Light spectral composition is a key factor in controlling plant growth and tuber quality of potato in controlled environment

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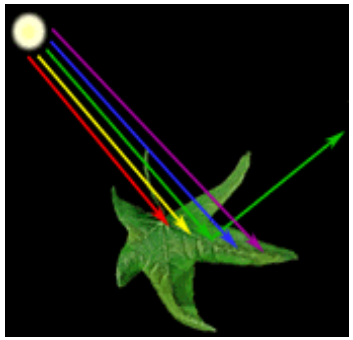
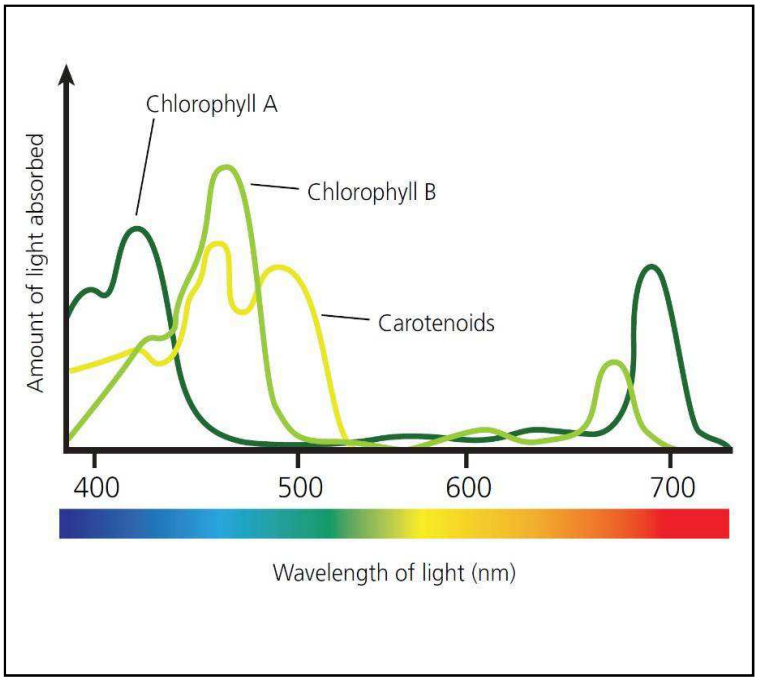
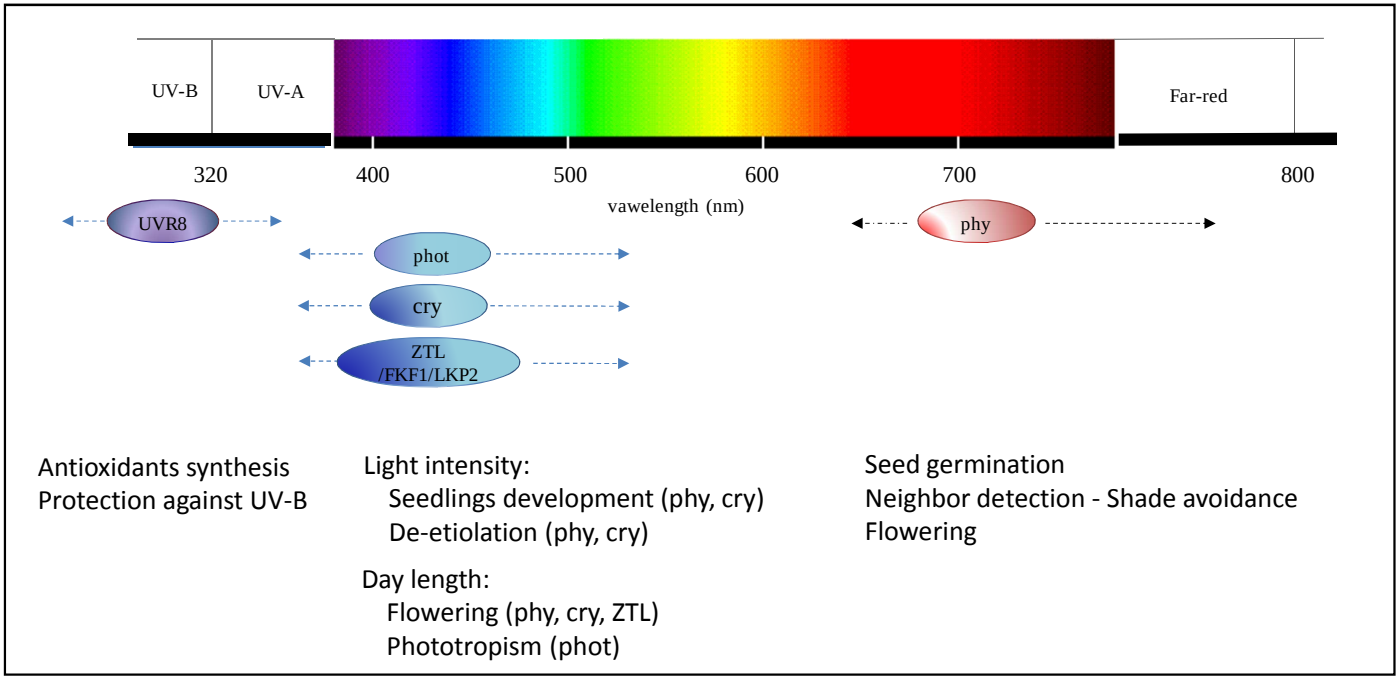
Light quality
and plant growth and development



