# Light Spectrum: Improving Plant Quality

*Masterclass 22 oktober 2015 HAS Den Bosch*
*BOGO project "Klimaat en energie: nieuwe low input teeltsystem in de tuinbouw"*

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# Challenges in horticulture

- Grower & consumer
  - Plant quality
  - Increased yield, shorter cropping cycle
- General public
  - Demands for food quality and health
  - Food with 'added value'
- Industry
  - Need for sustainably produced phyto-extracts, i.e. medicines, marketable products
  - Plants products with 'added value'

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# Plants sense their light environment:

Quantity (fluence rate)
Duration (day length)
Direction
Quality (wave length/colour)

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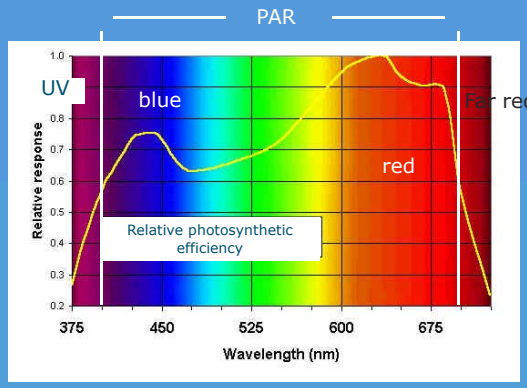
# Which wave lengths does a plant 'see'?

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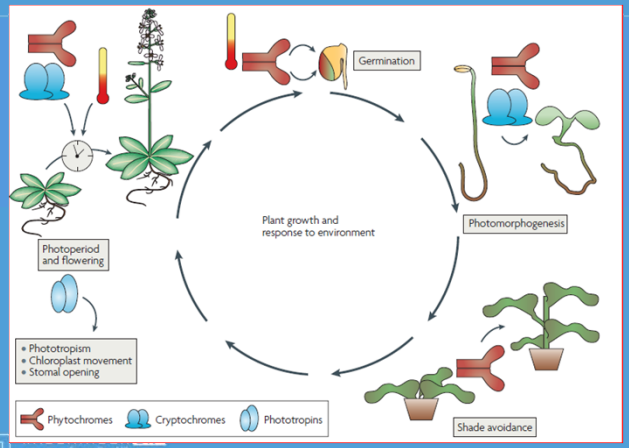
Aangepaste McCree curve, naar Runkle

## Photoreceptors in a plant's Life cycle




From Jiao, 2006

## How to steer light?

- Sunlight, change in R:FR, dusk, dawn
- HPS, limited spectrum
- LEDs have possibilities for spectral manipulation = tools
  - Choice of wave length (combinations)
  - Dimming
  - Long life-time (ca. 50,000 h)
  - Low radiative heat production

## LEDs near/in the crop

## Total light control in a multi-layer system

## Photomorphogenesis

= light dependent development of plants, mediated by all photoreceptors

- Germination, stem elongation, flowering (red, far red)
- Stomatal opening, chlorophyll formation, phototropism (blue)
- Also secondary metabolites (UV, blue, red, far red)

## Phytochrome

- Phytochrome changes in form and function ~ red and far red wave lengths

Pr ⟷ Pfr

absorbs red — absorbs far red

- Pr – absorbs red light (660 nm)
  - Stem and cell elongation, flowering
- Pfr – absorbs far red light (730 nm)
  - Germination at low light intensities, perceives day length

## Role of phytochrome?

Flowering reactions

- LD & SD plants (day length determines flowering); day neutral plants (temperature sum determines flowering)

Growth responses

- Germination in soil, determines seedling elongation
- Chlorophyll production, leaf growth

## Red:far red ratio

- Plant response depends on red:far red ration -> sunlight 1:2

  light under leaves 0.13


Night interruption by red light

Germination depends on last light(colour) flash

## Far red light

- Inhibits germination (deep in soil, under vegetation
- Stimulates elongation (in shadow of vegetation)

