the microgreenhouse effect

Models can predict how a hollow stems internal temperature affected by:

1. **Ambient air** around the stem
2. **Solar** radiation
3. **Plant tissue properties**

- Results useful to growers environmental management plan
- Provide theoretical basis for **effects of extreme weather conditions on hollow plants**

Thank you!

This project is part of the Accelerating Green Plant Innovation for Environmental and Economic Benefit Cluster and is funded by the Canadian Ornamental Horticulture Alliance (COHA-ACHO) and by the Government of Canada under the Canadian Agricultural Partnership's AgriScience Program.

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Questions
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Comments?