Photosynthesis



Photomorphogenesis



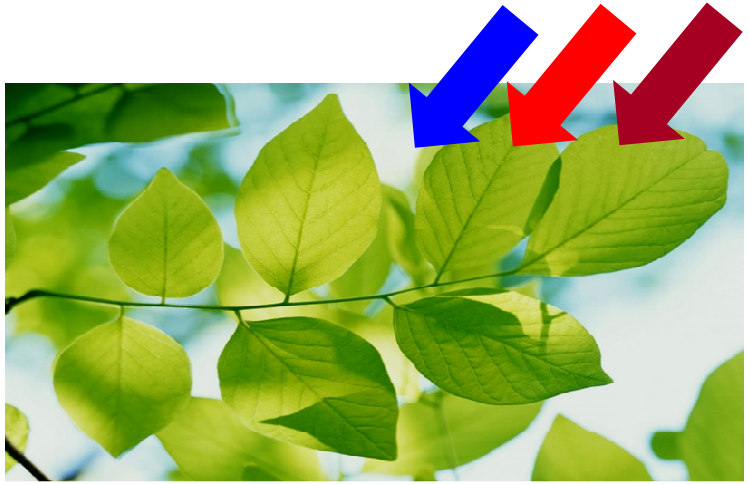
Antioxidants synthesis
Protection against UV-B

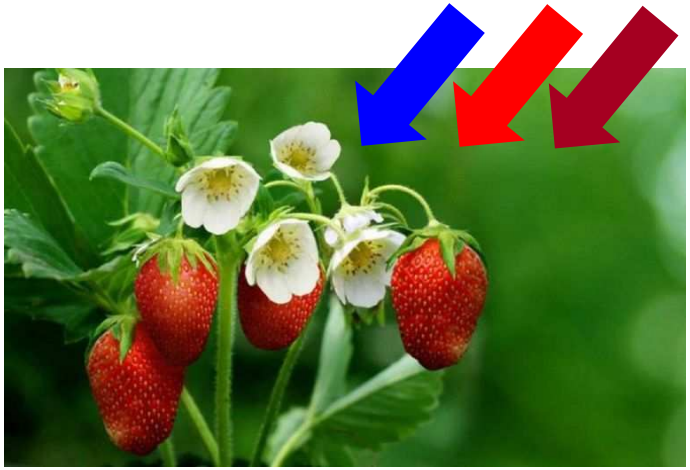
Light intensity:
- Seedlings development (phy, cry)
- De-etiolation (phy, cry)

Day length:
- Flowering (phy, cry, ZTL)
- Phototropism (phot)