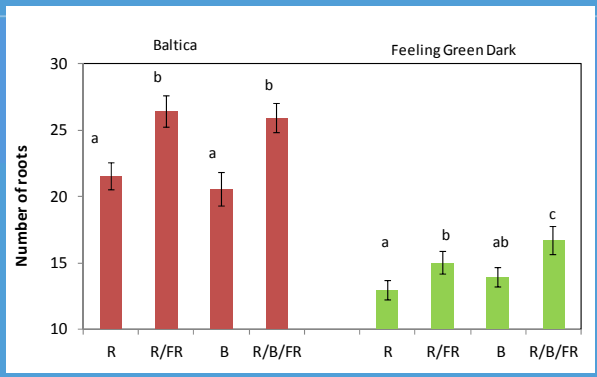
RB LEDs SON-T Plasma

Van Ieperen et al. 2010

## Rooting in Chrysanthemum, ca. 10 d


## Measuring roots

## Influence of red, blue and far red light on rooting of Chrysanthemum




1 day earlier = 1 M plants/year !

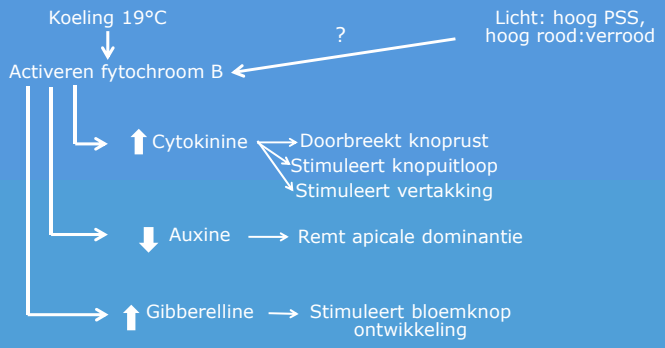
## Induction of flowering in Phalaenopsis

- Grown at 28°C, cooled to 19°C to induce flowering
- Cooling costs energy in summer
- Can light quality help to save (cooling) energy?
- "red light" predominates in winter (lamps)
- "far red light" predominates in summer (sunlight)

## Bloei-inductie bij Phalaenopsis

- Bloei-inductie ca. 6-9 wk
- Per bladoksel – 2 bloemknoppen
- Proces
  - Doorbreken knoprust
  - Groei van bloemtak(ken)
  - Bloemknop inductie

## Proces van bloei-inductie




## Rood:verrood verhoudingen in de kas

| Seizoen | Licht | | PSS* waarde | R:FR |
|---|---|---|---|---|
| Zomer | Zonlicht | - | 0.7 | Laag |
| | | | | |
| Winter | Zonlicht | - | 0.73-0.76 | Iets hoger |
| | Geen zonlicht | SON-T | 0.83 | Hoog |
| | Geen zonlicht | LEDs – rood | 0.87 | Nog hoger |

Waardes - uiteraard allemaal relatief

*PSS = phytochrome stationary state

## Hoe fytochroom B te activeren?

Knoprust doorbreken:

- Cytokinine stimuleren via SON-T (relatief veel rood licht, hoog PSS waarde)

Uitgroei bloemtakken:

- Auxine remmen via SON-T (remt apicale dominantie)?

