Monitoring supplemental light use by plants using remote sensing

Krishna Nemali
Purdue University
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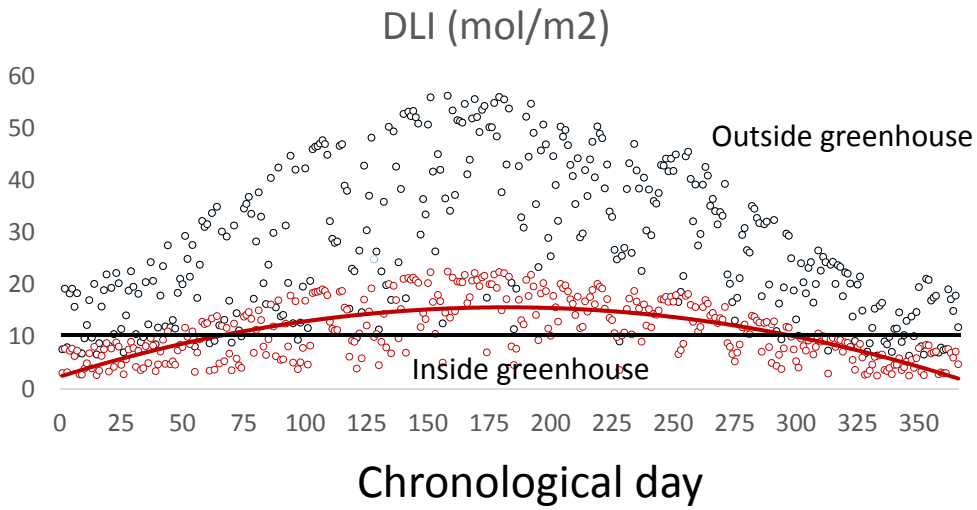
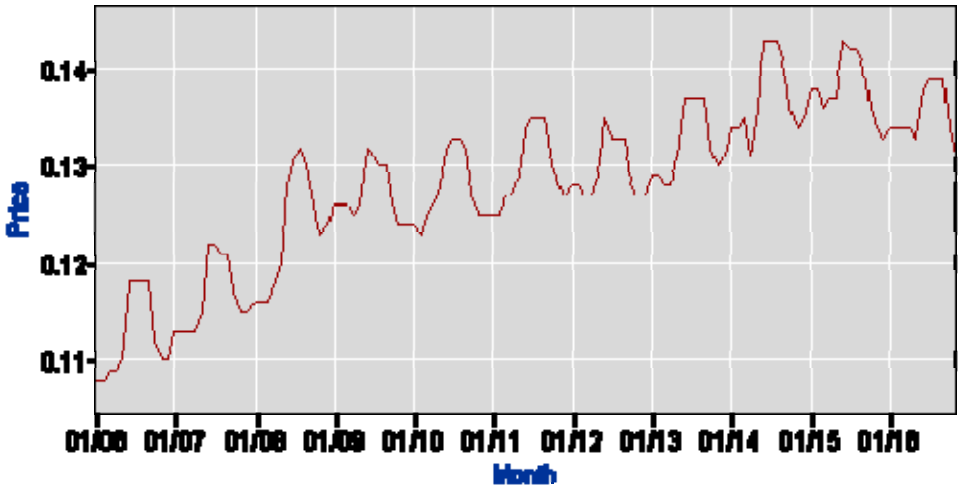
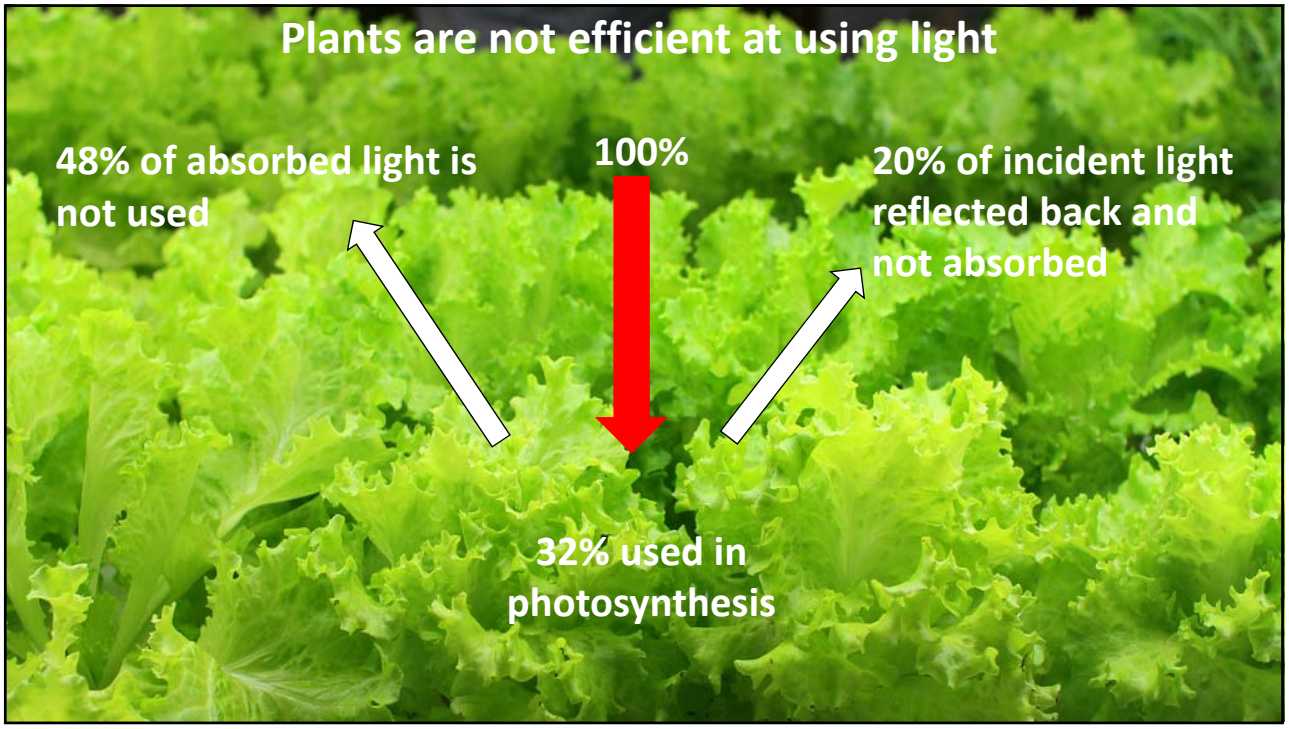
Supplemental lighting is needed to grow quality plants in the winter months



