Shedding the light on plant pathogen interactions

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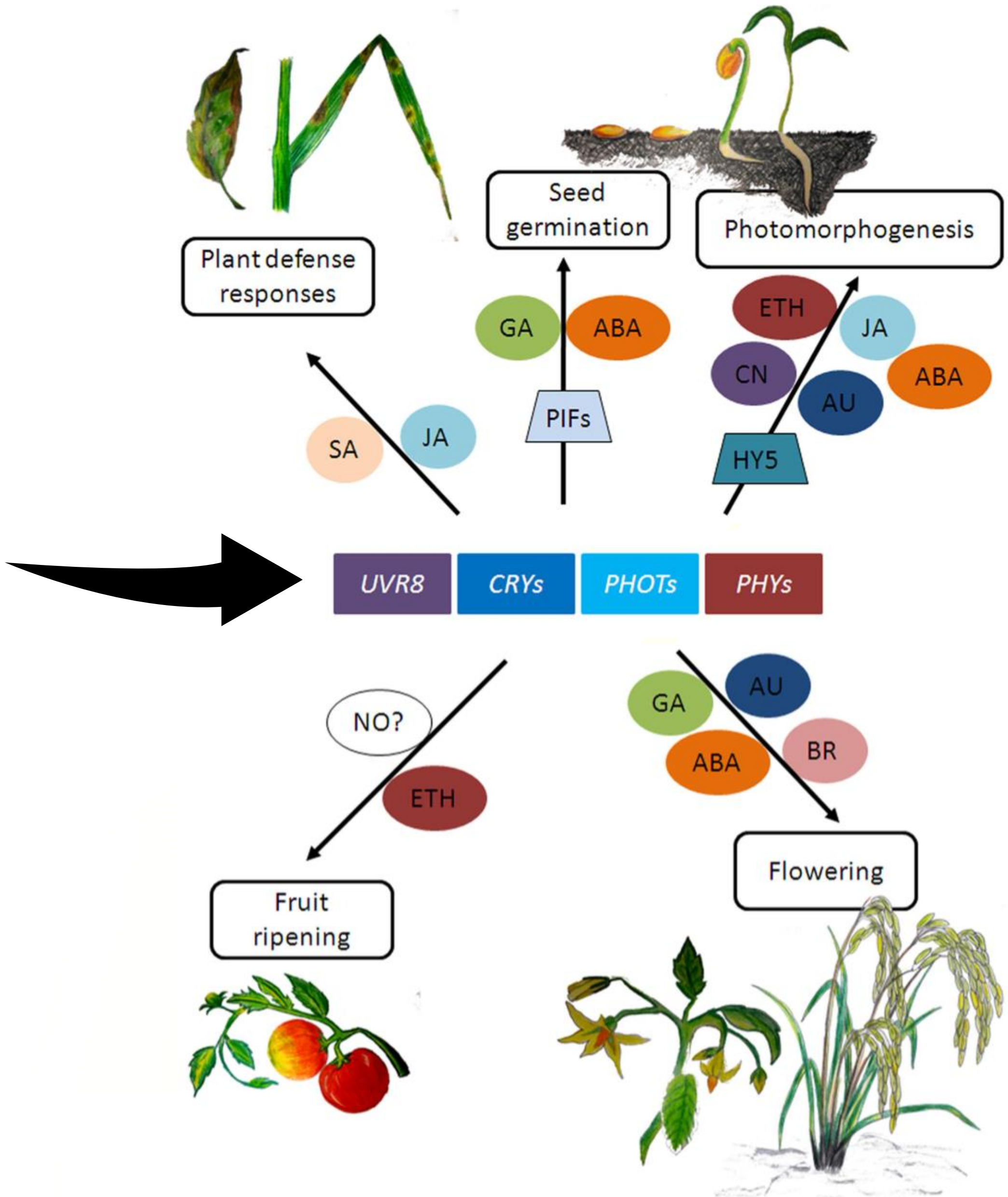
Workshop PathoLED – 14th May 2019

GEVES
Expertise & Performance

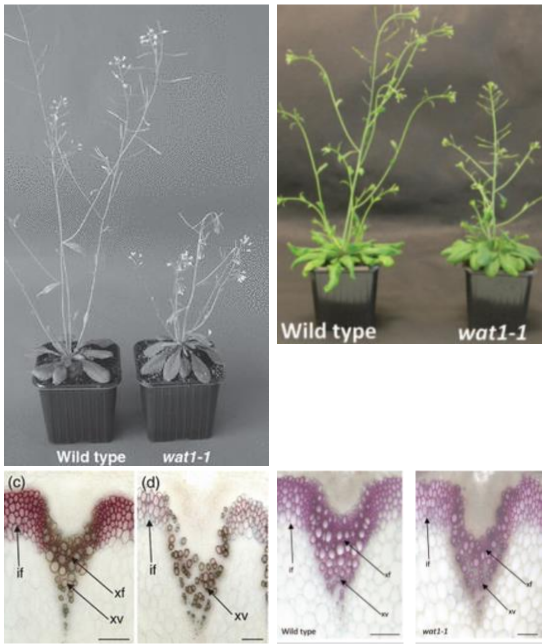
From light perception to plant growth: a complex network



