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MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Photosynthetic characteristics and composition of phenolic compounds in barley grown under blue, red and green light

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Tato akce se koná v rámci projektu:
Vybudování vědeckého týmu environmentální metabolomiky a ekofyziologie a jeho zapojení do mezinárodních sítí (ENVIMET; r.č. **CZ.1.07/2.3.00/20.0246**) realizovaného v rámci Operačního programu Vzdělávání pro konkurenceschopnost.

The aims of this presentation are

- to summarize our unpublished results of experiments focused on the effects of different spectral composition of PAR on the assimilation apparatus of barley

- to provoke discussion about the direction of further research and the suitable design of experiments aimed at study of interactive effects between different spectral quality of PAR and UV radiation

What we measured

We examined the following characteristics of barley grown under blue (B), red (R), green (G) and white (W) light:

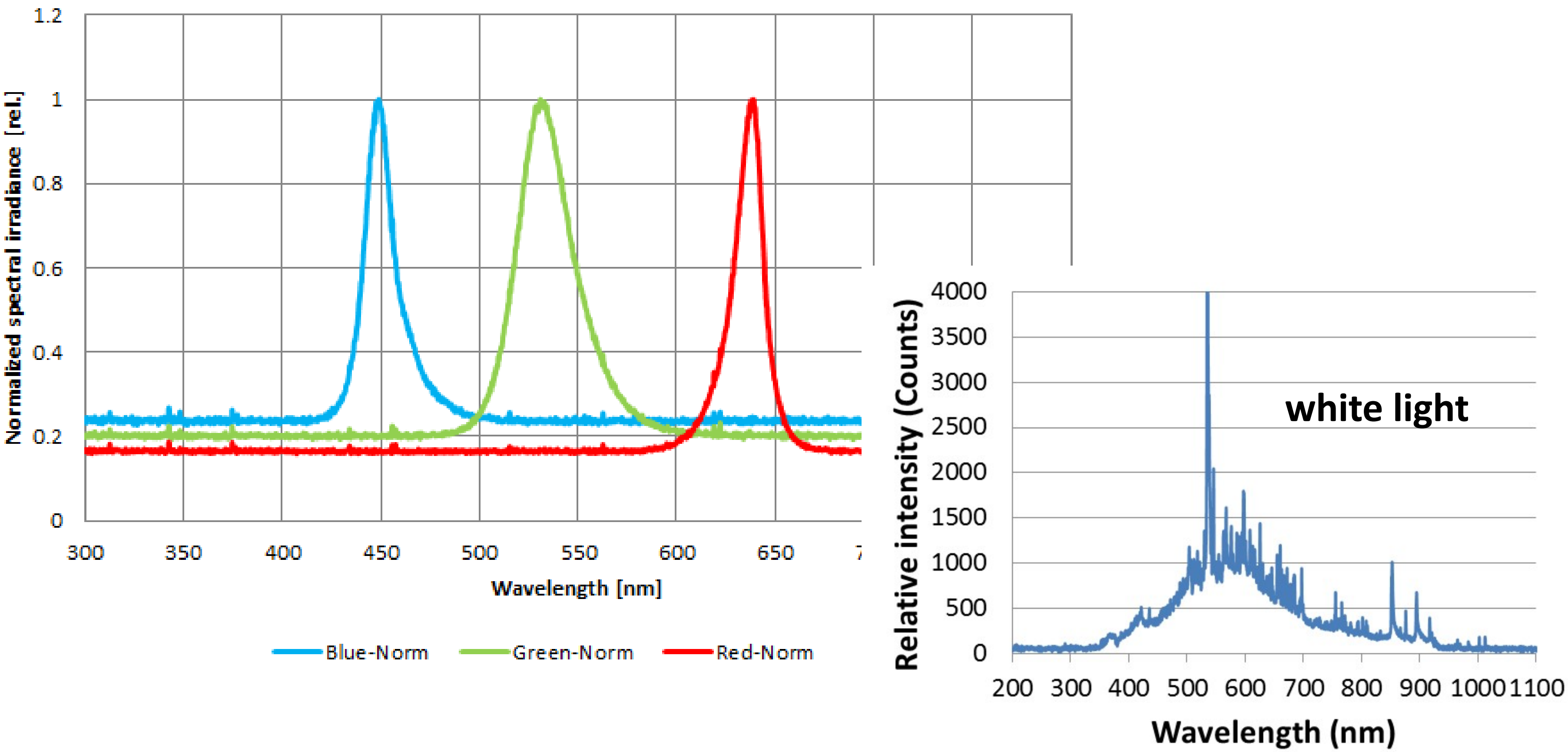
- basic morphology of leaves – length of leaves, amount of dry weight, fresh weight to leaf area ratio, cross sections of leaves
- composition of photosynthetic pigments and phenolic compounds (spectrophotometric, HPLC and HPLC-MS analysis)
- CO_2 assimilaton rate (Li-6400, Li-Cor)
- photosystem II activity (PAM chlorophyll fluorescence)
- UV-shielding (Dualex measurements)
- penetration of radiation into leaves (fluorescence microscopy)

Additionally, short-term effects (a few minutes) of B, R and G light exposure on the function of photosynthetic apparatus in all plant variants were assessed.

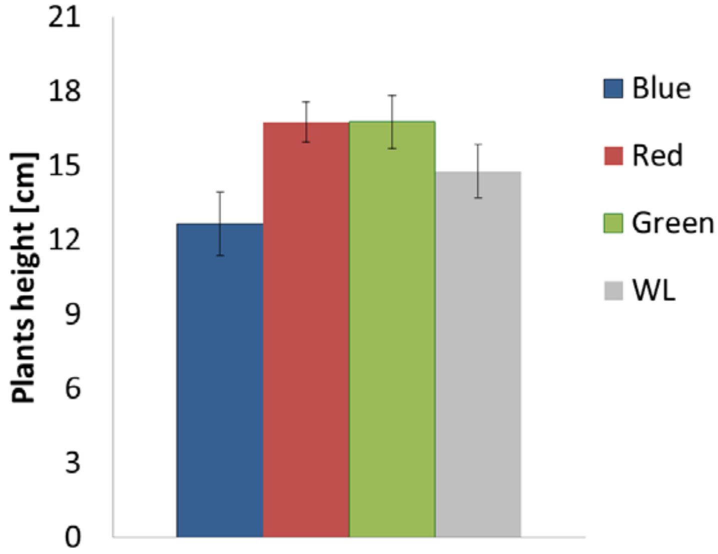
Experimental design, cultivation conditions

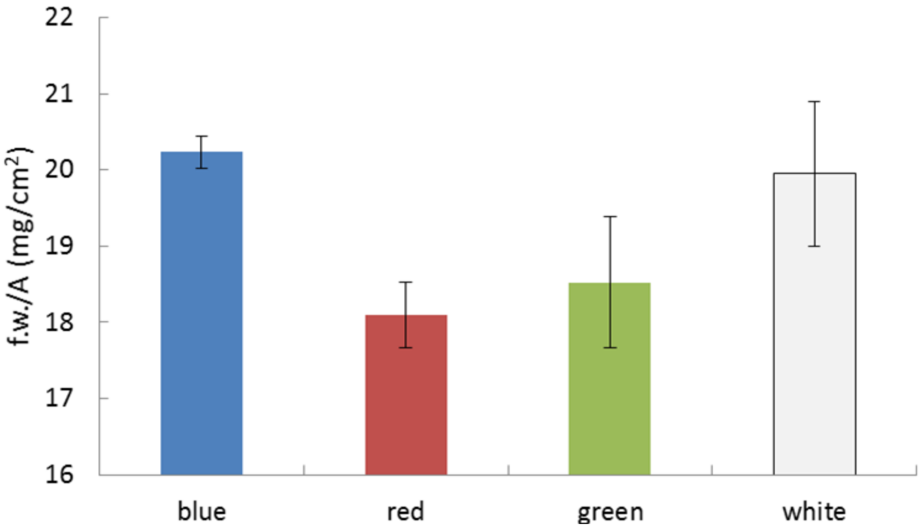
Barley plants (*Hordeum vulgare* L. cv. Bonus) were grown from seeds under blue (450 nm), red (640 nm) and green (530 nm) LED illumination and under white light provided by halogen lamps with the same **PPFD of 240 µmol m^{-2} s^{-1}** (16/8 h, 22/20 °C day/night cycle).

