High-power LEDs for plant cultivation

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Outline

- Horticulture + LED = efficient production of safe food
- Illumination facility

- Growth experiments

- Conclusions

Photosynthesis

light absorption by chlorophyll *a* 660 nm
chlorophyll *b* 640 nm

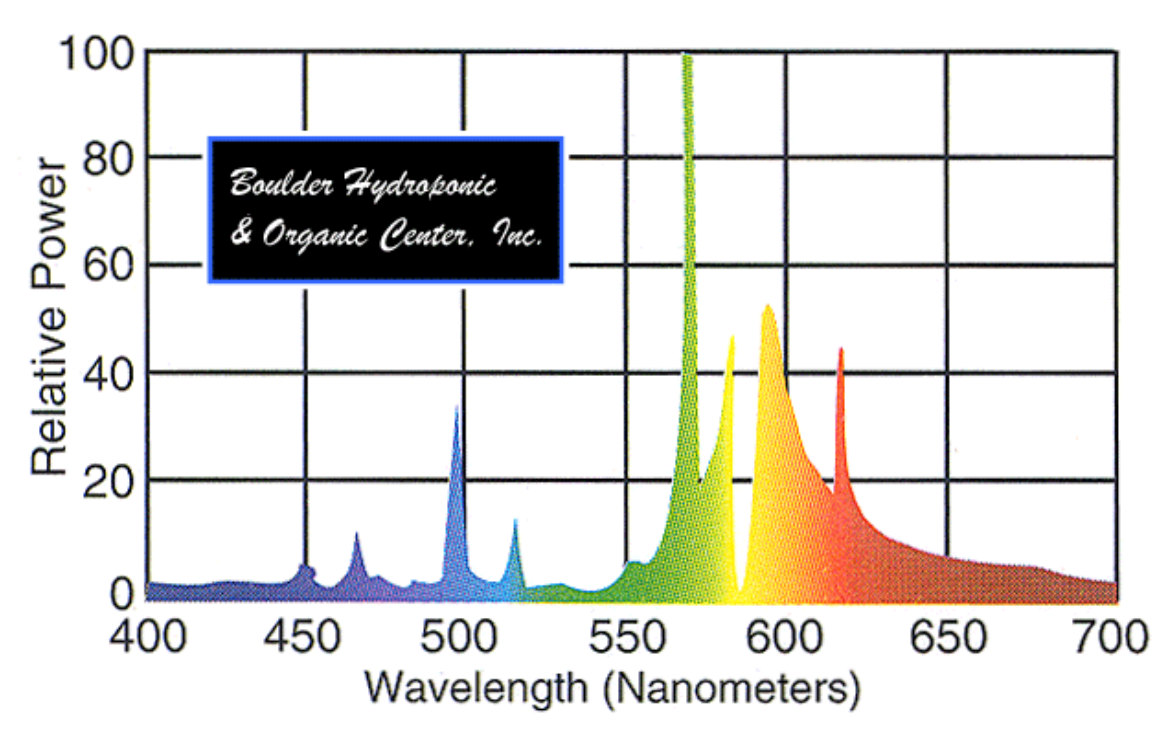
Phototropy

light absorption at 455 nm

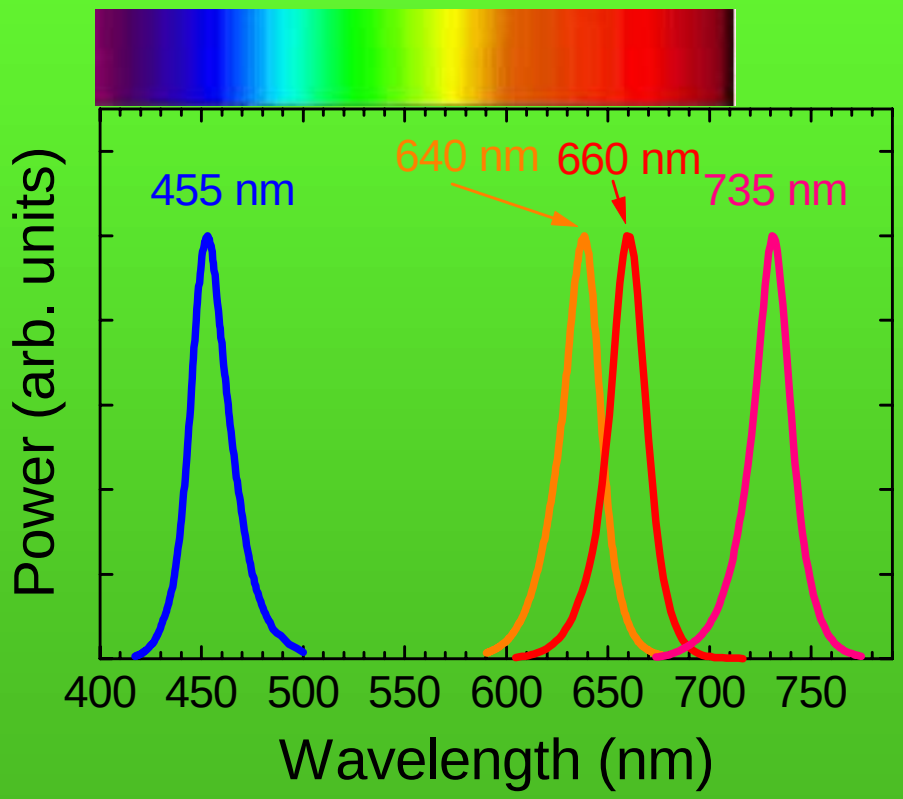
Photomorphology