Seed germination
Neighbor detection - Shade avoidance
Flowering

Light quality
and plant growth and development

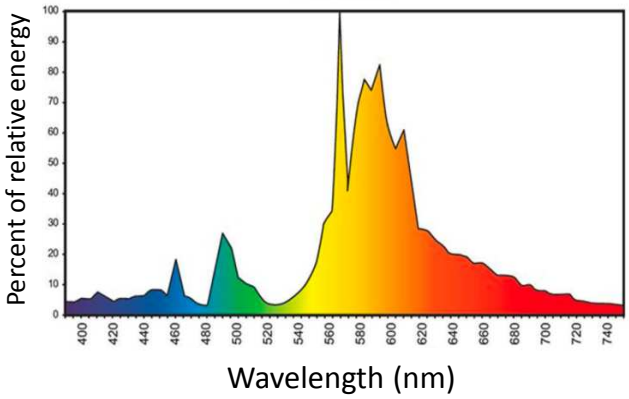




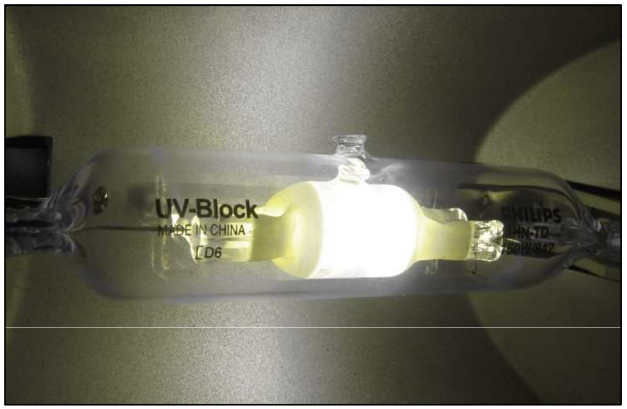
Artificial lighting in growth chamber

High-Pressure Sodium lamp

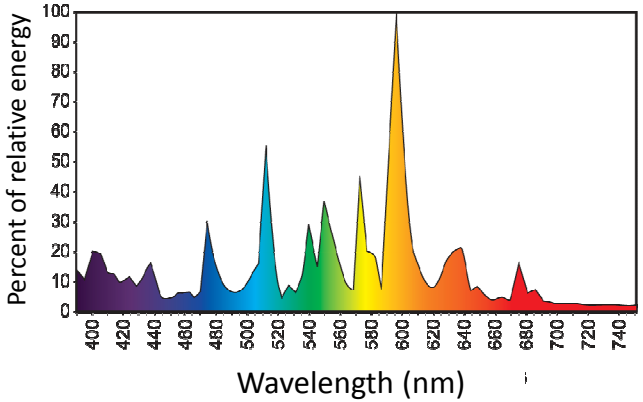
Eye Hortilux Super HPS
https://eyehortilux.com/grow-lights/super-hps/



Metal-Halide lamp

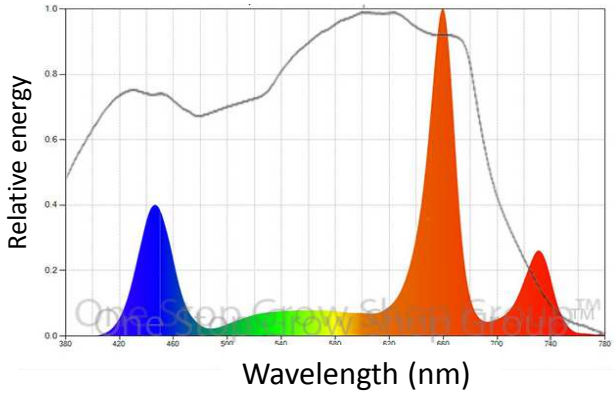


Eye Hortilux MH
https://eyehortilux.com/grow-lights/standard-metal-halide/



Light Emitting Diode panel

Heliospec LX601C
https://www.heliospectra.com/



Potato as a candidate crop for BLSSs

- Staple crop
- Good source of carbohydrate, proteins and minerals
- Highly productive crop

bread wheat

soybean

lettuce

durum wheat

spinach

tomato

Objective

To evaluate the influence of *cultivar* and light source on potato plants grown in phytron, under controlled environment

Treatments

Two cultivars of *Solanum tuberosum* L.

- 'Avanti' (Stet Holland B.V.)
- 'Colomba' (HZPC Holland B.V.)

Two light sources

- White fluorescent tubes: WF
- Red:Blue LEDs at 8:1 ratio: RB

White fluorescent tubes

LEDs panels

Materials and methods

Cultivation conditions

- Pre-sprouted tuber seeds
- 12 - L pots, sphagnum peat
- Fertigation: 3 times/week
- Nutrient solution: EC 1.8 dS m^{-1}, pH 5.5
  (Molders et al. 2012, Adv Space Res 50:156-165)
- Cultivation cycle: 76 days (beginning of tuberization)