Mawphlang & Kharshiing, Front. Plant Sci. (2017)

Arabidopsis thaliana growth is influenced by the light regime

Light duration



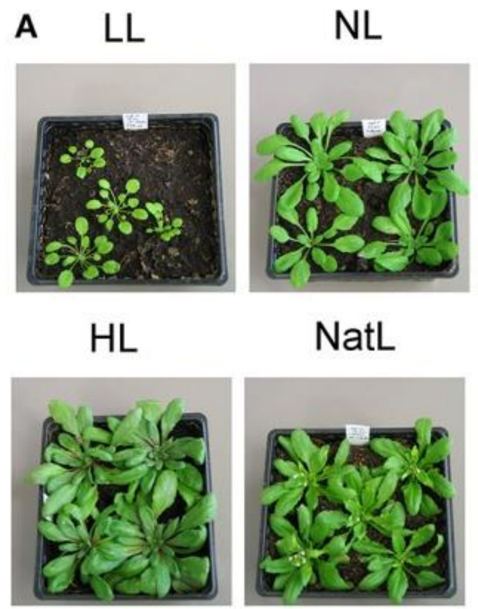
Short day (9h) **Continuous (24h)**

120 µmol photons/m/s

22°C night/day

65% RH

Light intensity

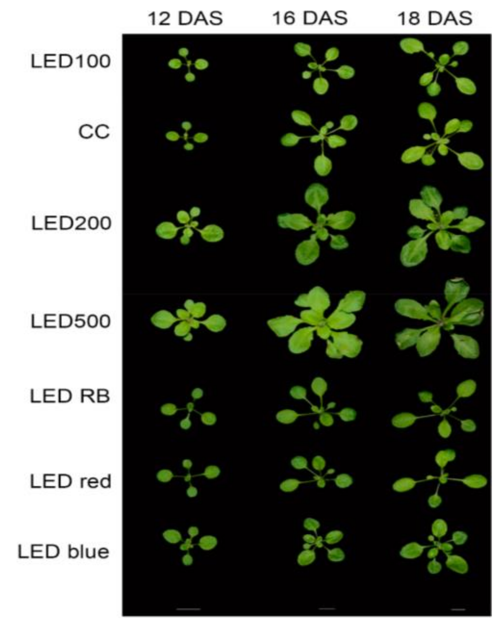


Long day (14h)

Low: 25 µmol photons/m/s
Normal: 100
High: 500
Natural: up to 1400 (med.: 150)

LL, NL, HL: 20°C night/day
NatL: outside conditions

Light source



Long day (16h)

White LED: 100-200-500 µmol photons/m/s
CC (fluoresence): 100
Red, Blue, Red/Blue LED: 500

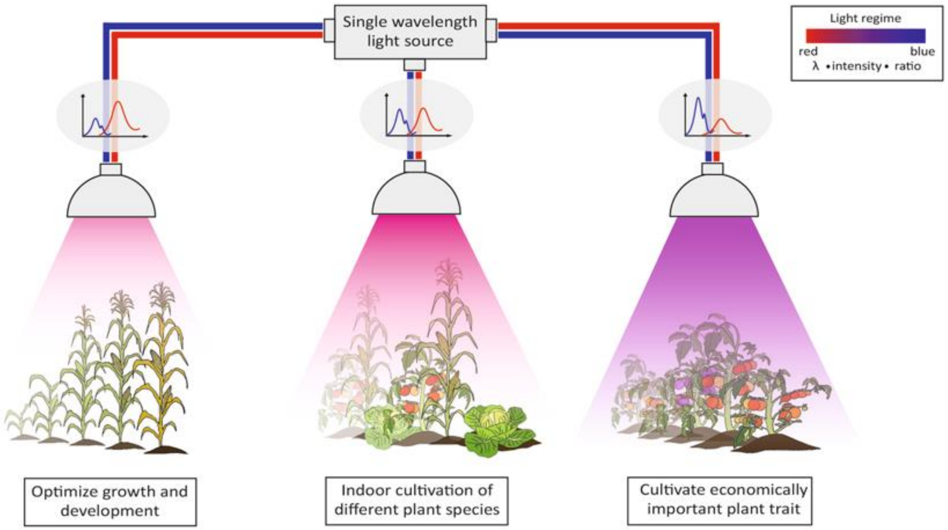
18°C night/ 22°C day

50-65% RH

Light-dependent phenotypical diversity

Denancé et al., Plant Sign. Behav. (2010); Ranocha et al., Plant J. (2010); Schumann et al., Front. Plant Sci. (2017); Seiler et al., Plants (2017)

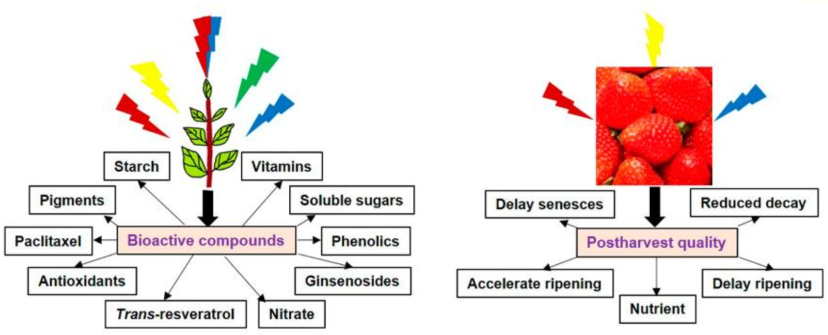
Towards light-based horticultural uses to improve crop quality