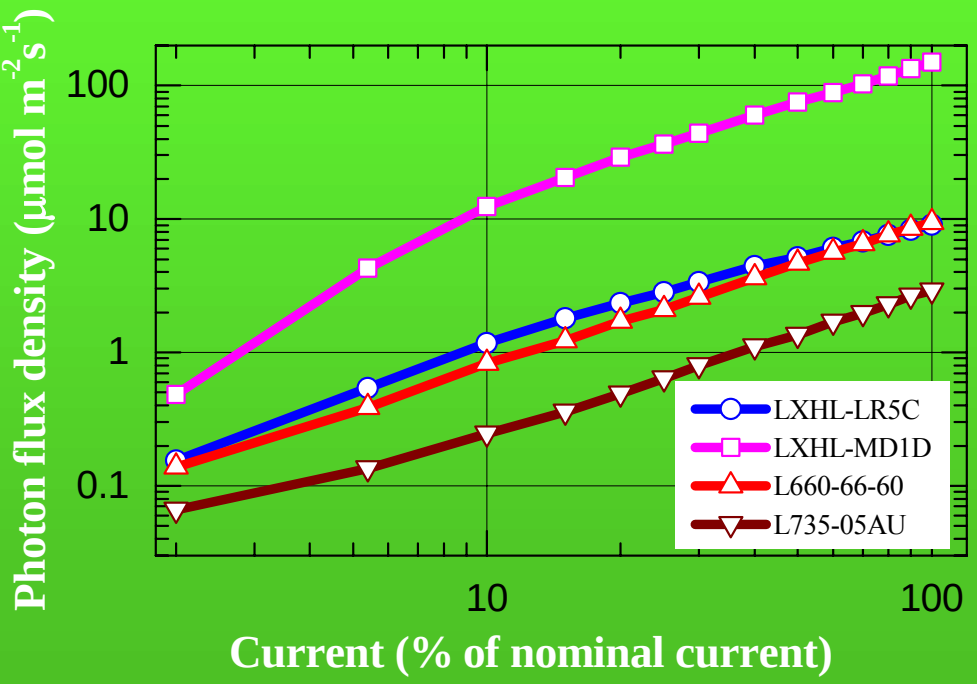
light absorption at 735 nm

High pressure sodium lamp



www.bhocenter.com/ ag_light/,


455 nm
640 nm
660 nm
735 nm
Power (arb. units)
400
450
500
550
600
650
700
750
Wavelength (nm)


Photon flux density (µmol m-2 s-1)
100
10
1
0.1
10
100
Current (% of nominal current)
LXHL-LR5C
LXHL-MD1D
L660-66-60
L735-05AU

Shares in total price and in typical total photon flux for four LED groups used in the illuminator designed.

