Blue and Red PF Ratios for the Production of Vegetable Transplants

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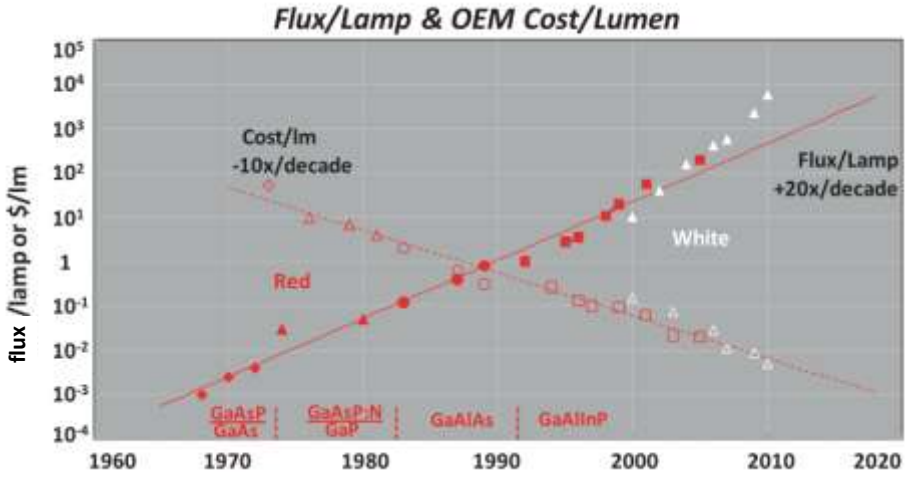
LEDs as sole-source light for plants

LEDs
- Solid state
- Low operating temperature
- Robust
- Selective spectral output
- Efficiency of converting electricity to light (increasing).

LEDs as sole-source light for plants



Haitz and Tsao, 2011

HAITZ, R. & TSAO, J. Y. 2011. Solid-state lighting: 'The case' 10 years after and future prospects. *physica status solidi (a),* 2008**,** 17-29.

LEDs as sole-source light for plants

- With the continuous increase of light emitting diodes (LEDs) energy-to-photon conversion efficiencies, LEDs have become a viable light source for compact plant production under closed-type conditions.

Lamps	Photon flux /W ($\mu mol\ s^{-1}\ W^{-1}$) or ($\mu mol\ J^{-1}$)
fluorescent 	0.8-1.5*
LED (red)  LED (blue) 	1.6-2.3**
HPS 	1.5-1.85***

* Estimated from lumens converted to photons by factors reported by Thimijan and Heins (1983)
**Philips catalogue and Nelson and Bugbee (2013)
***Philips catalogue data for HPS lamp (600 W GreenPower)

Plant production under closed type systems

(Mirai Co., Ltd., Japan)

(bergearth co.,ltd., Japan)

Spectral quality for plant growth

Indoor light quality experiments demonstrated that red light supplemented with blue light is optimum for plant growth.

- Goins G. D. *et.al* (1997) showed an increase in wheat shoot dry matter and Pn rate from **1%** blue to **10%** blue.
- Matsuda R. *et. al* (2004) reported higher Pn rate and higher N content of rice leaves on **20%** blue compared to all red LEDs.
- Hyeon-Hye K. *et.al* (2004) showed comparable levels of stomatal conductance, and shoot dry matter in lettuce comparing 16%B with CWF lamps.
- Hogewoning S. W. *et. al* (2010). Concluded that 7% blue light was sufficient to prevent any dysfunctional Pn in Cucumbers. Also they reported an increase of Pn capacity with increasing blue ratio up to 50%.

Objectives

Evaluate LED technology for the production of vegetable transplants.

To evaluate different blue and red photon flux (PF) ratios using LEDs for the production of vegetable transplants.

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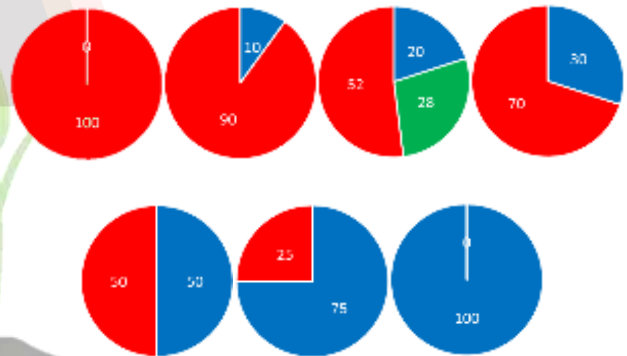
Materials & methods: Treatments

Testing different BLUE:RED PF ratios providing 100 µmol m^{-2} s^{-1} for 18 hours = 6.5 mol m^{-2} d^{-1} of electrical LED light.