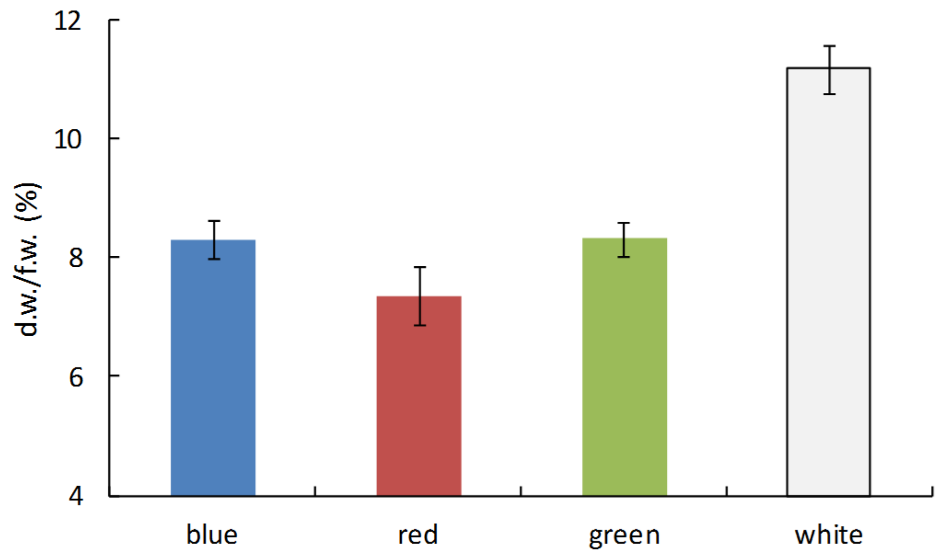
The primary leaves of **8-day-old plants** were used.