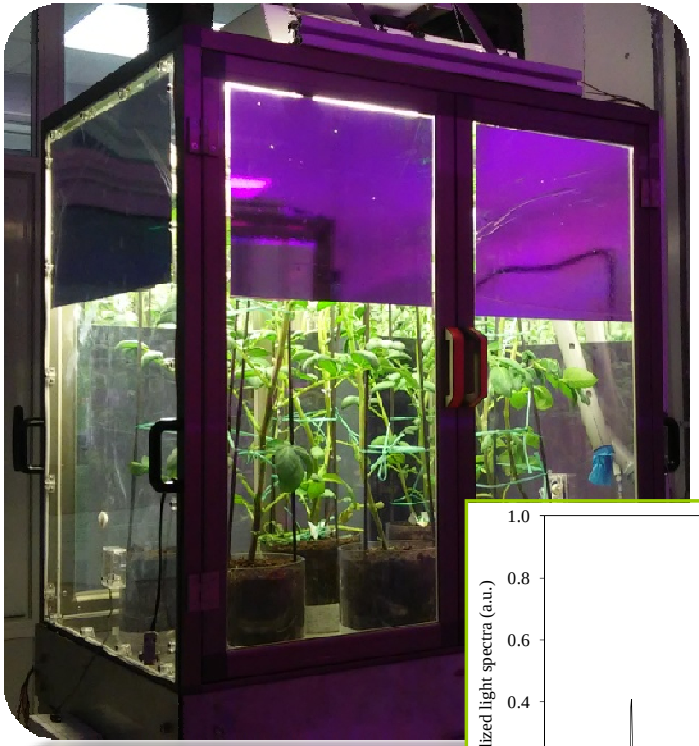
Environmental conditions

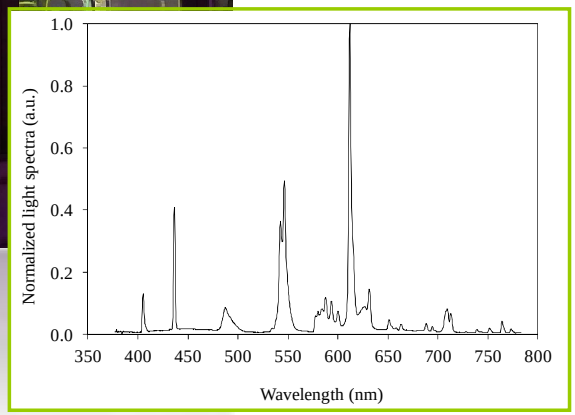
- Temperature : 22/18 °C (light/dark)
- Photoperiod: 12 hours
- Light intensity: average PPFD 200 µmol m^{-2} s^{-1}
- RH : 60 ± 10%
- CO_2 concentration: 420 ppm (average)



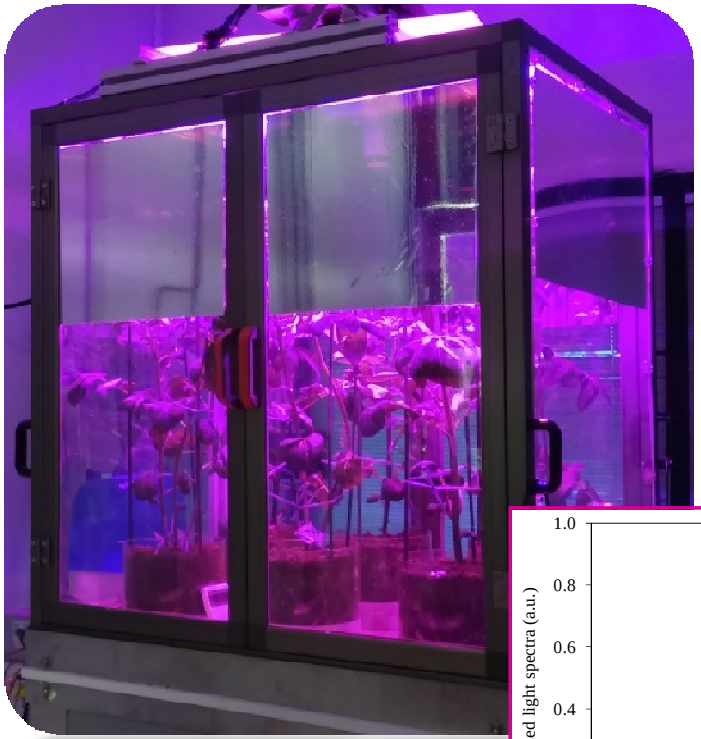

Materials and methods

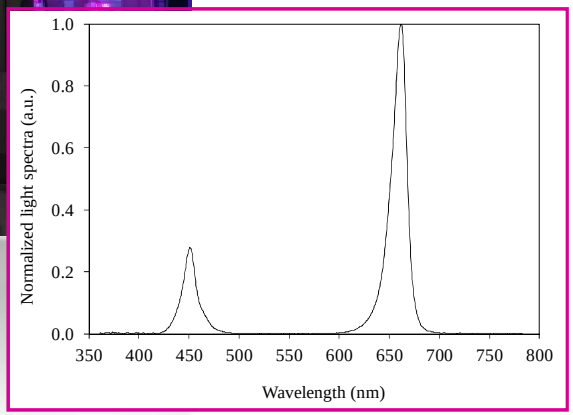
4 warm white light fluorescent tubes
(Philips Sylvania Linx - LE 55W/830)