Blue = 455 nm, Red = 661 nm



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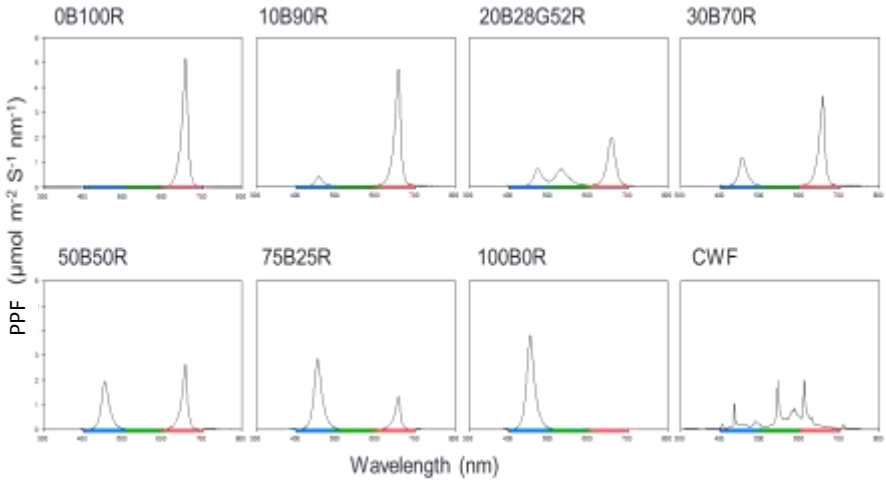
Materials & methods: Treatments



Materials & Methods: Treatments

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Plant material and measurements

Cucumber 'Cumlaude'
Tomato 'Komeett' and 'Beaufort'

- Leaf count
- Fresh mass
- Dry mass
- Chlorophyll
- Photosynthesis
- Plant height
- Hypocotyl length
- Epicotyl length
- Stem diameter
- Leaf area

- Air T (all treatments)
- Canopy Air T (all treatments)
- Light PPF
- RH

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Environmental parameters

Measurement	Units	Data	Specifications
Radiation	µmol m^{-2} s^{-1}	100	5 measurements per treatment area, performed twice during the growing cycle
Photoperiod	hours	18 hours	
Canopy Air Temperature	°C	24.5 ± 0.7	8 locations, in center under the canopy
Atmospheric moisture (RH)	%	55.4 ± 9.1	One measurement point, middle of the chamber
Atmospheric CO_2	µmol mol^{-1}	511 ± 159	One measurement point, middle of the chamber

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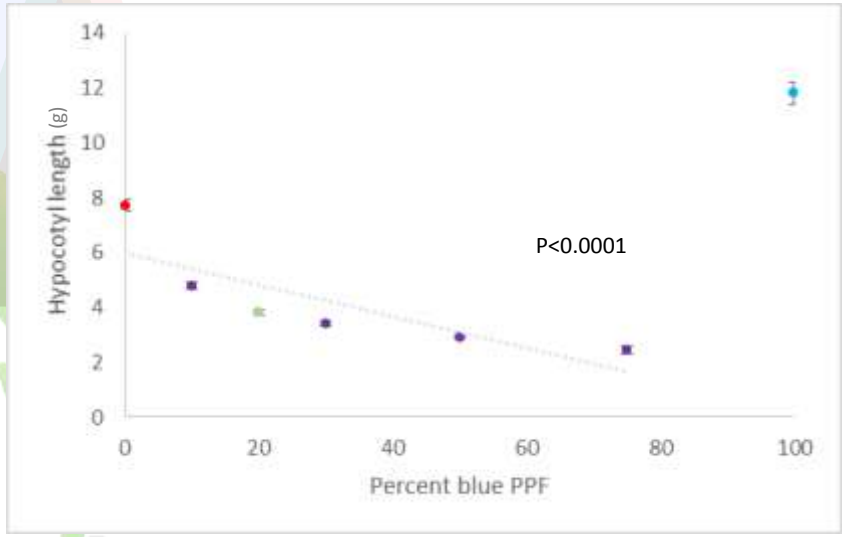
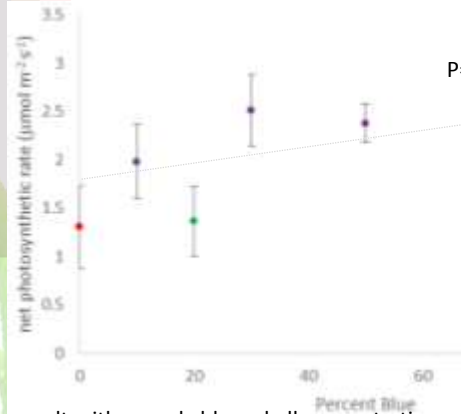
Results: Cucumber B:R PF ratio