LED-triggered phenotypes in vegetables, field crops & trees:

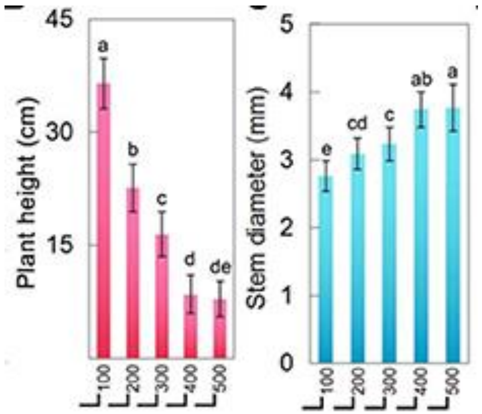
LED Light	Light Intensity	Crops	Synthesis of Bioactive Compounds and Crop Traits
Red	50 μmol m^{-2} s^{-1}	*Gossypium hirsutum*	Sucrose, starch, soluble sugar
	50 μmol m^{-2} s^{-1}	*Vitis* root-stock	Sugar, starch
	80 μmol m^{-2} s^{-1}	*Brassica campestris* L.	Starch
	500 μmol m^{-2} s^{-1}	*Glycine, Sorghum*	Starch
	30 μmol m^{-2} s^{-1}	*Betula pendula* Roth	Starch
	50–80 μmol m^{-2} s^{-1}	*Vitis vinifera*	Stilbene
	50 μmol m^{-2} s^{-1}	*Malus domestica* Borkh	Anthocyanin
	500 μmol m^{-2} s^{-1}	*Triticum aestivum* L.	Lignin
	128 μmol m^{-2} s^{-1}	*Pisum sativum*	β-Carotene
	50 μmol m^{-2} s^{-1}	*B. oleracea* var. *italic*	Delayed senescence
Blue	100–200 μmol m^{-2} s^{-1}	*Lactuca sativa*	Phenolic content, Vit-C, tocopherol, carotenoid
	50 μmol m^{-2} s^{-1}	*Vitis* root-stock	Sugar, starch
	80 μmol m^{-2} s^{-1}	*Brassica campestris* L.	Vit. C
	>20–40 μmol m^{-2} s^{-1}	*Fragaria × ananassa*	Organic acids, anthocyanin, ripening
	50–80 μmol m^{-2} s^{-1}	*B. rapa, B. oleracea* var. *capitata*	Vit. C, polyphenolic content
	85–150 μmol m^{-2} s^{-1}	*Solanum lycopersicum*	Proline, Reactive Oxygen Species, scavenger activities, polyphenolic compounds, γ-aminobutyric acid, shelf-life
Blue	40 μmol m^{-2} s^{-1}	*Myrica rubra* Sieb. and Zucc.	Anthocyanin
	40 μmol m^{-2} s^{-1}	*Prunus persica*	Ripening
	40 μmol m^{-2} s^{-1}	*Citrus reticulate*	Reduced postharvest decay
	40–630 μmol m^{-2} s^{-1}	*Citrus* hybrid	Reduced pathogen infection
	-	*Panax ginseng*	Ginsenosides
	60 μmol m^{-2} s^{-1}	*Taxus wallichina* Zucc	Paclitaxel
	80 μmol m^{-2} s^{-1}	*Vitis vinifera*	*Trans*-resveratrol
Green	~200 μmol m^{-2} s^{-1}	*Lactuca sativa, Lens culinaris, Triticum aestivum* L., *B. oleracea* var. *capitata, Fragaria × ananassa*	Phenolic content, Vit-C, α-tocopherol, anthocyanin
Yellow	~100 μmol m^{-2} s^{-1}	*Raphanus sativus, Malus* sp., *S. lycopersicum, C. annuum*	Vit-C, α-tocopherol, γ-tocopherol, lutein
Red+Blue	70 μmol m^{-2} s^{-1}	*Doritaenopsis* hort	Carotenoids, starch, sucrose, glucose, fructose
	>20 μmol m^{-2} s^{-1}	*Fragaria × ananassa*	Organic acids
	90 μmol m^{-2} s^{-1}	*Lactuca sativa*	Anthocyanin
	-	*B. rapa, B. alboglabra*	Polyphenol, flavonoids, glucosinolates
Red + Blue + White	210 μmol m^{-2} s^{-1}	*Lactuca sativa*	Soluble sugar, nitrate contents
Red + far – red	50–200 μmol m^{-2} s^{-1}	*Lactuca sativa, Petunia*	Phenolic content, volatile compounds

Some benefits of LEDs:



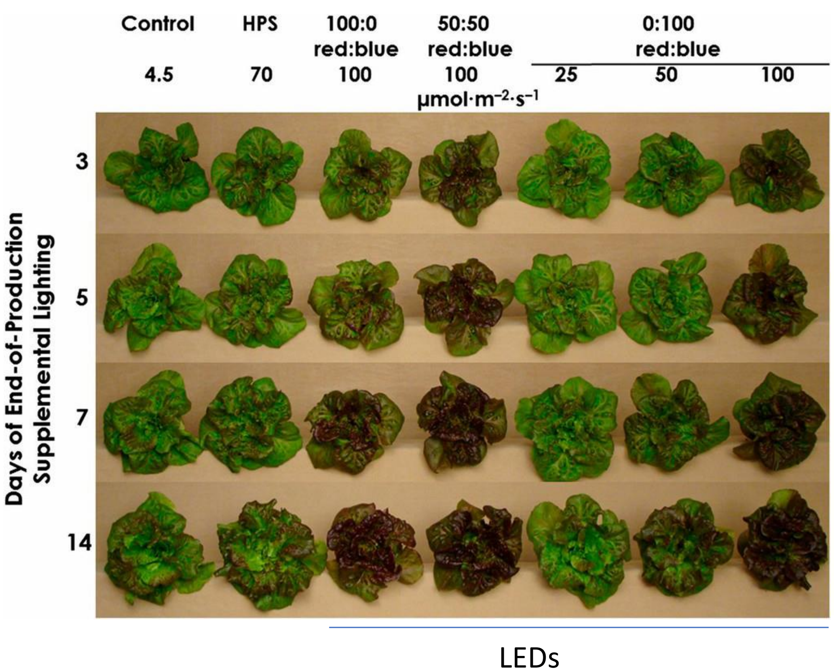
Hasan et al., Molecules (2017); Marondedze et al., Hort. Res. (2018)

Examples of soybean and lettuce



Short day (10h)