6 Red:Blue LEDs arrays (8:1 ratio)
each containing 16 LEDs 660 nm (Red) + 2 LEDs 445 nm (Blue)
(Osram Oslon SSL 80 LH CP7P 1 W + LD CQAR 2 W)



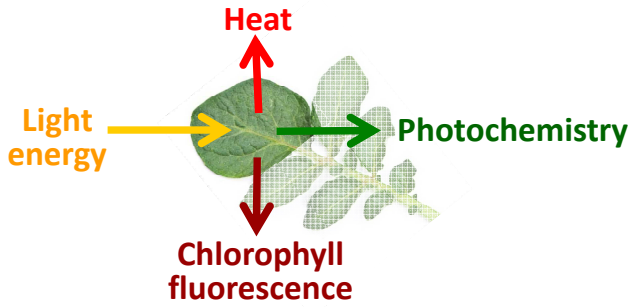


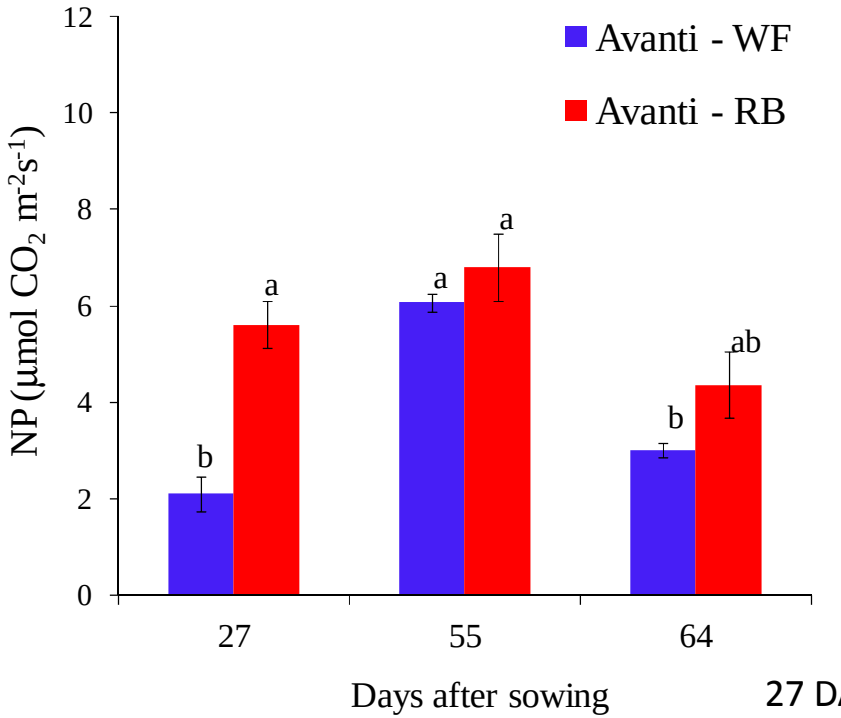
Materials and methods

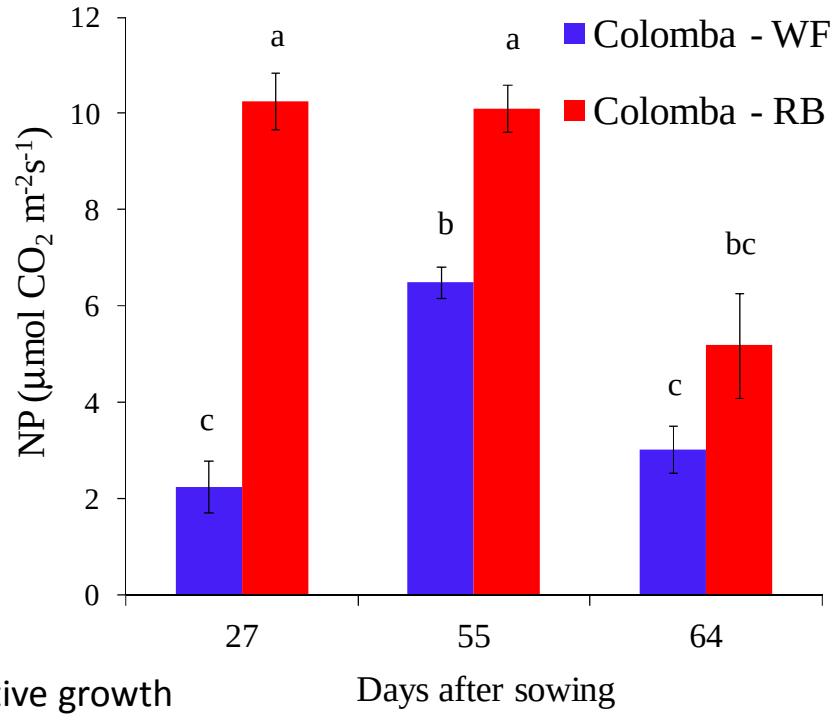
Measurements:

- **Net photosynthesis**
  Infra Red Gas Analyzer HCM 1000 (Walz, Germany)
- **Chlorophyll *a* fluorescence**
  FluorPen FP100 (Photon System Instr., Czech Republic)
- **Pigments concentration in leaves**
  Carotenoids, Chlorophyll a and b
  Spectrophotometric measure (HACH DR 4000) of leaf extracts in acetone
- **Plant growth**
  plant height, n. of leaves, leaf area (Li-cor 3100 area meter), fresh and dry mass
- **Tuber yield and quality**
  tuber quantity (g/plant), proteins, starch, total dietary fiber (TDF), glycoalkaloids

Net photosynthesis



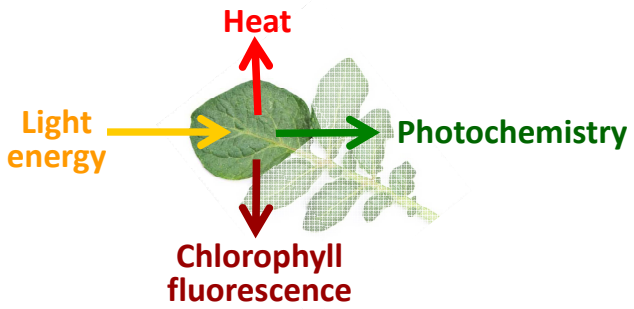


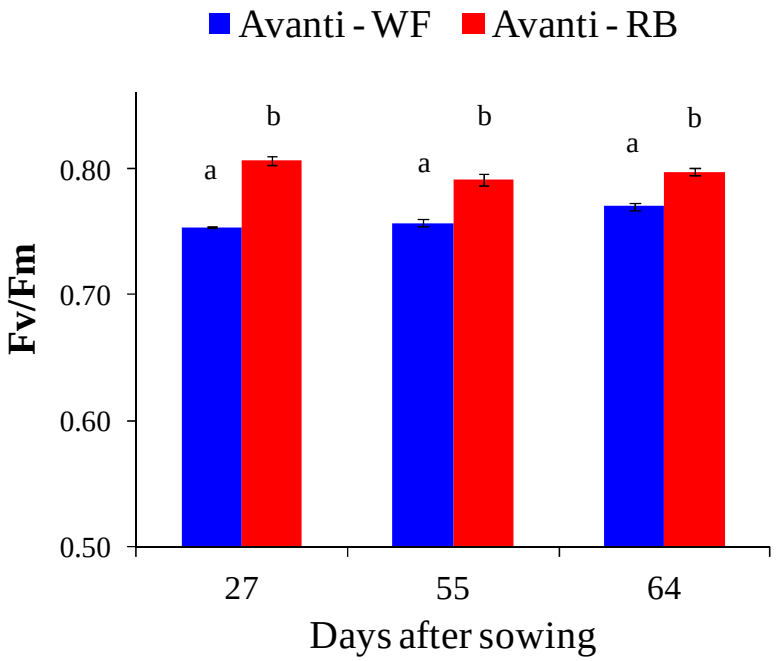


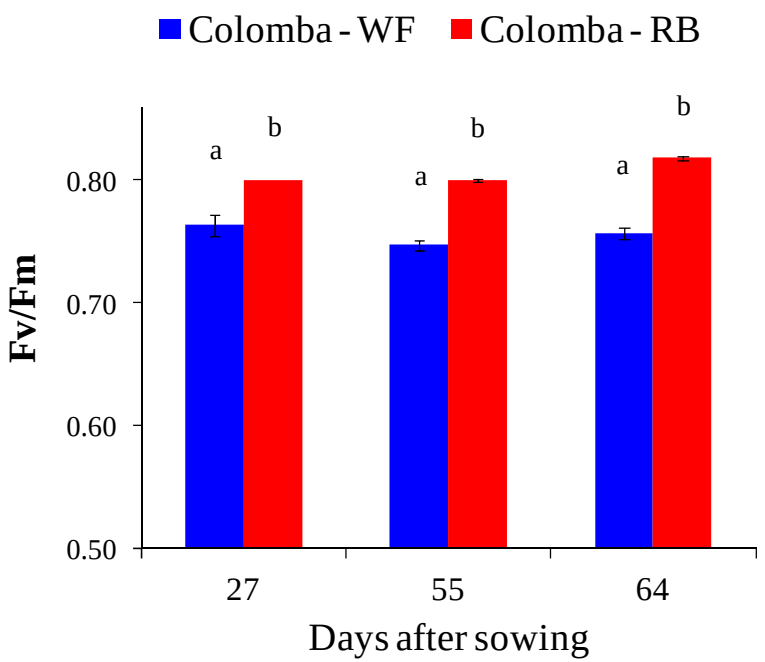
27 DAS = Vegetative growth
55 DAS = Flowering
64 DAS = Tuber bulking