Basic morphology of leaves

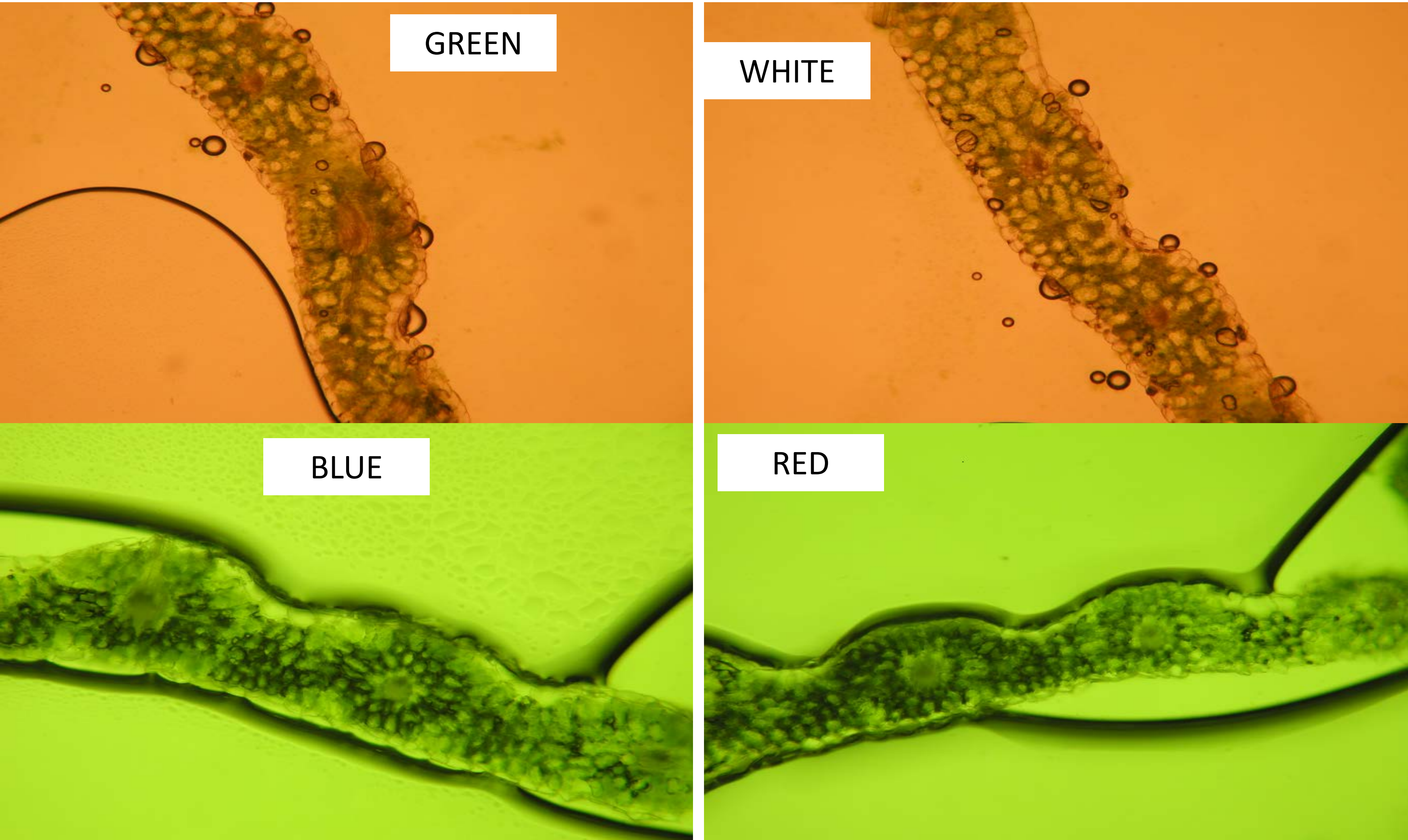




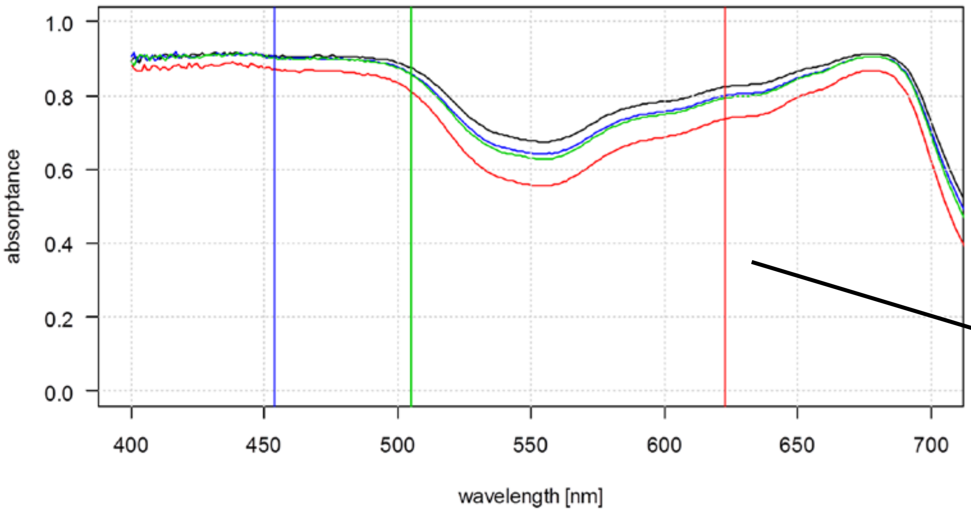


Native leaf cross-sections

- mesophyll cells in BL- and RL-grown plants seems to be more arranged

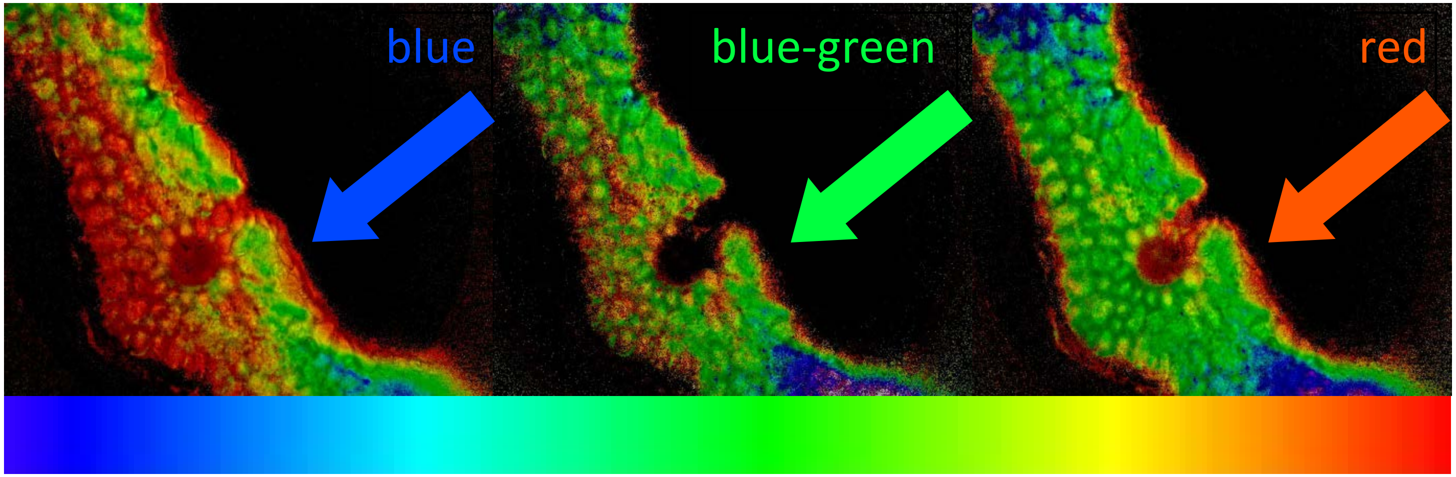


Different penetration of blue, red and green light into leaves should be taken into account in these experiments and measurements (e.g. chlorophyll fluorescence)



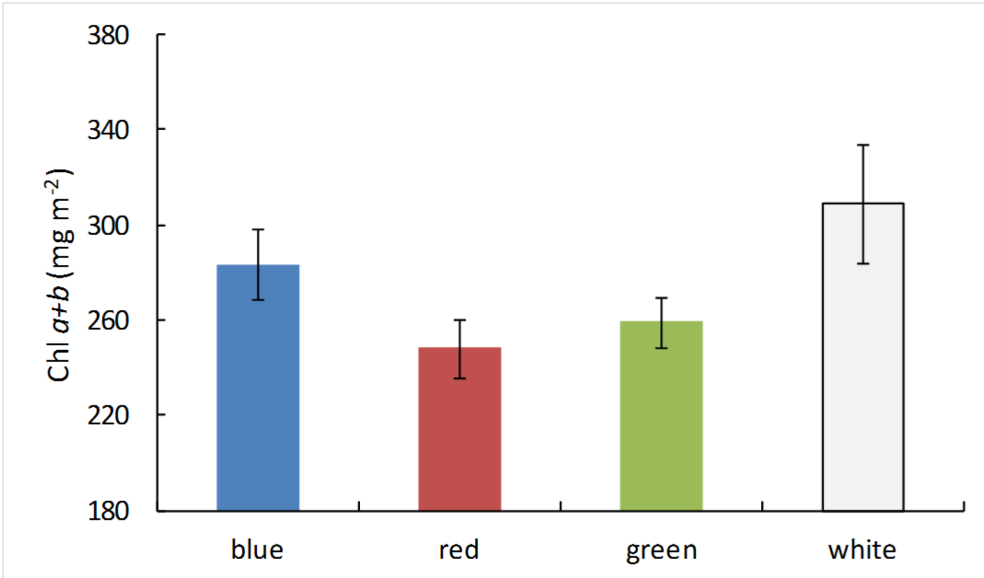
vertical lines indicate wavelengths of light for excitation of Chl fluorescence

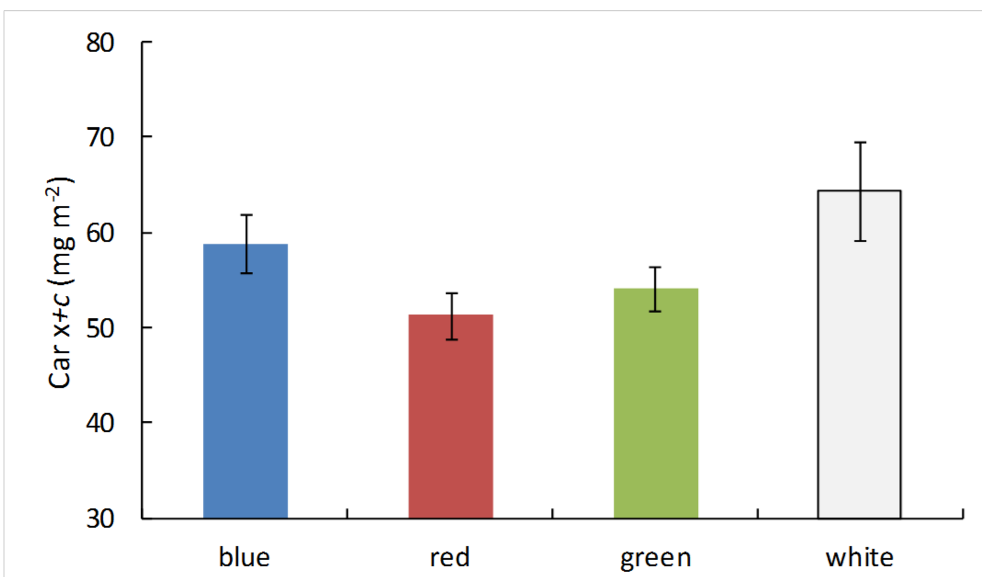
Absorptance spectra for B, R and GL-grown plants and control plants (grown under all light colors)



Chl fluorescence intensity increases from red to blue

Analysis of photosynthetic pigments revealed a different response in BL-cultivated plants