- LED: 100 to 500 µmol photons/m/s
- 20°C night / 25°C day
- 60% RH

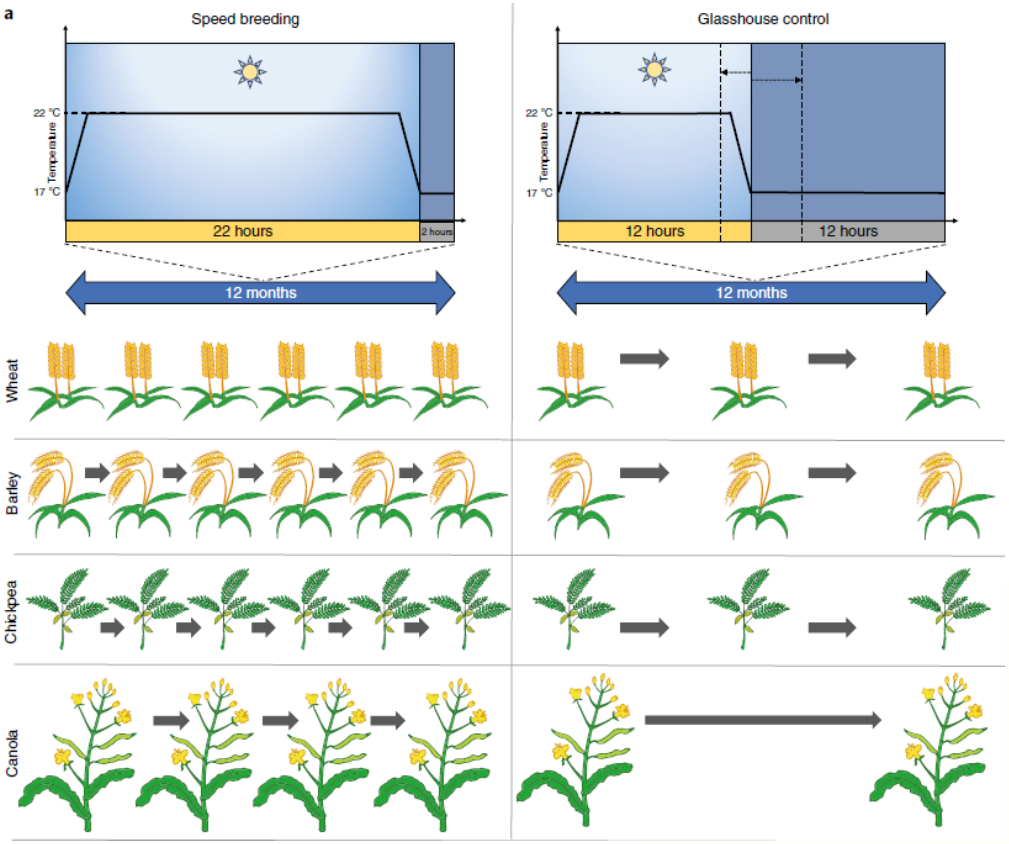


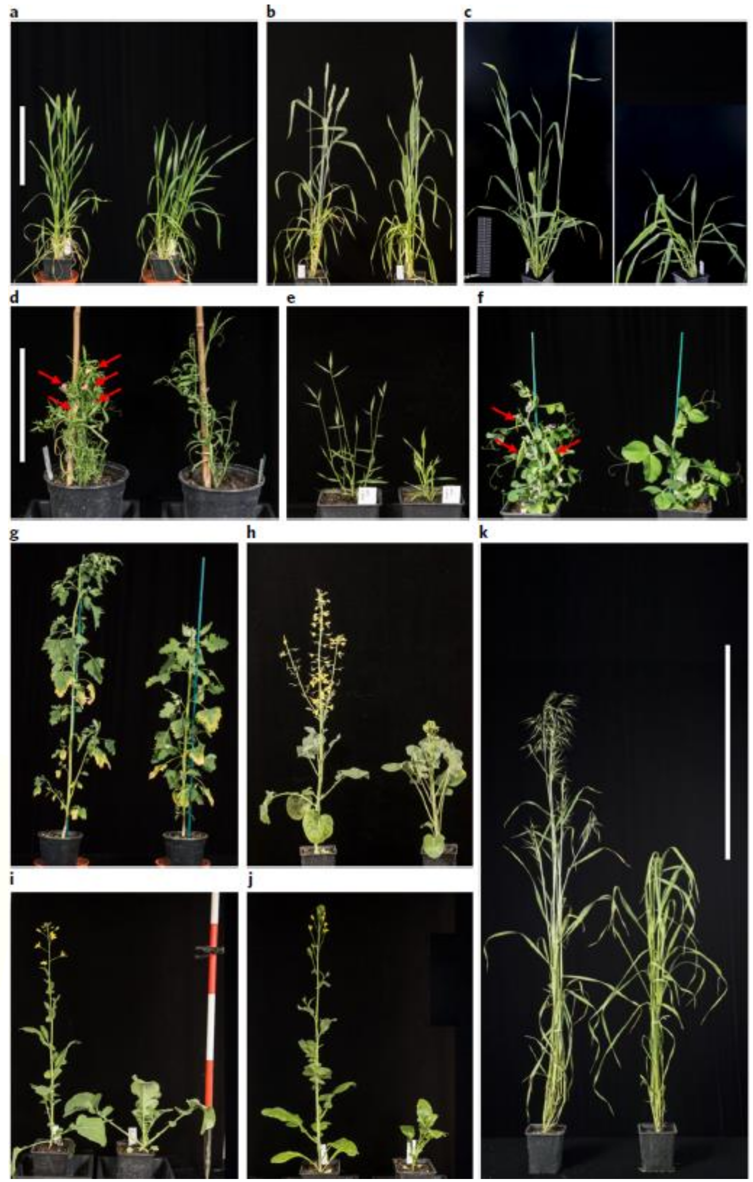
Supplemental lighting with red and blue LEDs **influences red pigmentation in lettuce**

Owen & Lopez, Hort. Sci. (2015); Feng et al., Front. Plant Sci. (2019)

'Speed breeding': improving crop production thanks to LED technology

White LED + Far red LED + metal halide lamp
360-380 µmol photons/m/s (bench height)
490-500 µmol photons/m/s (adult plant height)