Nominal wavelength, nm	**735**	**660**	**640**	**455**
Type	**L735-05-AU**	**L660-66-60**	**LXHL-MD1D**	**LXHL-LR3C**
Materials system	**AlGaAs**	**AlGaAs**	**AlGaInP**	**AlInGaN**
Share in total price, %	**3**	**32**	**60**	**5**
Share in typical photon flux, %	**2**	**7**	**85**	**6**

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High-power LED emission at 652 nm demonstrated:

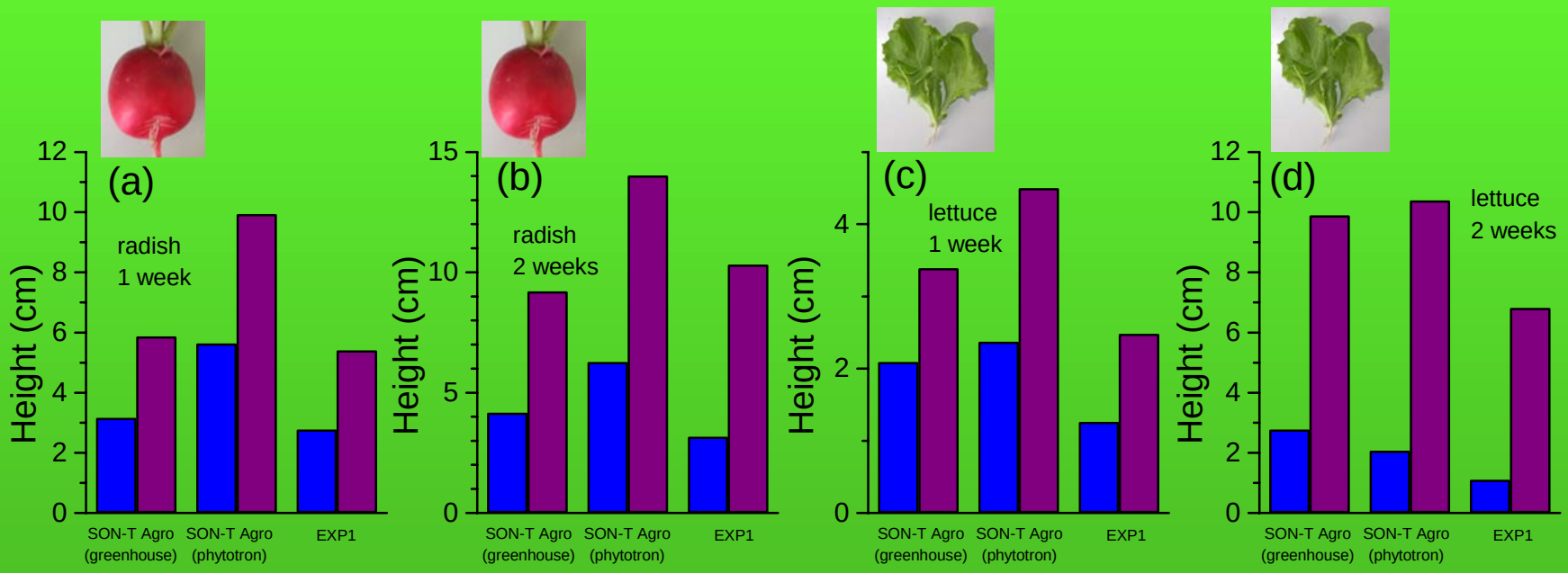
M. R. Krames et al. "High-power truncated-inverted-pyramid **$(Al_xGa_{1-x})_{0.5}In_{0.5}P/GaP$** light-emitting diodes exhibiting >50% external quantum efficiency," *Appl. Phys. Lett.* **75**, 2365 (1999).

Photon flux densities, in μmol m^{-2} s^{-1} and % of the total day or night flux density, produced by LEDs with peak emission wavelengths, indicated, in four different plant growth experiments, numbered as EXP1 to EXP4.

	455 nm		640 nm		660 nm		735 nm	
	day	night	day	night	day	night	day	night
EXP1	**9** (6.4%)	0	**120** (85%)	0	**9.4** (6.6%)	0	**2.9** (2%)	0
EXP2	**9** (6.5%)	0	**120** (86.7%)	0	**9.4** (6.8%)	0	0	**2.9** (100%)
EXP3	**9** (8.8%)	0	**80** (79%)	0	**9.4** (9.3%)	0	2.9 (2.9%)	0
EXP4	**9** (6.5%)	0	**120** (86.7%)	0	**9.4** (6.8%)	0	0	**2.9*** (100%)

* Illumination by 735 nm LEDs was on only for 1 hour between 2-3 AM in EXP4

Height of radish until apex (blue columns) and of the whole plant (violet column) of radish (a, b) and lettuce (c, d) measured after one week in the stage of cotyledons formation (a, c) and after two weeks, when leaves are formed (b, d)