P<0.0001

Hernández, R., Kubota, C. 2015 submitted: Environmental and Experimental Botany

Results: Cucumber R:B ratio



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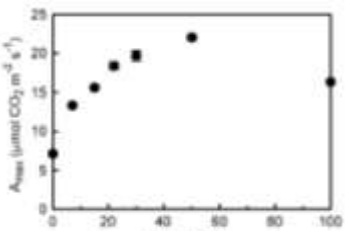
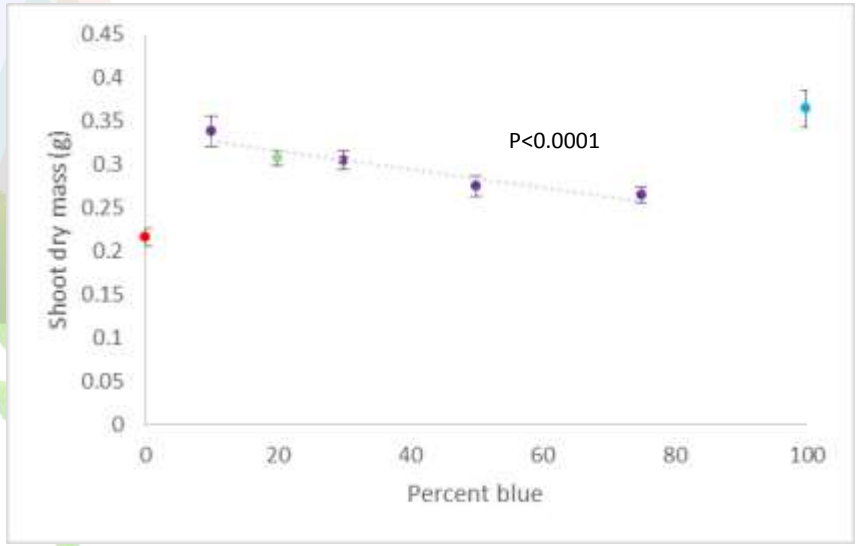


Similar result with g_s and chlorophyll concentration

Hernández, R., Kubota, C. 2015 submitted: Environmental and Experimental Botany

Results: Cucumber R:B ratio



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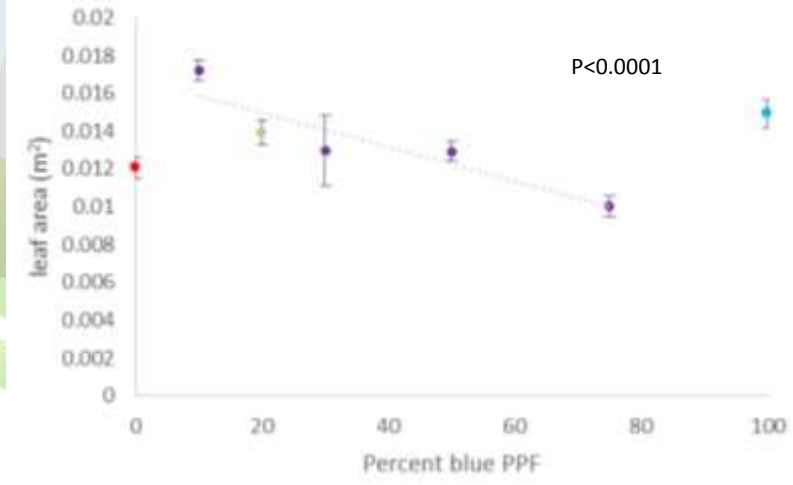