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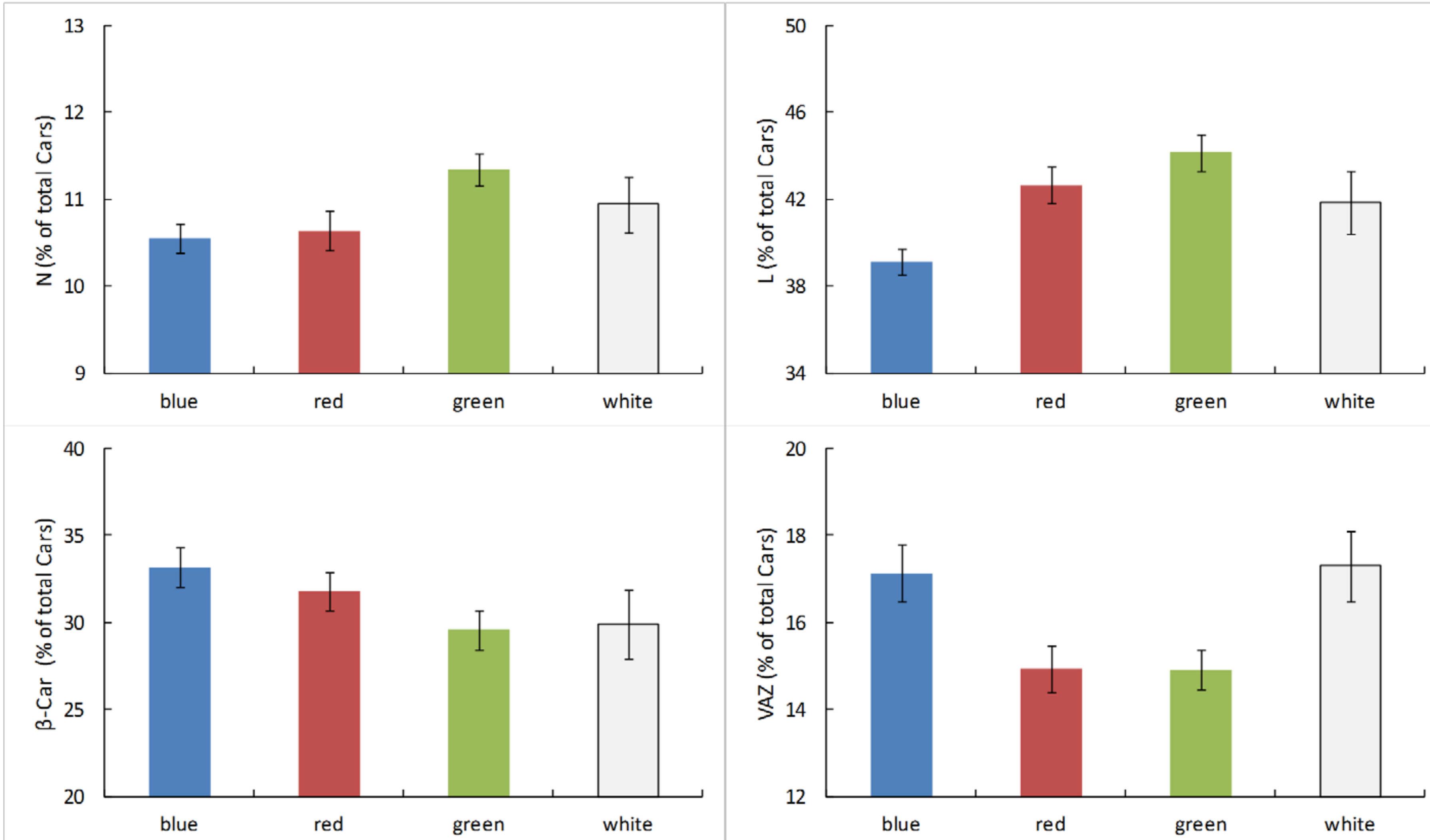
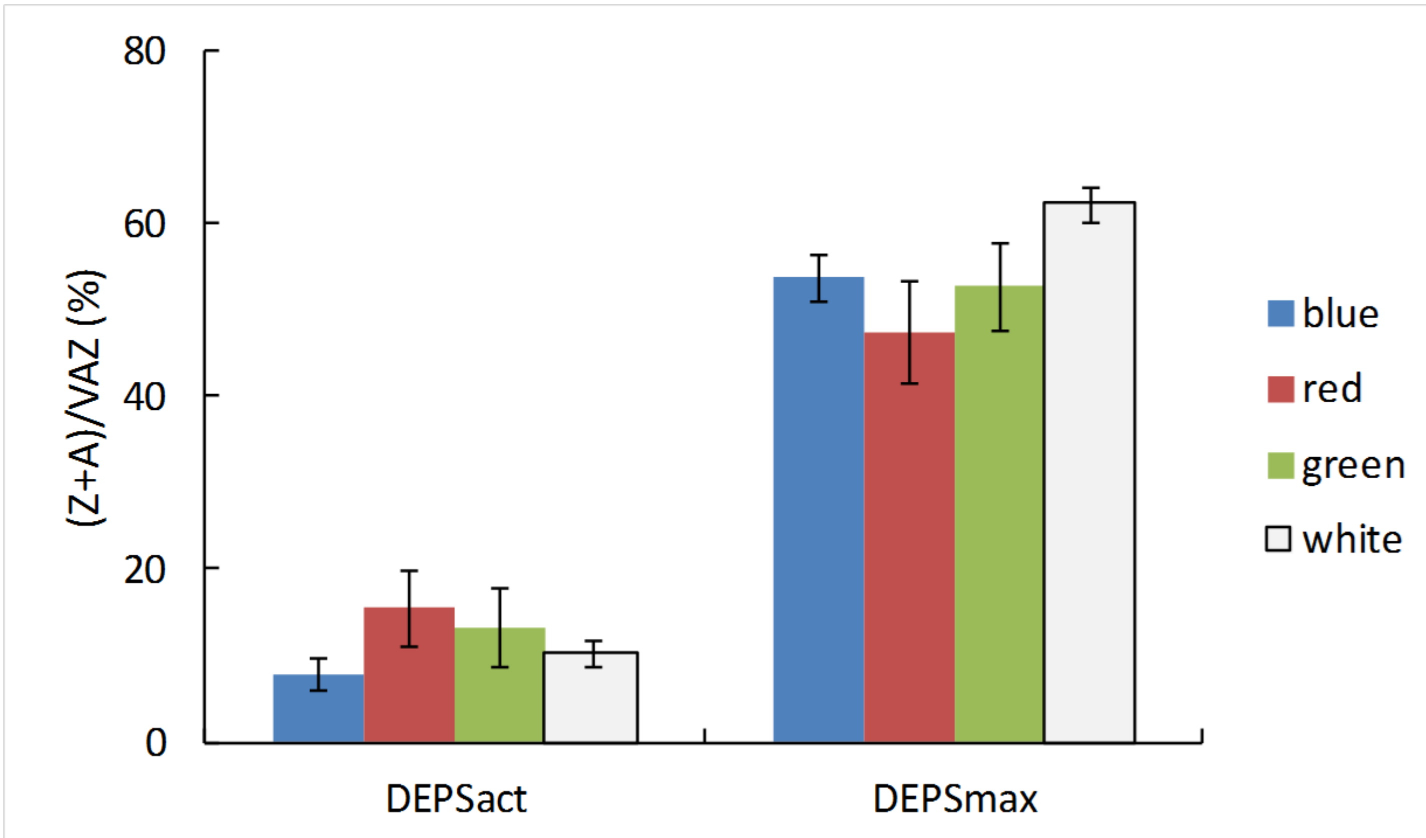


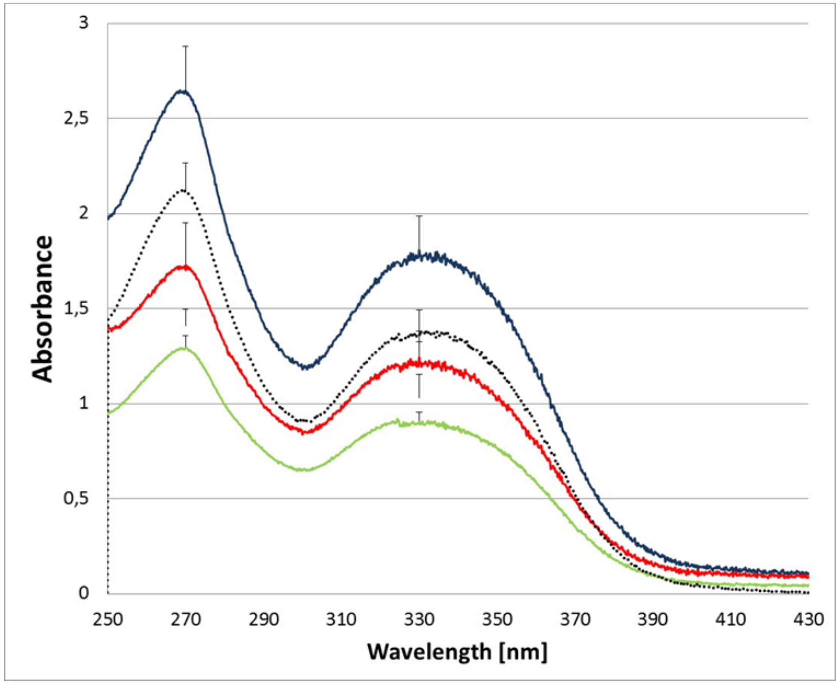
Analysis of photosynthetic pigments revealed a different response in BL-cultivated plants