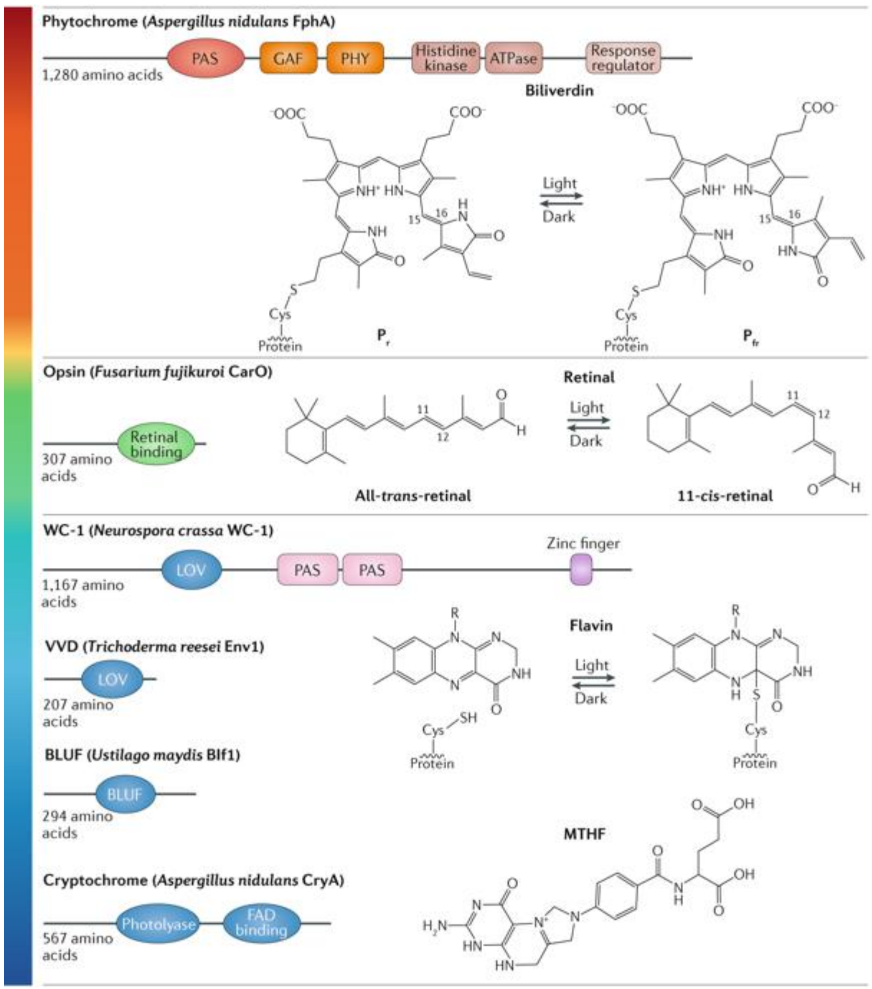




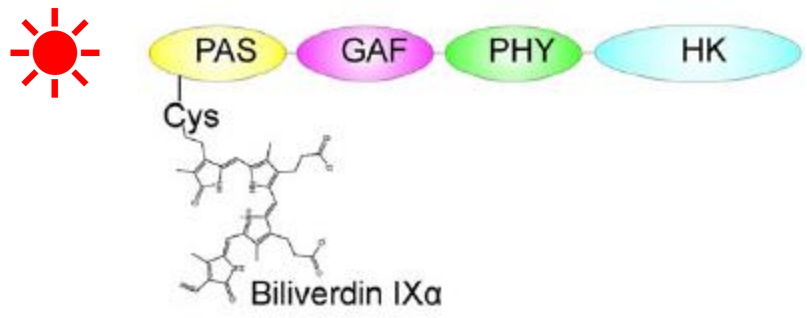
a, *T. aestivum* (cv. Crusoe)
b, *T. aestivum* (cv. Cadenza)
c, *H. vulgare* (cv. Manshuria)
d, *L. sativus* (cv. Mahateora)
e, *B. dystachion* (accession Bd21)
f, *P. sativum* (accession JI2822)
g, *C. quinoa* (accession QQ74)
h, *B. oleracea* (line DH1012)
i, *B. napus* (line RV31)
j, *B. rapa* (line R-0-18 87)
k, *A. strigose* (accession S75)

Watson et al., Nat. Plants (2017); Ghosh et al., Nat. Protocols (2018)

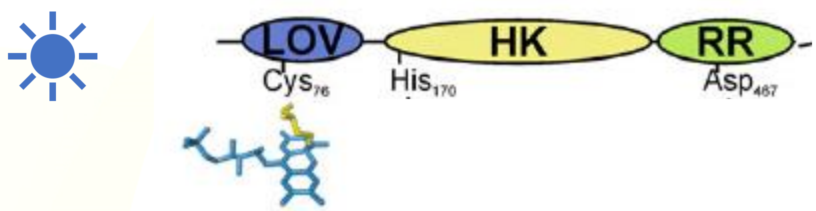
Seeing the Light: Plant pathogens have their own photoreceptors



***P. syringae* pv. *tomato* (DC3000)**

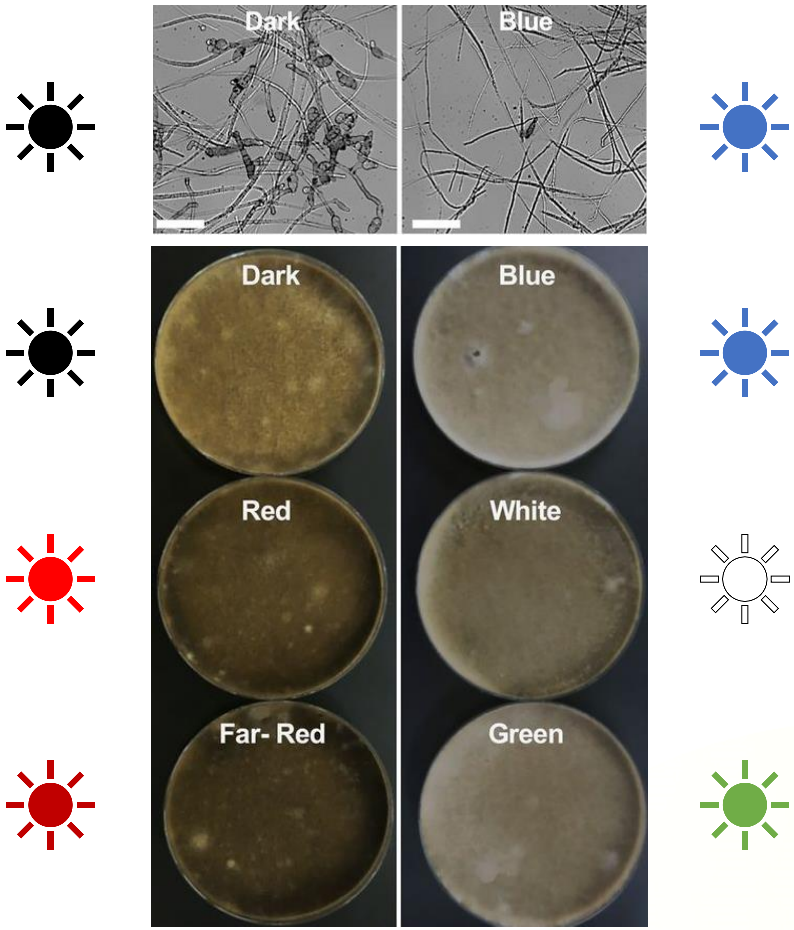


X. citri* pv. *citri



Burgie & Vierstra, The Plant Cell (2014); Kraiselburd et al., Photochem. Photobiol. (2017);Yu & Fisher, Nat. Rev. Microb. (2019)