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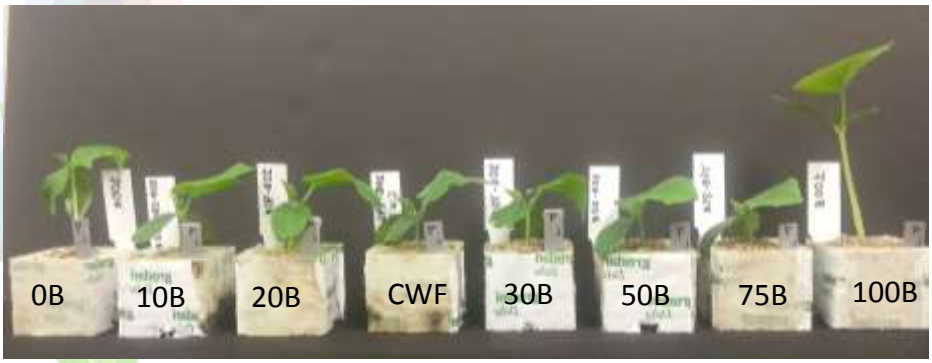

Percent blue

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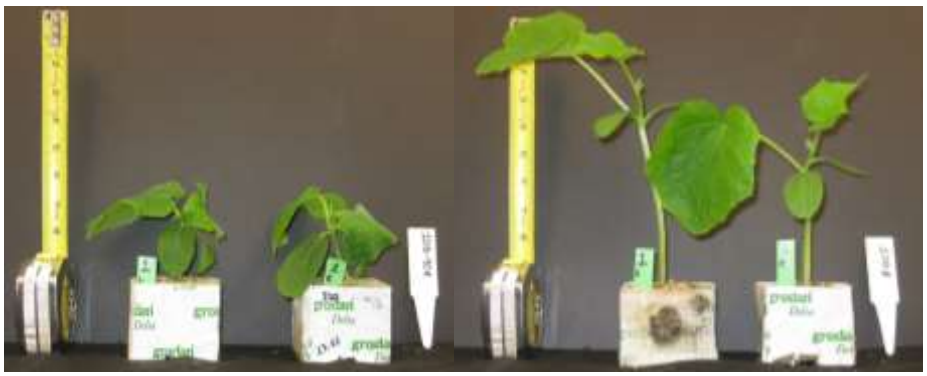
Results: Cucumber R:B ratio



10B 100B

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Discussion

- *Pn* increased with the increased of percent blue PF
- Shoot dry mass decrease with the increase of blue PF, except for the 100% blue treatment.
  - 10% and 100% blue had the highest growth rate
- Hypocotyl length decrease with the increase of percent blue PF, except for the 100% blue treatment.
  - 75% blue had the shortest hypocotyl and 100% blue the longest.

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Discussion

- Pn by itself is not always a good indicator for plant growth.