Chlorophyll a fluorescence

(Fv/Fm = Maximum quantum efficiency of PSII photochemistry)







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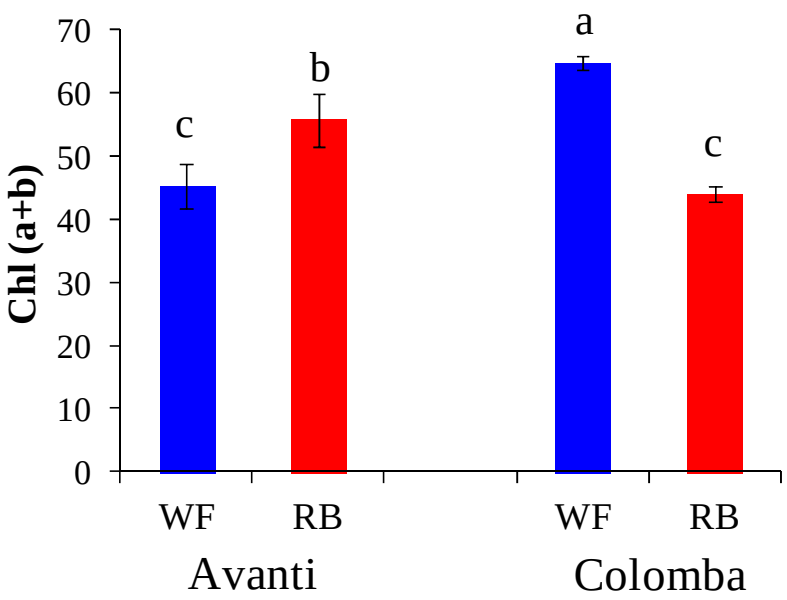
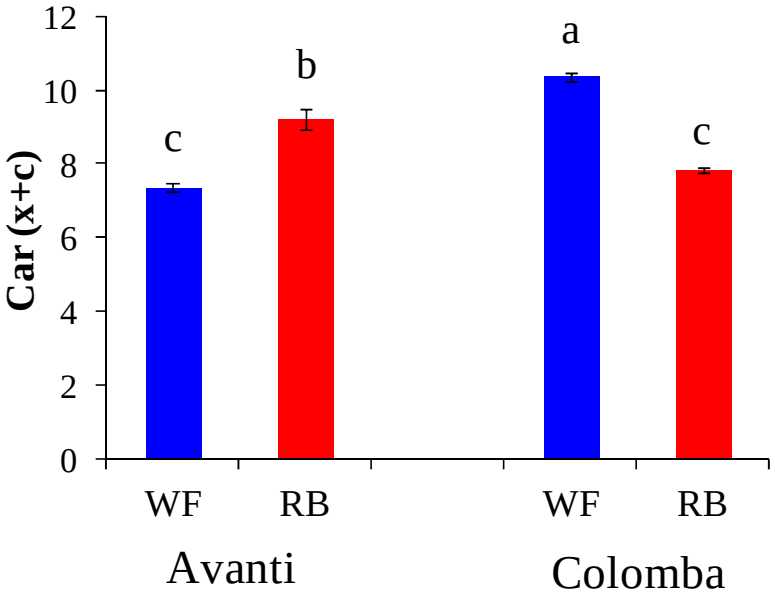
Leaf photosynthetic pigments

Chlorophyll *a* and *b*
(µg/cm²)