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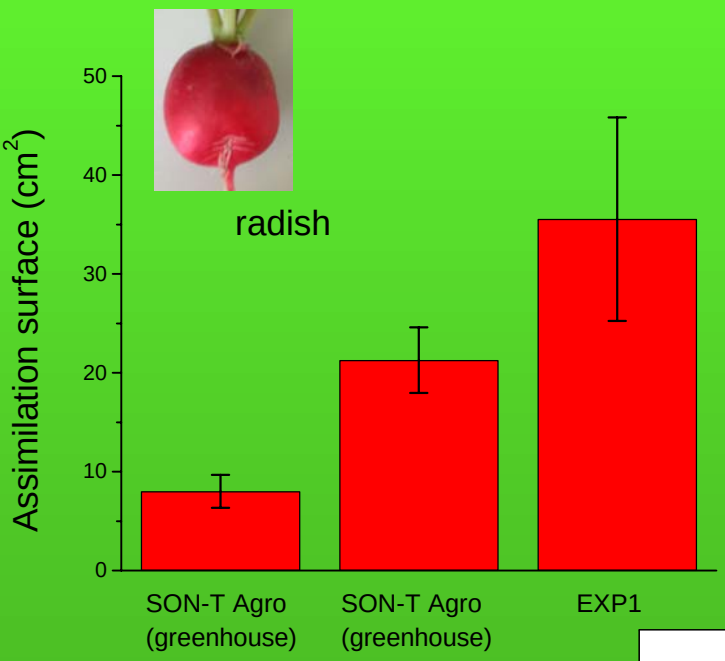
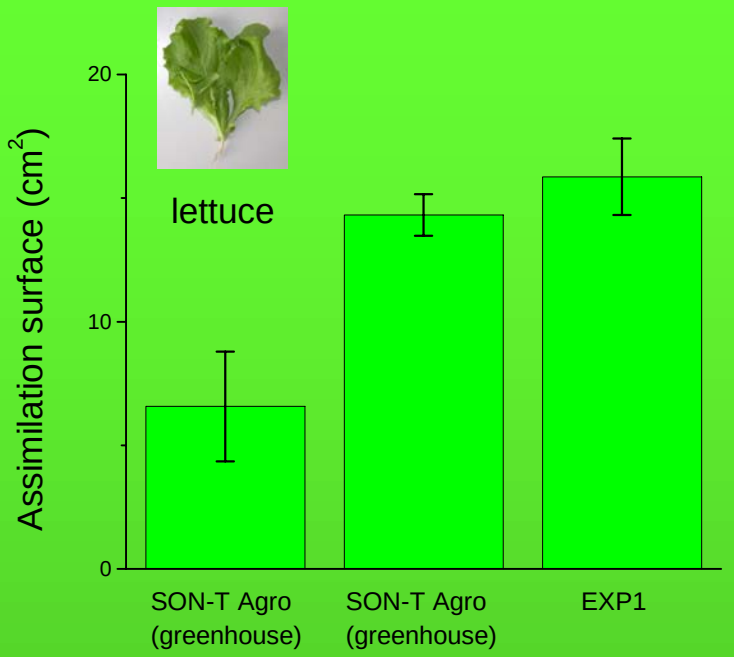
Assimilation surface