Relative Growth Rate =
Net Assimilation Rate x Leaf Area Ratio

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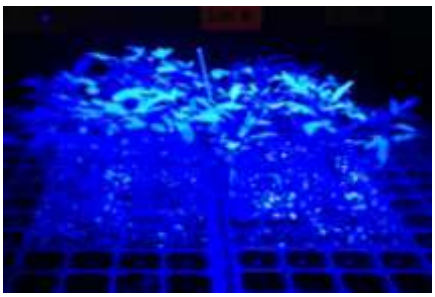
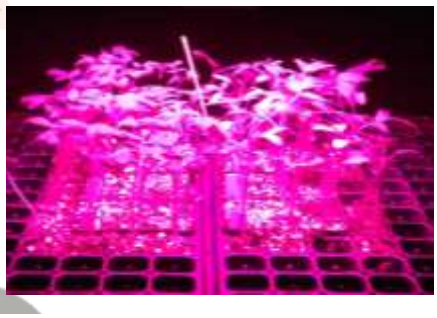
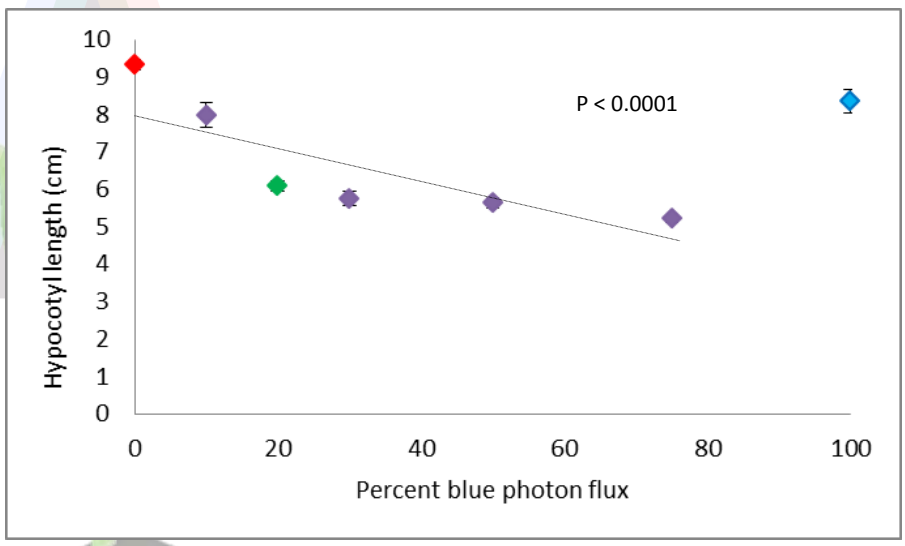
Tomato seedlings ‘Komeett’ and ‘Beaufort’





Results: Tomato ‘Komeett’ B:R PF ratio



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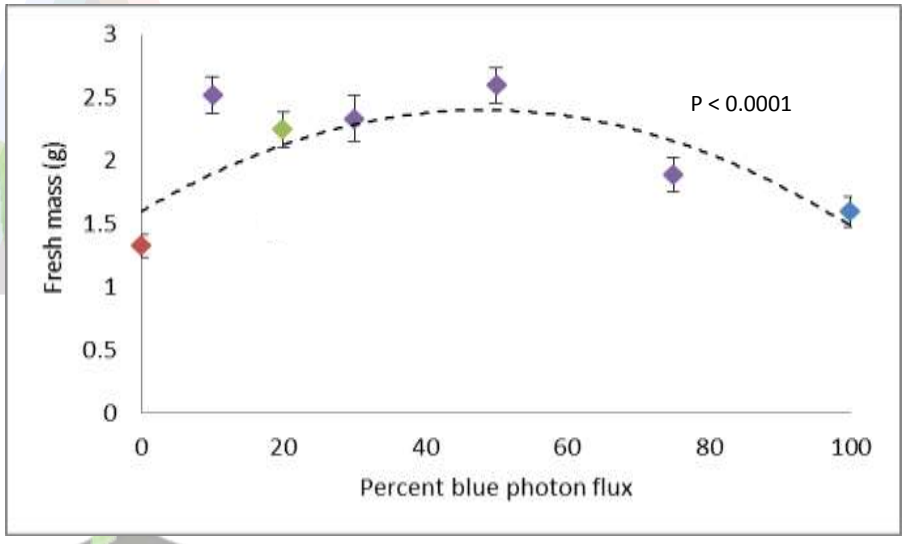

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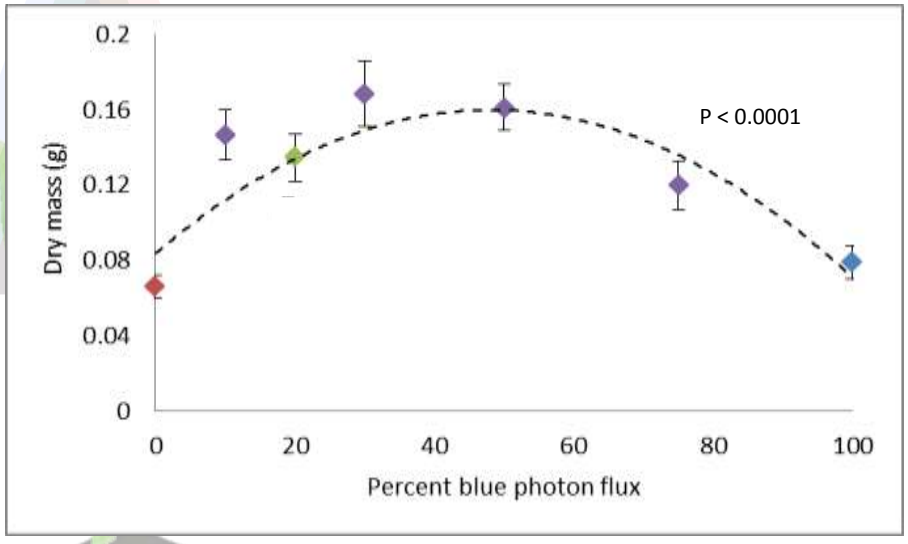