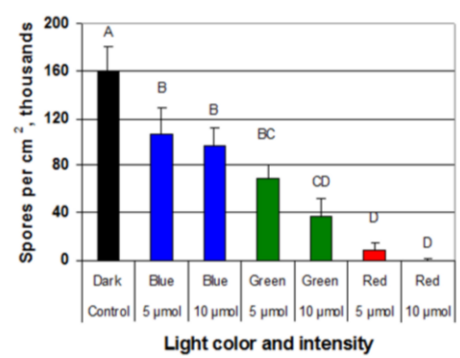
Alternaria alternata & Peronospora belbahrii

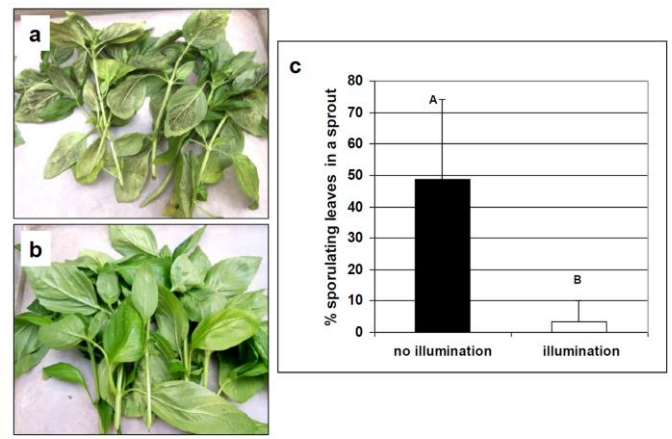


A. Alternata

Dark brown appearance
↕
More spores

Pale appearance
↕
Less spores





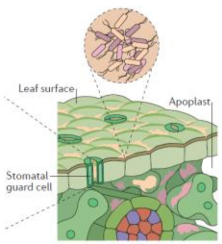
***P. Belbahrii* (basil downy mildew)**

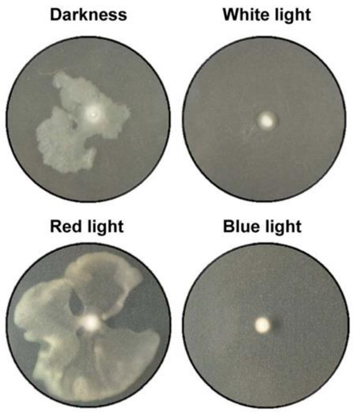
Top: level of **sporulation depends on the light** colour & intensity

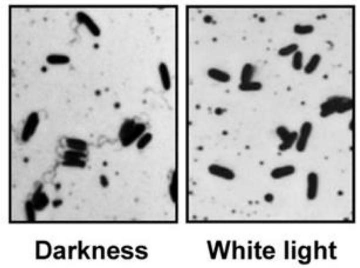
Bottom: **illumination during the night suppresses disease** development in newly-developed basil sprouts in the field

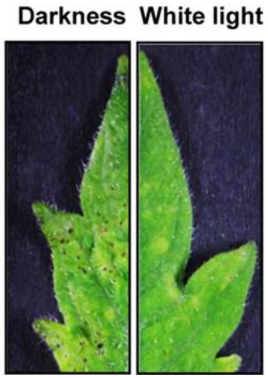
Cohen et al., PLoS ONE (2013); Igbalajobi et al., mBio (2019);