Price per KWH is continuously increasing in the US



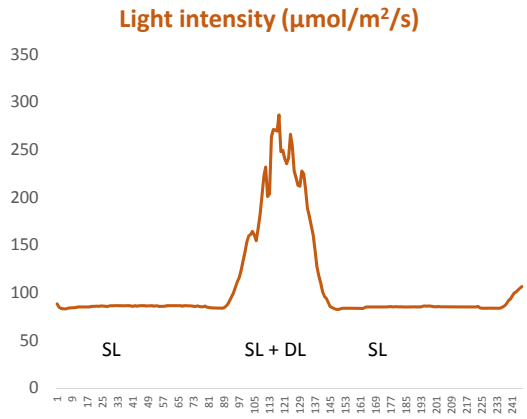


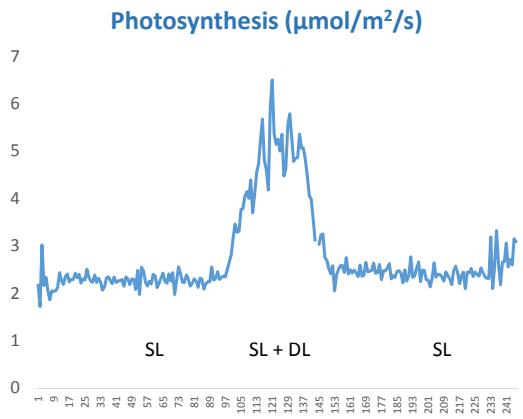
- We are ‘supplementing’ light to grow quality plants
- Further reducing supplemental light intensity is not a right approach
- Use energy efficient approaches and ensure supplemental light is not wasted during production

How to know if plants are wasting supplemental light?

- A typical light sensor measures the amount of light incident on plants
- One can measure the fraction of light reflected by plants using a light sensor (inverting over plants) but with less precision

Photosynthesis is directly affected by light intensity





Why not measure photosynthesis to monitor changes in light absorption and use?