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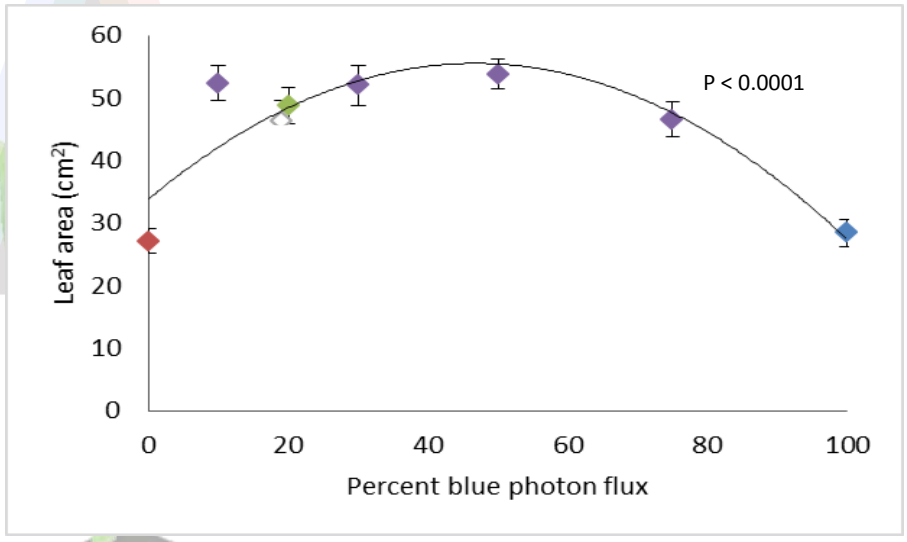

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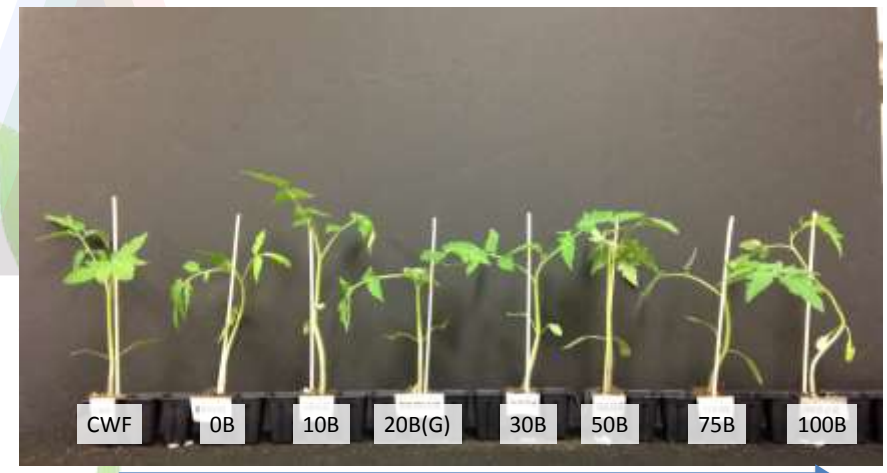