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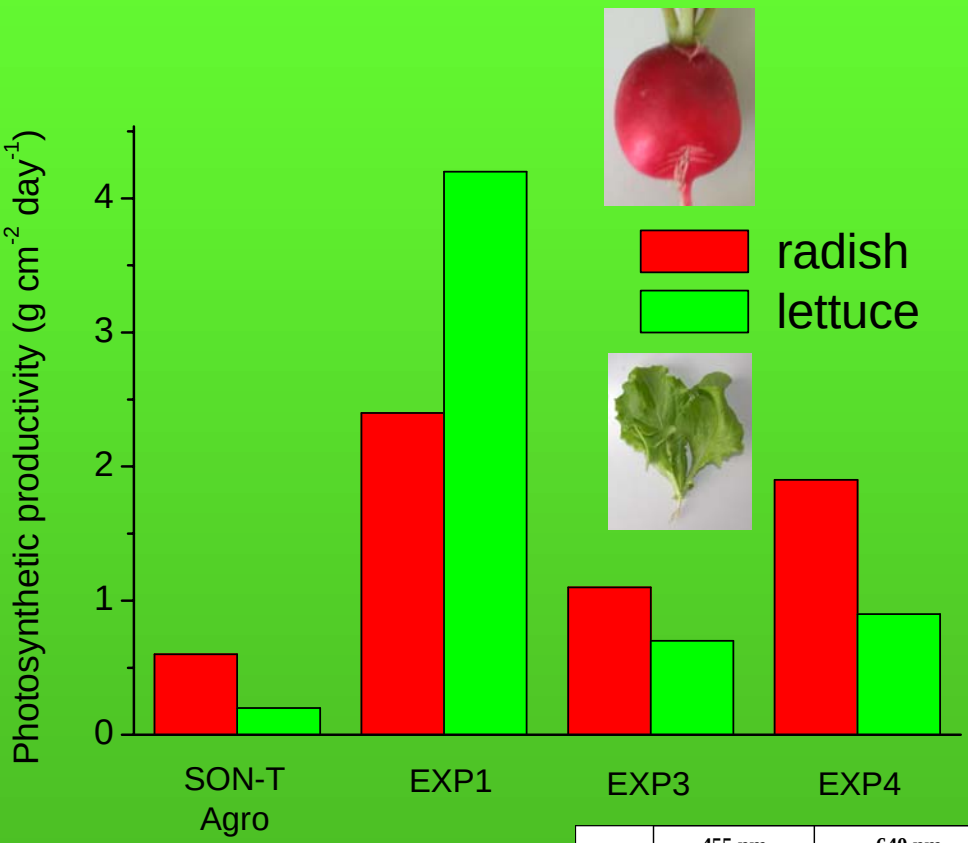
Net photosynthetic productivity



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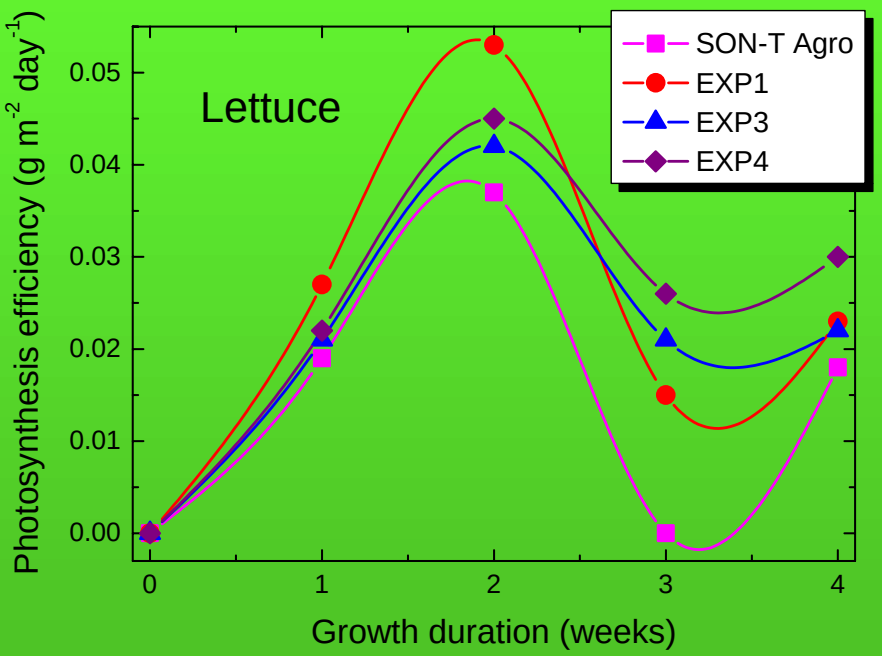
Dynamics of photosynthetic productivity in growth experiments under illumination with different spectrum