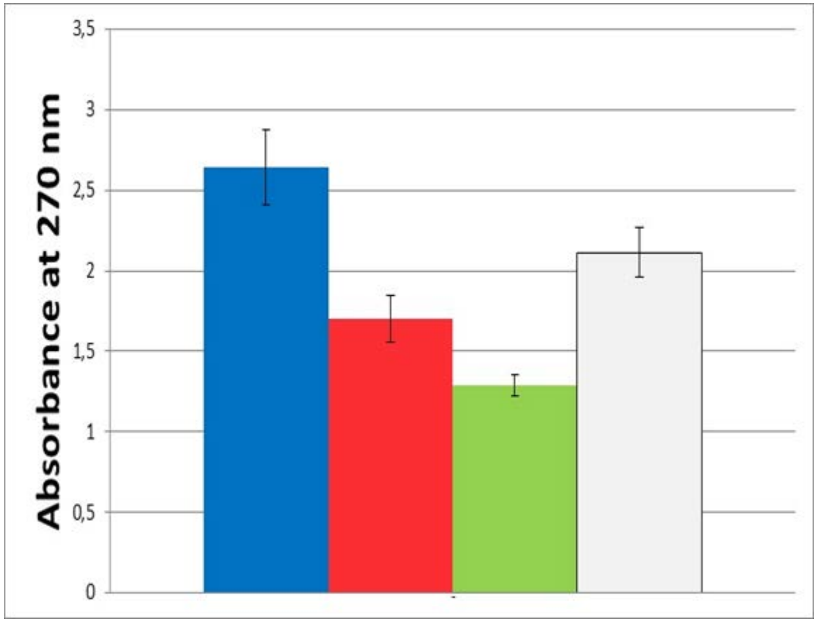


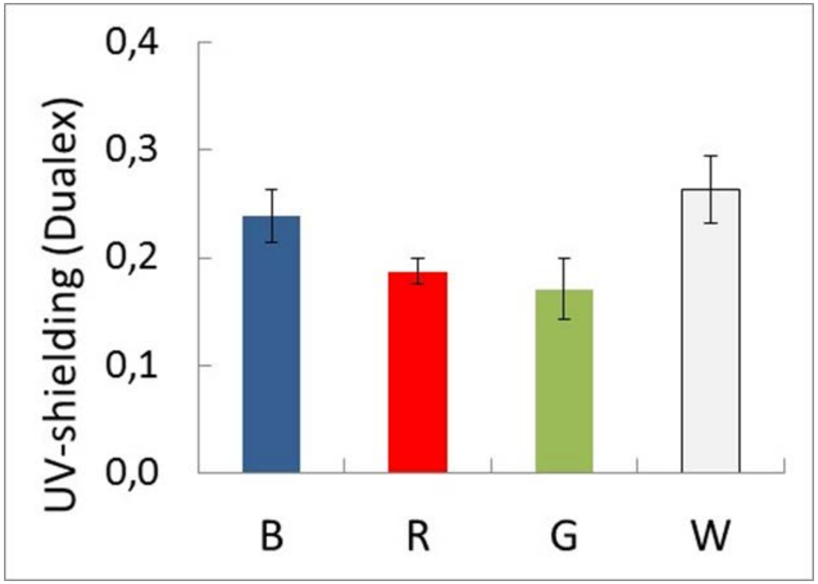
determined under corresponding cultivation light

determined after 15 minutes of exposure to saturation white light (1400 µmol m^{-2} s^{-1})

The amount of total soluble UV-absorbing phenolics and epidermal UV-shielding

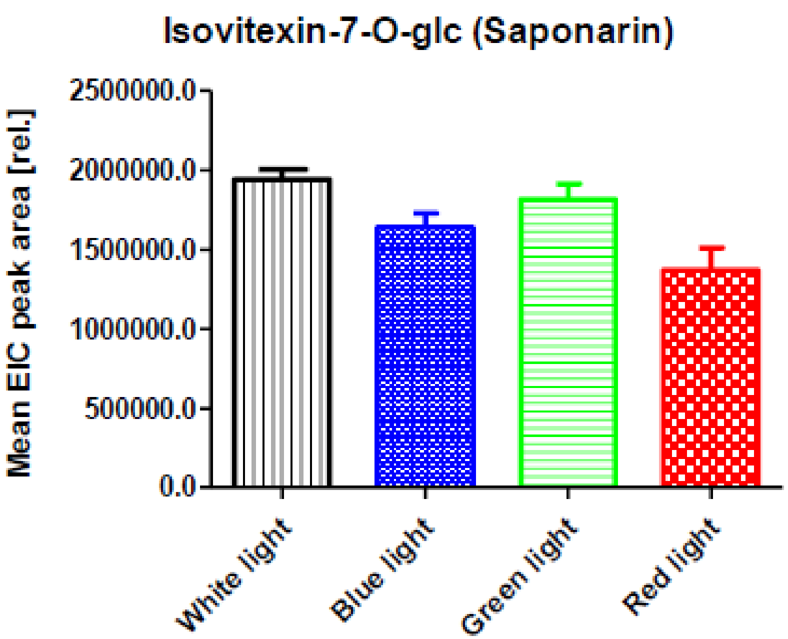


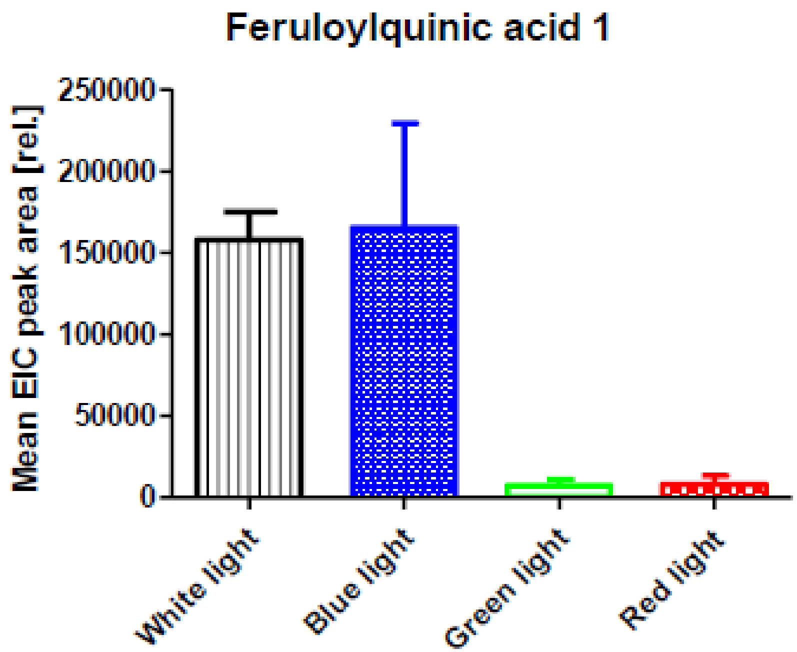




- Blue light stimulated accumulation of UV-absorbing phenolic compounds more than WL
- The changes of absorption spectra (lower A270/A330 in BL-grown barley) suggest that different compounds are induced by BL and WL
- BL stimulated accumulation of UV-absorbing phenolics in leaf mesophyll (to higher extent than WL)