- Photosynthesis measurement systems may be robust but are
  - expensive ($45 K)
  - complicated to use
  - measure small leaf sections

Photosynthesis measurement system

Spectral reflectance sensors (SRS) may provide solution

- Low cost (~ $750)
- Can be connected to any data monitoring devices
- Measure groups of plants

Before we used spectral reflectance sensors, we tested their efficacy

- Two sensors namely **PRI** (**p**hotochemical **r**eflective **i**ndex) and **NDVI** (**n**ormalized **d**ifference **v**egetation **i**ndex) were tested
- PRI sensor may measure the extent of supplemental light not used in photosynthesis
- NDVI sensor may measure the extent of supplemental light reflected back by plants
- If the sensors are working as expected, they should affect photosynthesis in plants
- Sensors were tested by comparing them with high cost photosynthesis measurements

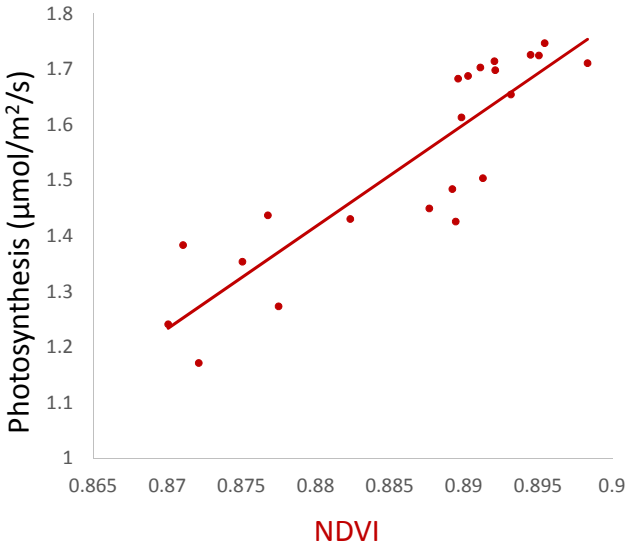
Setup to test SRS sensors for efficacy

NDVI sensor

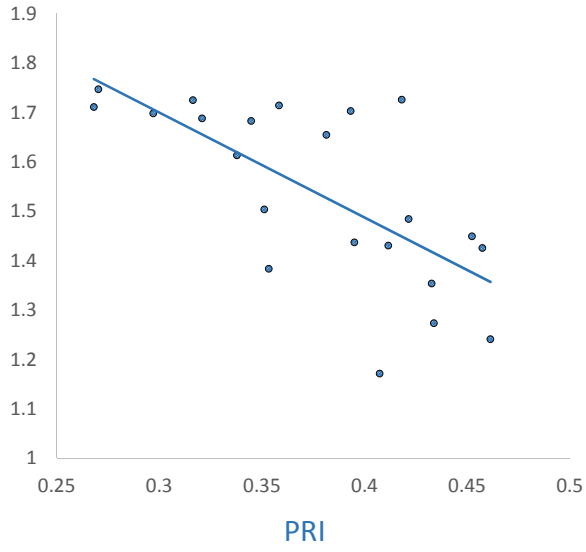
PRI sensor

Photosynthesis system

Higher NDVI indicates higher light absorption



Higher PRI indicates lower light use

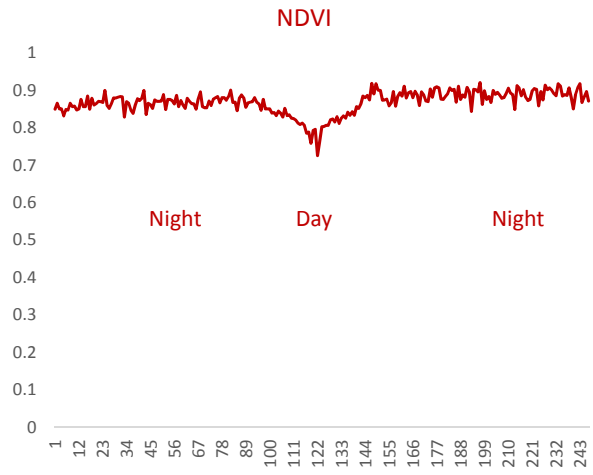


Data collected from petunia plants

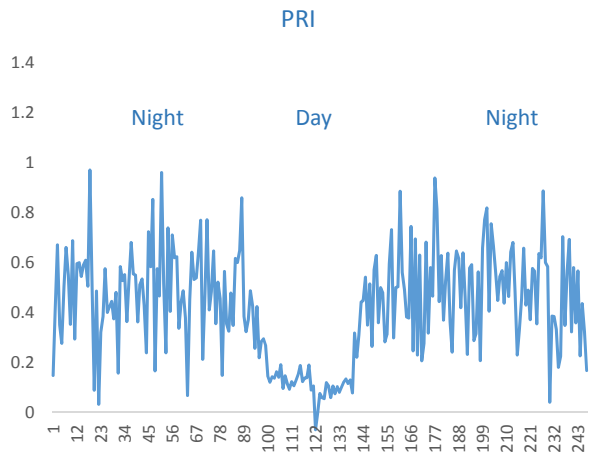
Questions for the experiment using SRS

- Can plants use supplemental light with similar efficiency during both daytime and nighttime?
- Can environmental stress like low temperature or drought further lower supplemental light use by plants?