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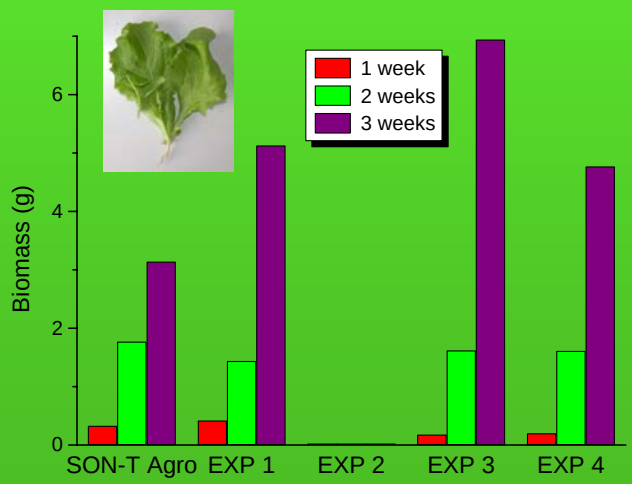
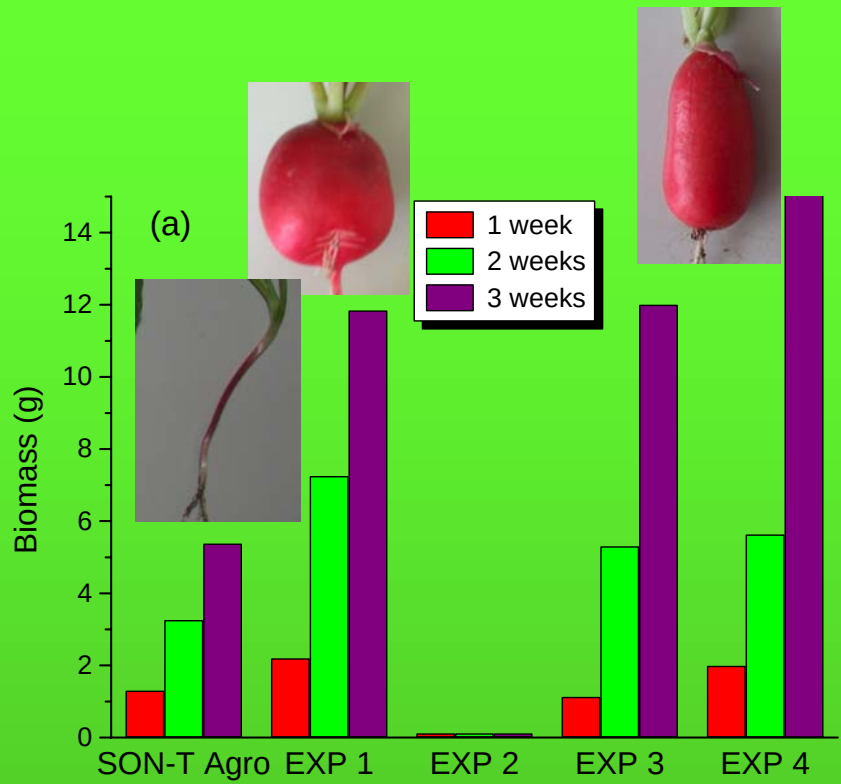
Green mass production





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Dependence of rhizocarp shape on illumination spectrum