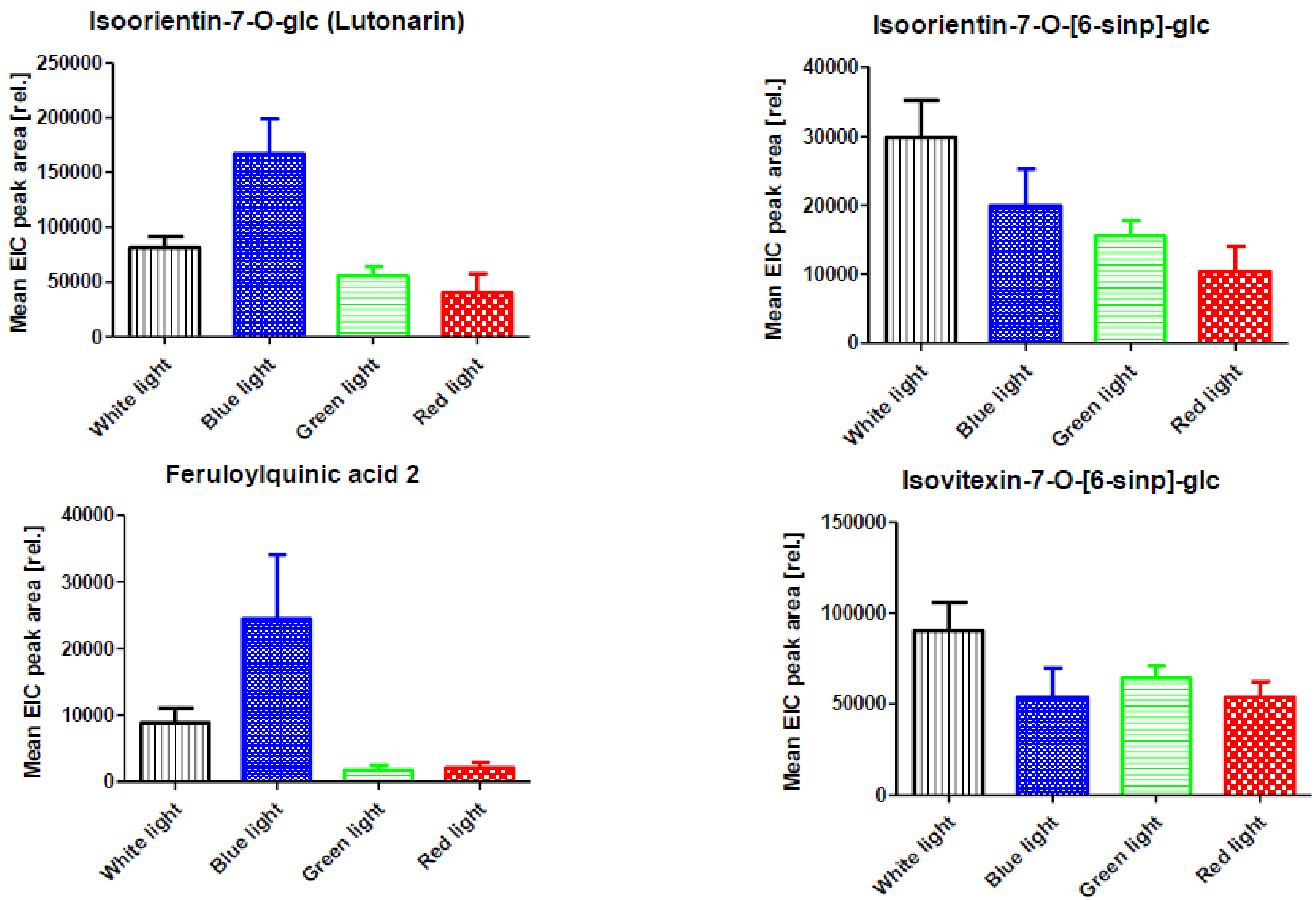
The individual phenolic compounds identified by HPLC-MS





- Saponarin (a main barley flavonoid) accumulates under all light regimes
- Feruloyl quinic acid (a main barley fenolic acid) accumulates only under BL and WL

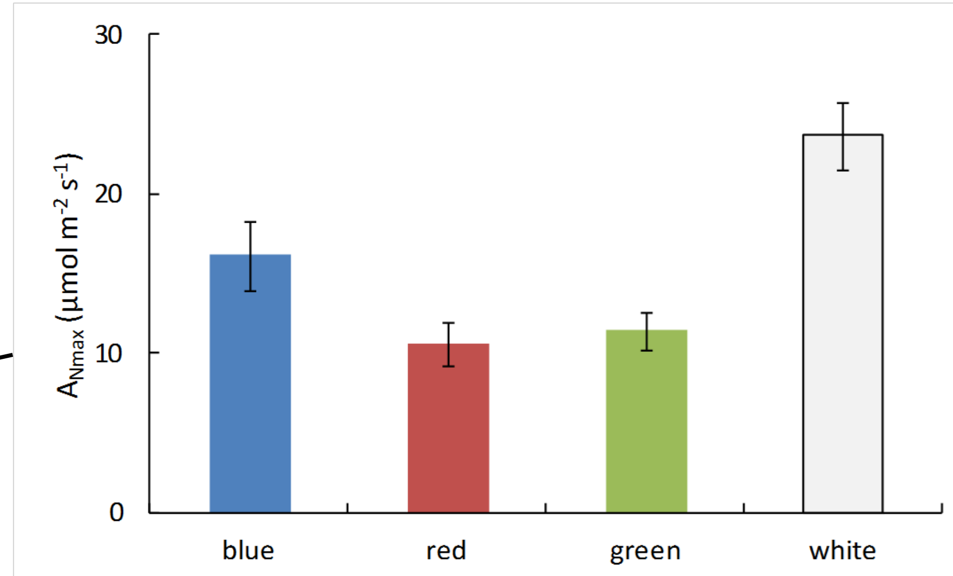
The individual phenolic compounds identified by HPLC-MS

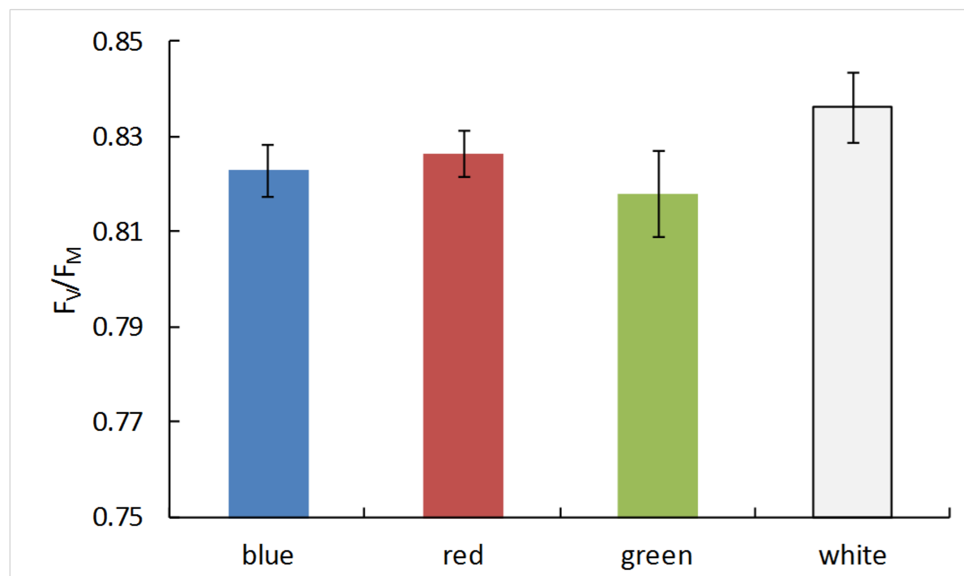


- both lutonarin and isomer of FQA as effective antioxidants accumulated under BL
- di-glucosides with bound phenolic acid that have a higher molecular weight were upregulated by WL
- BL up-regulates preferentially phenolic compounds with antioxidant activity and mesophyll localization