Light absorption was slightly higher & light use was slightly lower when supplemental light is provided at night than day

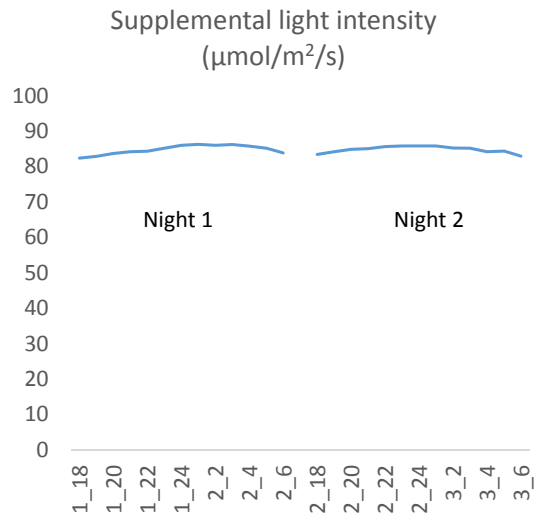


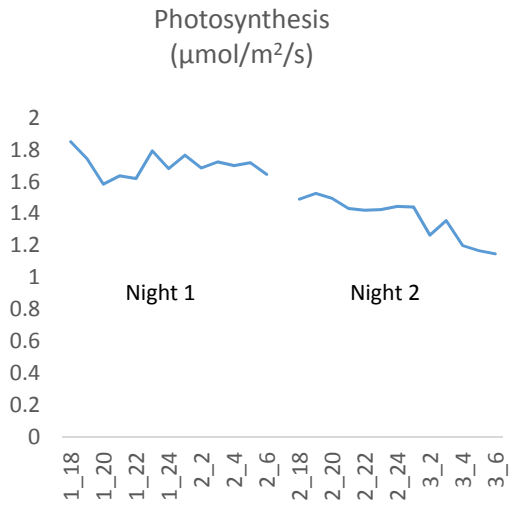
Higher better



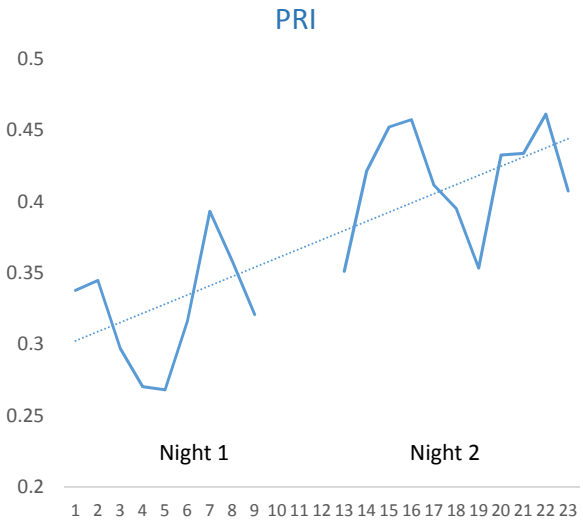
Lower better

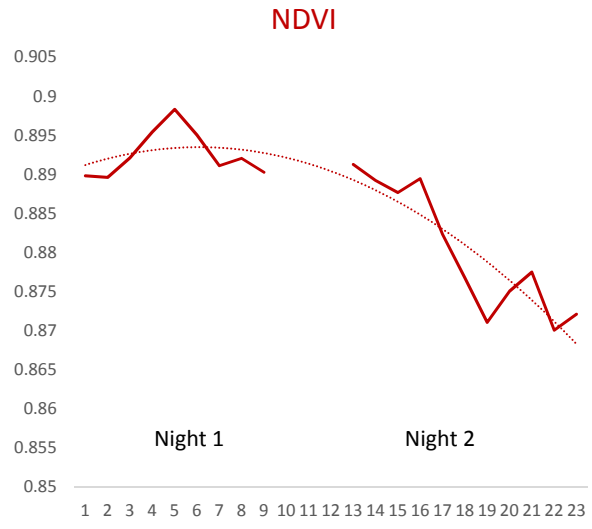
Petunia plants grown in 4-inch containers were subjected to drought stress





PRI increased (lower light use) and NDVI decreased (lower light absorption) as drought stress progressed





Conclusions

- Supplemental lighting is an expensive but essential input for producing quality plants
- Plants only use only 1-3% of supplemental light
- Spectral reflectance sensors may offer viable solutions to monitor light absorption and use by plants
- Plants appear to use light relatively similar at night compared to day
- Transient stress can further reduce supplemental light use efficiency