Discussion: Tomato 'Komeett' B:R PF ratio

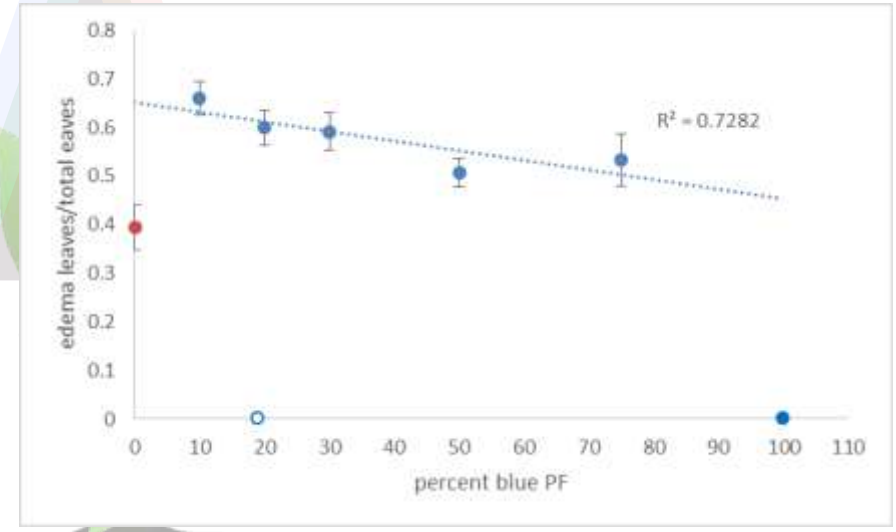
- **Hypocotyl length :** decreased with the increase of % blue PF, except for the 100% blue treatment.
  - 75% blue had the shortest hypocotyl and 0% blue had the longest.

- **Shoot dry mass :** increased with the increase of % blue PF up to 30-50% blue.
  - 30% and 50% blue had the highest shoot dry mass.

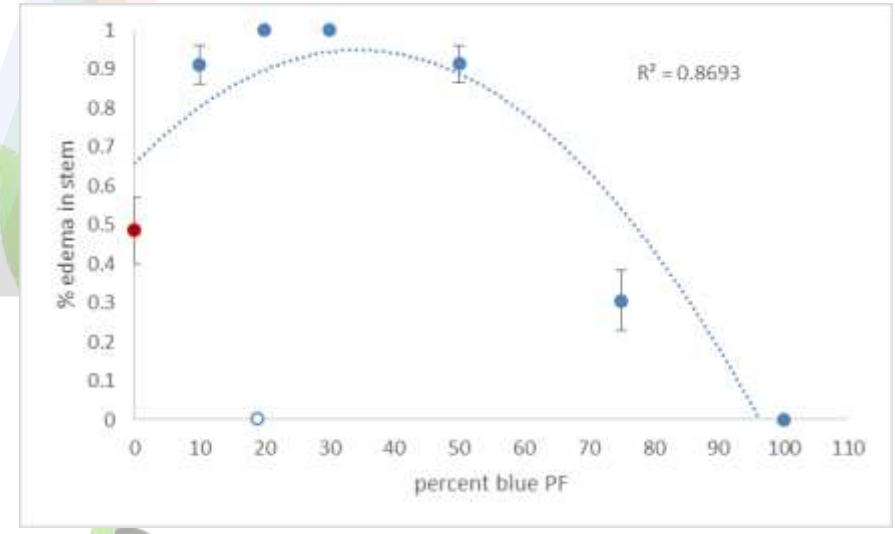
Intumescences: Tomato B:R PF

- Non-pathogenic physical disorder, characterized by small protrusions on leaf tissues that become necrotic over time.
- Occurs in red light-dominant environments with little or no UV-B light.
- Beufort is a sensitive cultivar (*S. lycopersicum* × *S. habrochaites)*

Tomato ‘Beaufort’ intumescences



Tomato 'Beaufort' intumescences



Tomato intumescences

- Currently working on solving the issue of tomato intumescence using light quality.
- Please visit the poster and talk to Tomomi Eguchi to see the latest update.

Summary

- Plant responses to light quality are species specific and cultivar specific.
- For cucumber R and B PF is required for proper growth and development, using 10% B PF will be a good compromise between plant growth and development.
- For to tomato 30-50% B PF is recommended for optimal growth and development. Interspecific hybrids such as ‘Beaufort’ and ‘Maxifort’ need solution for intumescence development.

Summary

- More crop species need to be examined from a wide range of families relevant to CEA plant production.
- Crop species should be classified according to their light quality sensitivity.

Acknowledgments

- Mark Kroggel (UA, CEAC)
- Tomomi Eguchi
- Neal Barto (UA, CEAC)
- Murat Daveci
- CCS, Inc. (Kyoto, Japan)
- Grafted Growers
- USDA SCRI

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National Institute of Food and Agriculture