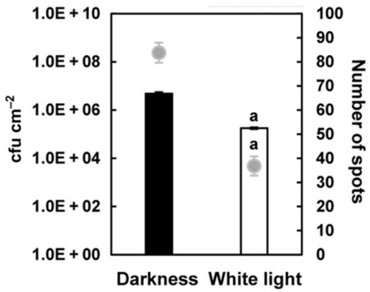
Pseudomonas syringae pv. *tomato*

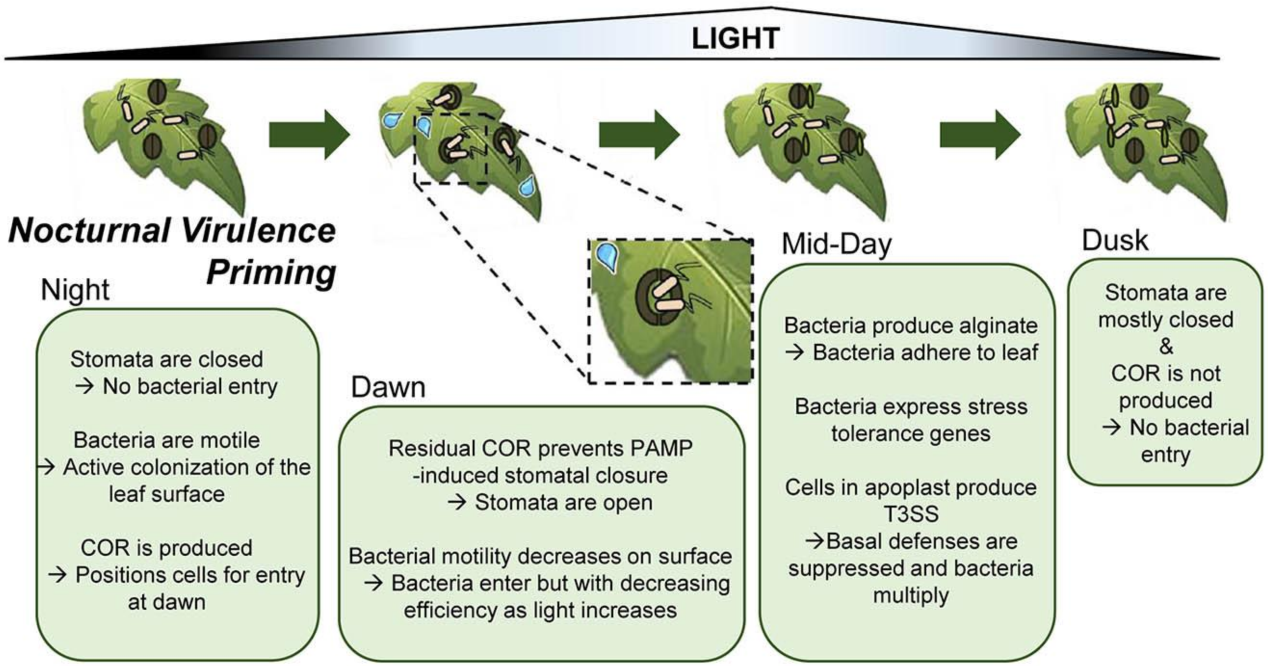












Rio-Alvarez et al., Environ. Microbiol. (2013); Santamaria-Hernando et al., Environ. Microbiol. (2018); Xin et al., Nat. Rev. microbiol. (2018)

It's trendy: crops grown with LED light are more resistant to pathogens

LED Light	Light Intensity	Crops	Effect on Disease
Red	261–550 μW/cm^2	*Vicia faba*	Induces resistance against *B. cinerea*, *Alternaria tenuissima*
	250–287 μW/cm^2	Rice *sl* mutants cultivar (Sekiguchi-asahi and Sekiguchi-himenomochi)	Induced resistance against *Magnaporthe grisea*
	287 μW/cm^2	*Arabidopsis*	Induced resistance against *M. javanica*, *P. syringae* pv. *tomato* DC 3000
	287 μW/cm^2	*Piper nigrum*, *Cucurbita*, *Solanum lycopersicum*	Induced resistance against *P. capsici*
	137 μW/cm^2; 350 μmol m^{-2} s^{-1}	*Cucumis sativus*	Induced resistance against *C. cassiicola* and *S. fuliginea*
	80 μmol m^{-2} s^{-1}	*Vitis vinifera*	Induced resistance against *B. cinerea*
		Nicotiana benthamiana	Induced resistance against *P. syringae* pv. *tabaci*
Blue	200 μmol m^{-2} s^{-1}	*Lactuca sativa*	Induced resistance against grey mold by *B. cinerea*
	50–150 μmol m^{-2} s^{-1}	*Solanum lycopersicum*	Induced resistance against gray mold disease by *B. cinerea*
	150 μmol m^{-2} s^{-1}		Suppression of sporulation of *A. cichorii*, *P. pannosa*
	3.4 μW/cm^2		Reduced spore germination of *A. niger*
		Nicotiana benthamiana	Induced resistance against *P. syringae* pv. *tabaci*
Green	80 μmol m^{-2} s^{-1}	*Fragaria×ananassa*	*Glomerella cingulate*
		Cucumis sativus	*C. orbiculare*, *B. cinerea*

Hasan et al., Molecules (2017)

The use of LED in plant pathology is puzzling!

Plant:
Improved agronomic traits
Increased resistance

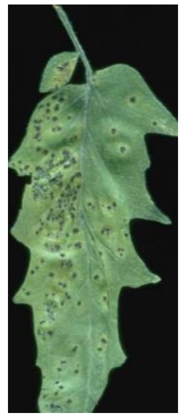
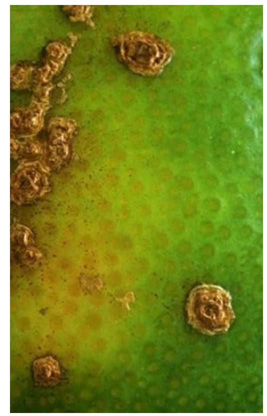
Pathogen:
Altered pathogenic traits
Reduced virulence

For certain purposes: **disease needs to occur**

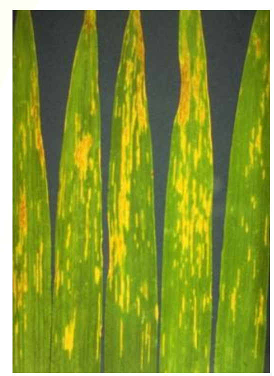
Disease resistance or growth:
Is there a trade-off in using LED technology?

Thank you for your attention






http://photos.eppo.int/index.php/