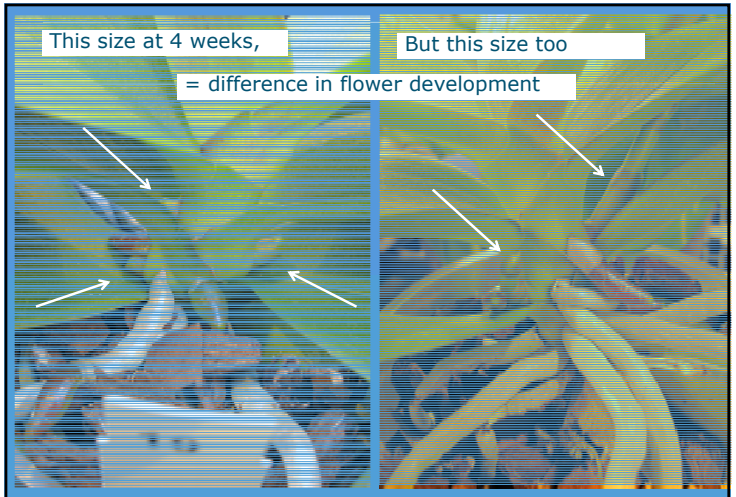
Induceren van bloemknoppen:

- Giberelline stimuleren via SON-T??

## Behandelingen

- Inductie periode
  - 8 weken, verdeeld in 2 perioden van 4 weken
  - Vanwege hypothese toetsing (knoprust, apicale dominantie, meertakkers)
- Afkweek periode

- Factoren
  - Temperatuur: 19 en 22°C
  - Licht: 'rood' = SON-T
    'verrood' = SON-T + verrode LEDs




## Cooling & multiple flower branches

| Induction period | | Quincy (2+) | Red Stones (3+) |
|---|---|---|---|
| 1st 4 weeks | 2nd 4 weeks | Multiple flower shoots (%) | |
| 19°C/red | 19°C/red | 92 | 32 |
| 19°C/red | 22°C/red | | |
| 19°C/red | 22°C/far red | | |
| 19°C/far red | 19°C/far red | 94 | 46 |
| 19°C/far red | 22°C/far red | | |
| 19°C/far red | 22°C/red | | |
| 22°C/red | 22°C/red | | |
| 22°C/far red | 22°C/far red | | |

Cooling always induces multiple flower branches

## Red light & multiple flower branches

| Induction period | | Quincy (2+) | Red Stones (3+) |
|---|---|---|---|
| 1st 4 weeks | 2nd 4 weeks | Multiple flower shoots (%) | |
| 19°C/red | 19°C/red | 92 | 32 |
| 19°C/red | 22°C/red | 90 | 30 |
| 19°C/red | 22°C/far red | | |
| 19°C/far red | 19°C/far red | | |
| 19°C/far red | 22°C/far red | | |
| 19°C/far red | 22°C/red | | |
| 22°C/red | 22°C/red | 92 | 34 |
| 22°C/far red | 22°C/far red | | |

Red licht induces multiple flower branches, whether cooled or not

## Cooling, red light, multiple flower branches

| Induction period | | Quincy (2+) | Red Stones (3+) |
|---|---|---|---|
| 1st 4 weeks | 2nd 4 weeks | Multiple flower shoots (%) | |
| 19°C/red | 19°C/red | 92 | 32 |
| 19°C/red | 22°C/red | 90 | 30 |
| 19°C/red | 22°C/far red | | |
| 19°C/far red | 19°C/far red | 94 | 46 |
| 19°C/far red | 22°C/far red | | |
| 19°C/far red | 22°C/red | | |
| 22°C/red | 22°C/red | 92 | 34 |
| 22°C/far red | 22°C/far red | | |

Red licht and/or cooling induces multiple flower branches

## Far red & multiple flower branches

| Induction period | | Quincy (2+) | Red Stones (3+) |
|---|---|---|---|
| 1st 4 weeks | 2nd 4 weeks | Multiple flower shoots (%) | |
| 19°C/red | 19°C/red | | |
| 19°C/red | 22°C/red | | |
| 19°C/red | 22°C/far red | | |
| 19°C/far red | 19°C/far red | 94 | 46 |
| 19°C/far red | 22°C/far red | 80 | 22 |
| 19°C/far red | 22°C/red | | |
| 22°C/red | 22°C/red | | |
| 22°C/far red | 22°C/far red | 81 | 21 |

Far red light treatment less effective without 8 weeks of cooling.

## Vragen?