HPS lamp

EXP1

EXP4

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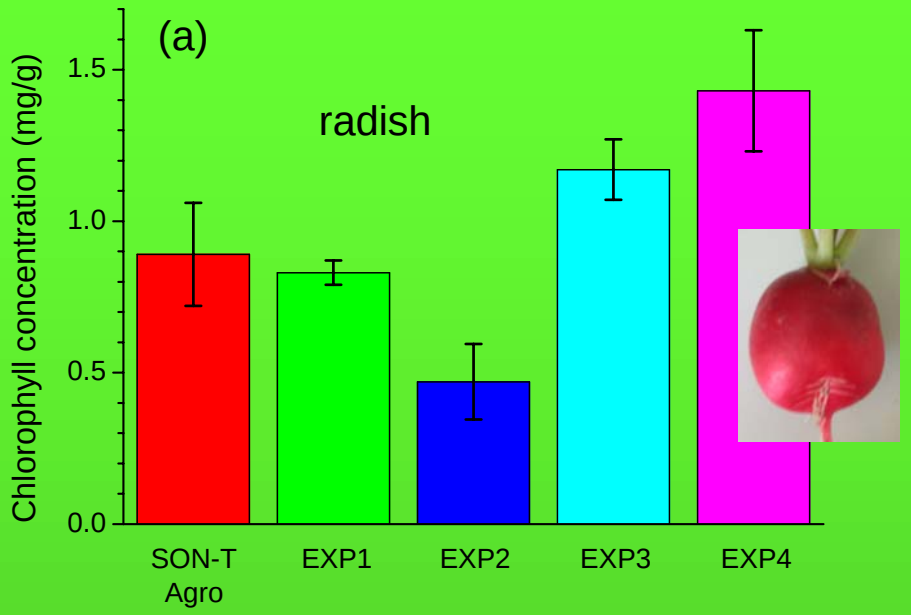
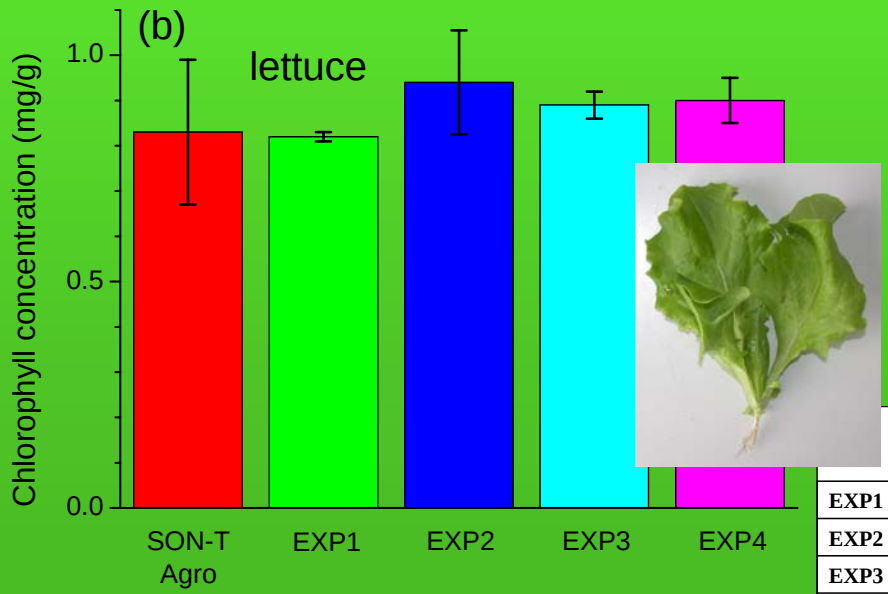
Concentration of chlorophylls *a* + *b*





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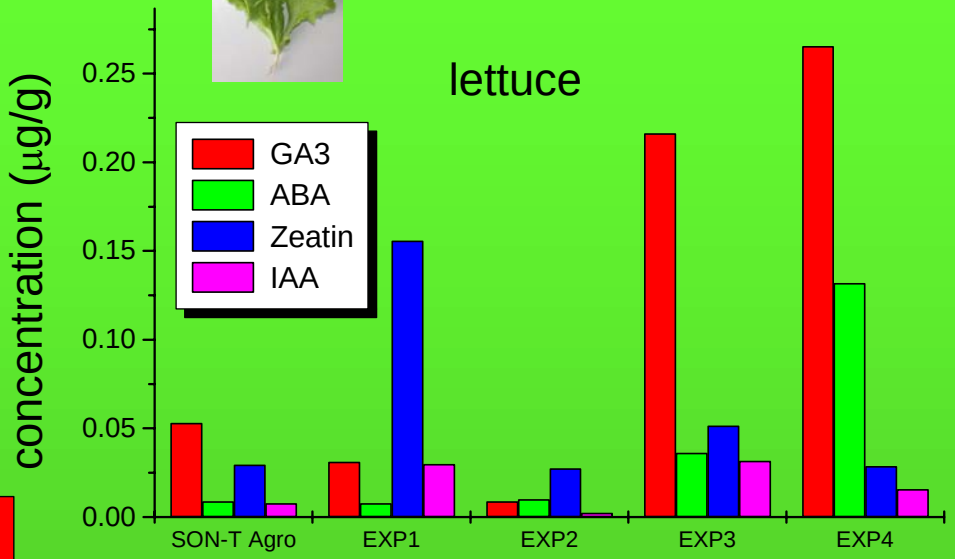
Concentration of phytohormones

gibberelic acid (GB3),

abscisic acid (ABA),

zeatin,

indole-3-acetic acid (IAA)



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CONCLUSIONS

- **The LED-based illumination with a proper proportion of light components enhances photosynthetic productivity and ensures better plant morphology in comparison with illumination using high pressure sodium lamps.**
- **The implementation of LED-based illumination on industrial scale for greenhouse plant cultivation requires lowering of LED prices, what might be achieved by producing LEDs specifically for horticulture applications.**
- **High-power AlInGaP-based red LEDs emitting at wavelengths as close as possible to 660 nm as well as further development of LEDs emitting in the vicinity of 640 nm are of major interest for horticulture applications.**