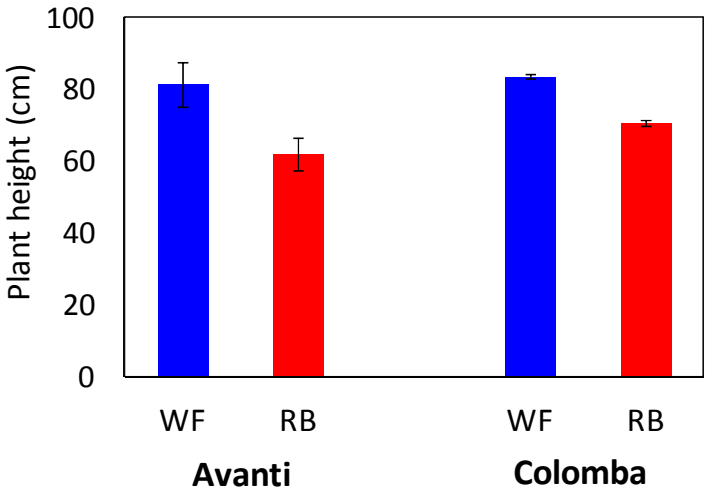


Carotenoids
(µg/cm²)

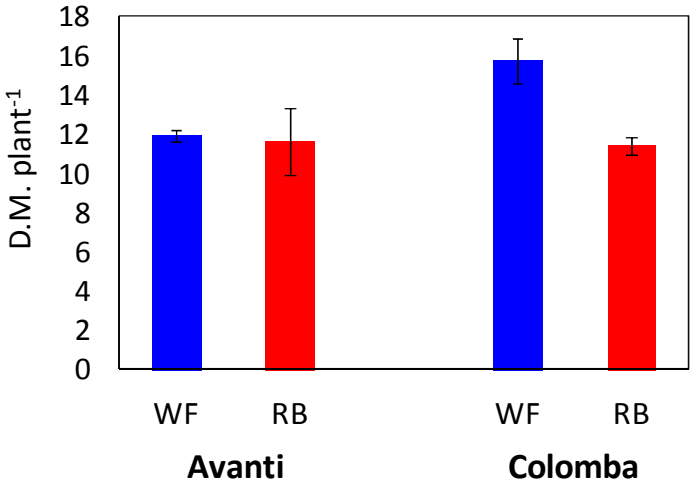


Plant growth

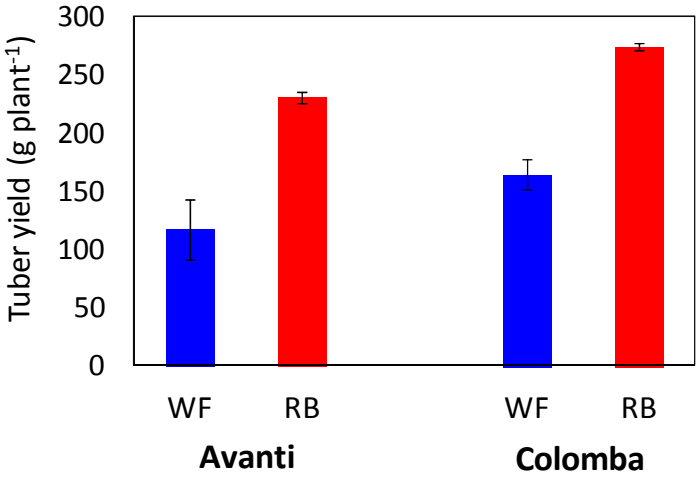
Plant height



Aerial dry mass



Tuber yield



Tuber quality

		Proteins (g 100 g^{-1} dw)	Starch (g 100 g^{-1} dw)	Total dietary fiber (g $^{-1}$100 g dw)	Total glycoalkaloids (mg kg^{-1} dw)	α-solanine (mg kg^{-1} dw)	α-chaconine (mg kg^{-1} dw)
'Avanti'	WF	11.49 a	86.6	10.6 a	209.4	25.8 b	183.6 ab
	RB	8.08 b	91.0	9.8 b	217.4	20.5 b	196.8 a
'Colomba'	WF	9.13 b	87.3	9.6 b	264.5	56.2 a	208.3 a
	RB	8.95 b	88.6	7.0 c	205.9	99.3 a	106.6 b
Significance							
Cultivar (C)		ns	ns	***	ns	*	ns
Light source (L)		*	ns	***	ns	ns	ns
C × L		*	ns	***	ns	ns	*

CONCLUSIONS

- Good adaptation to growth in controlled environment in both potato cultivars
- Increase of photosynthesis under R:B LEDs in the two cultivars through higher synthesis of photosynthetic pigments (‘Avanti’) and an improving of light conversion (both ‘Avanti’ and ‘Colomba’)
- Cultivar-dependent response to light source in plant growth (‘Colomba’ more sensitive to light source) and tuber quality (e.g. different trend in proteins, dietary fiber and α-chaconine)

- Our results highlight how interactions between light source and genotype need to be consider for potato cultivation under artificial lighting