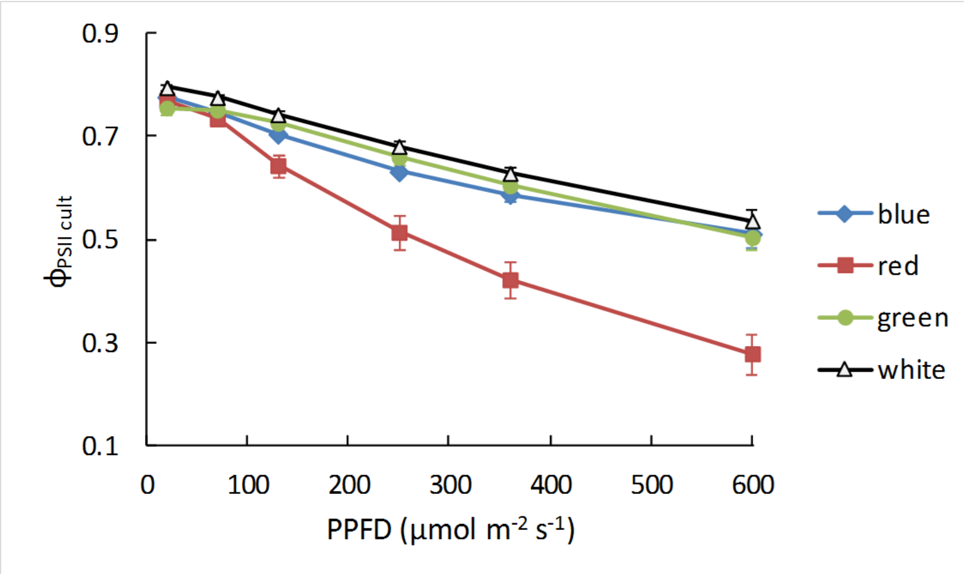
The maximal CO_2 assimilation rate and the maximal photochemical efficiency of PSII

measured under saturation white light together with saturation CO_2 concentration (1500 ppm)

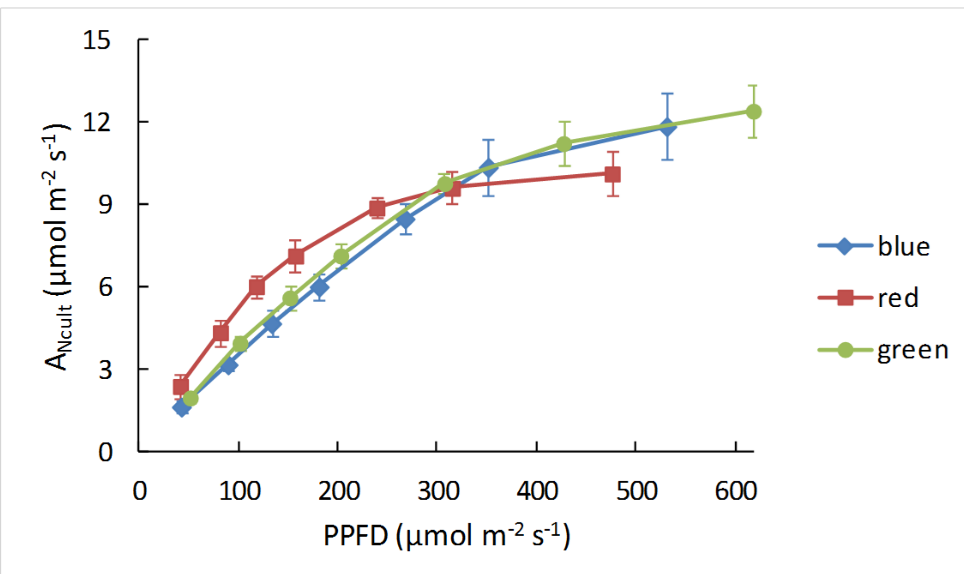




Light-response curves of the quantum yield of PSII photochemistry and CO_2 assimilation rate - measured under corresponding cultivation light

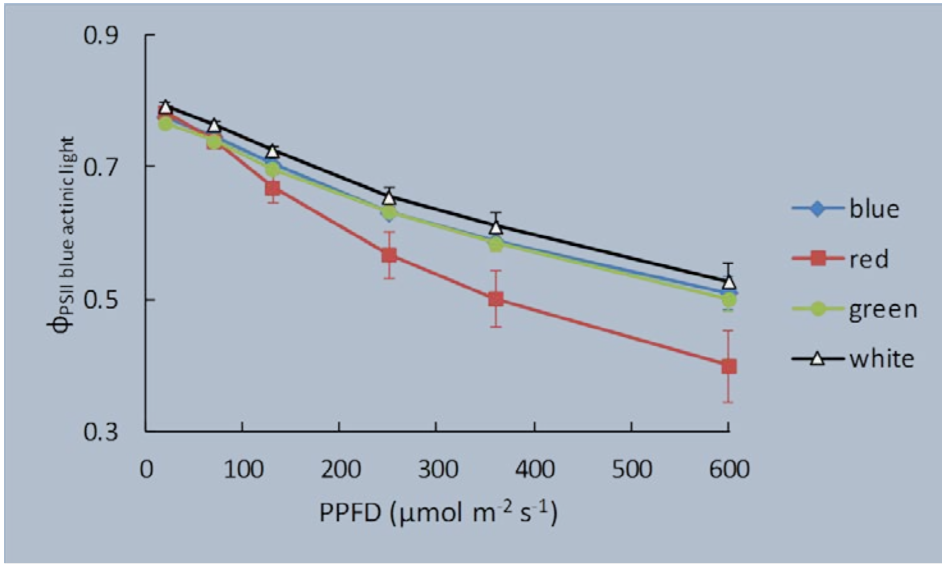


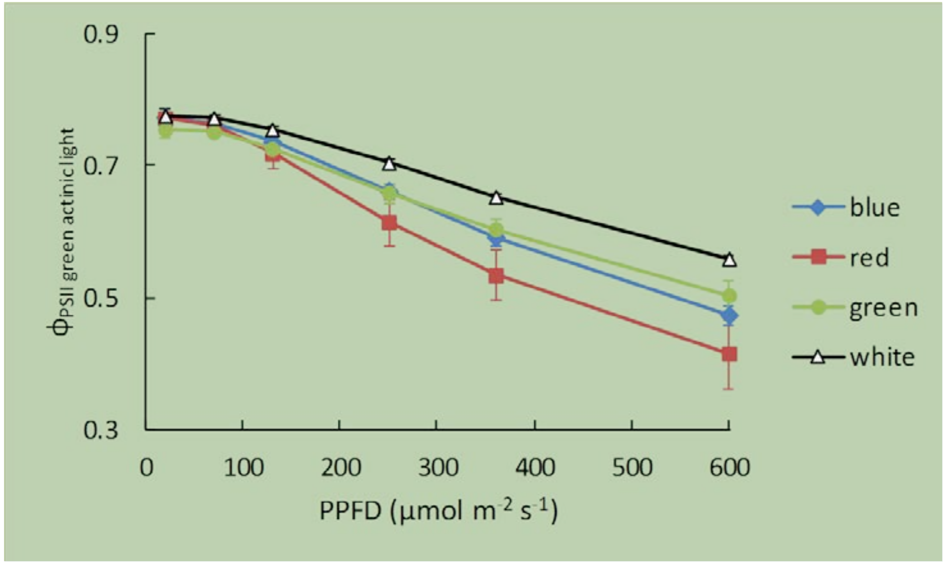
RL-grown plants showed pronouncedly reduced efficiency of light utilization in PSII photochemistry despite optimal F_V/F_M value and higher CO_2 assimilation rate at lower PPFDs

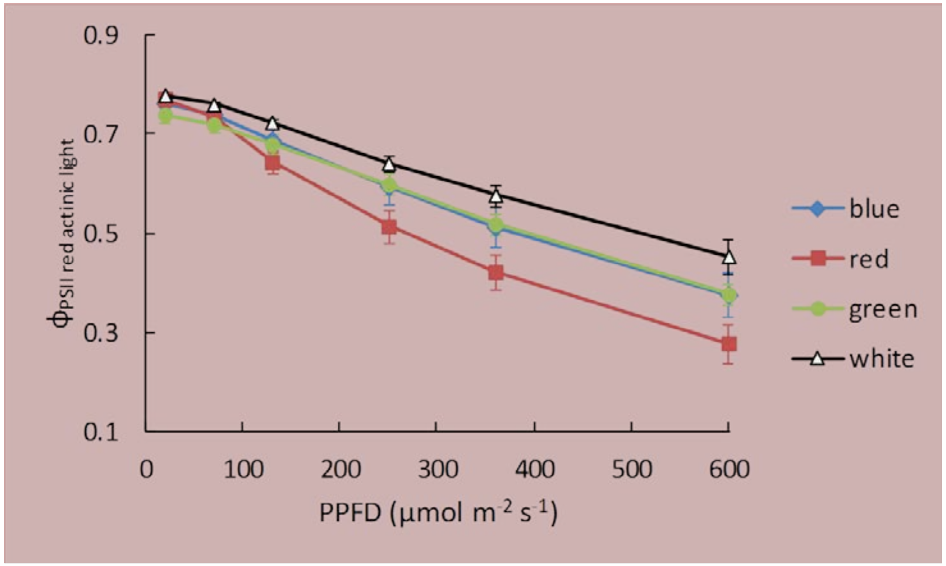


Light-response curves of A_N were measured under saturating CO_2 concentration (1500 ppm) to eliminate the effect of different light quality on stomatal conductance and CO_2 concentration in sub-stomatal cavity.

Light-response curves of the quantum yield of PSII photochemistry
- measured at different light colors *(= background of figures)*



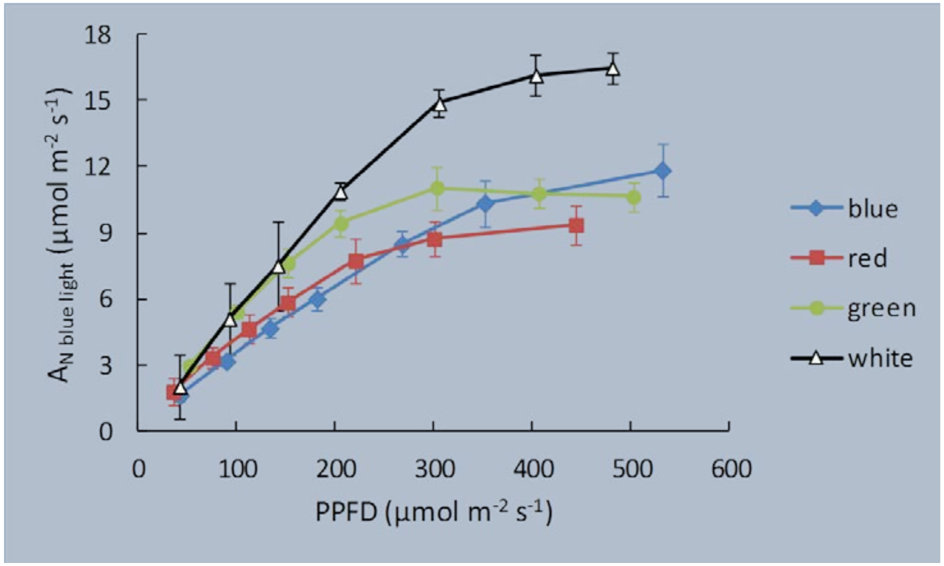


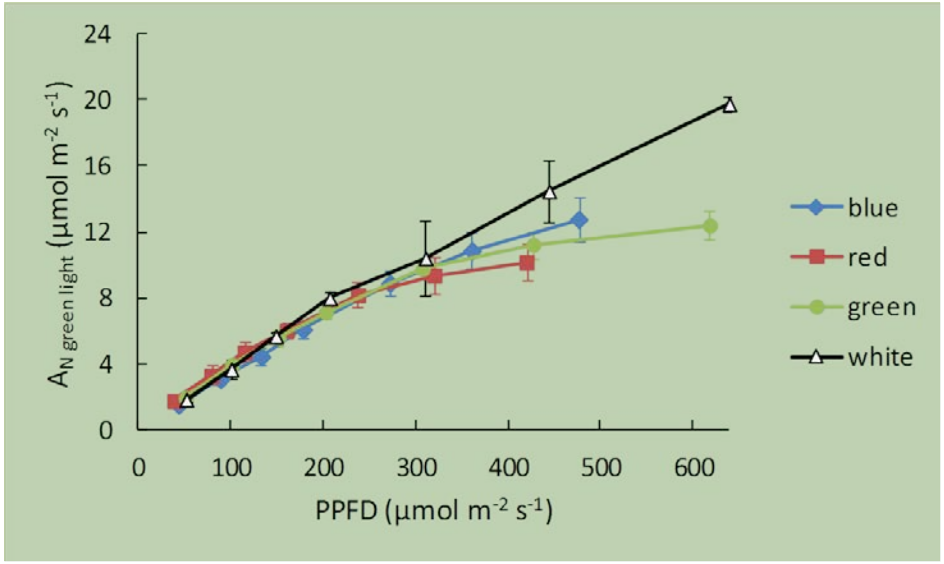


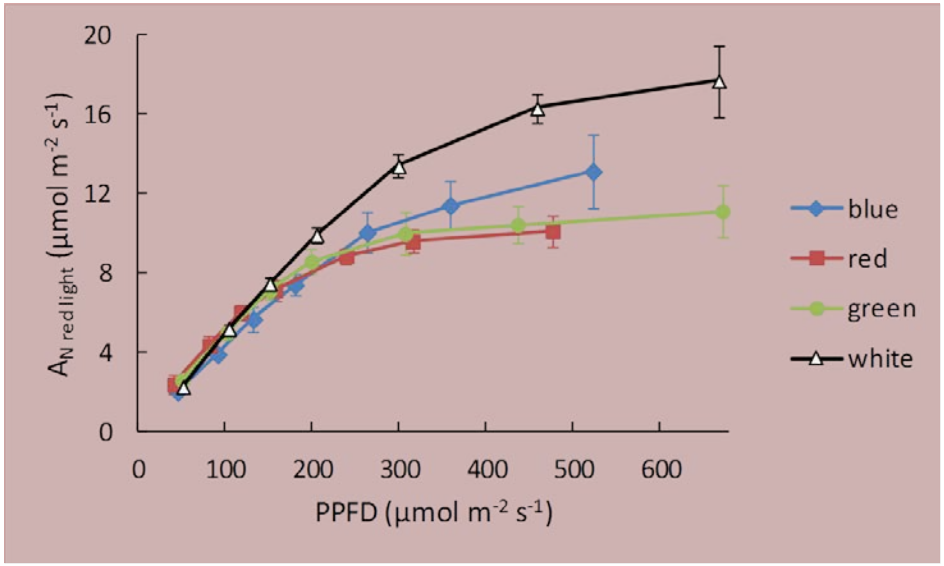
WL-grown plants have the greatest ability to utilize B, R and also G light in PSII photochemical reactions.

In contrast to B and G plants which had the highest ϕ_{PSII} under corresponding cultivation light, R plants had the lowest ϕ_{PSII} under cultivation light.

Light-response curves of CO_2 assimilation rate
- measured at different light colors *(= background of figures)*







The distinct response of ϕPSII in R barley in comparison with B and G plants was not however correlated with A_N response

The importance of blue light

Blue light initiates changes of leaf characteristics that occur during high light acclimation (Buschmann et al., 1978; Lichtenthaler and Buschmann, 1978; Hogewoning et al., 2010).

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High blue light improves acclimation and photosynthetic recovery of pepper plants exposed to UV stress

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Plant, Cell & Environment

PC&E

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Original Article

Epidermal UV-A absorbance and whole-leaf flavonoid composition in pea respond more to solar blue light than to solar UV radiation

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Our new equipment – xenon light source MAX-303 (Asahi Spectra) with filters

- can be used as a bright monochromatic and heatless light source by mounting the bandpass filters (FWHM: 10-12 nm)
- now we have filters with the maxima at 300, 340, 365, 450, 500, 520, 550, 660 and 730 nm
- opens the possibility to measure detailed spectral dependence of various responses