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Abstracts of the Final Network Meeting of COST Action FA0906 UV4growth

Bled, Slovenia, 30 March – 2 April 2014

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COST – Action FA0906

Final Network Meeting

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Sunlight, in its many guises, is the force that has shaped and driven the miraculous living fabric of this planet for billions years. It embodies the best engineering, the widest safety margins, and the greatest design we experience now. It provides amply for our needs, yet limits our greed… It is safe, eternal, universal and free.

Theodore B. Taylor, Sceptic (1977)

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About COST

COST - the acronym for European Cooperation in Science and Technology - is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds.

The funds provided by COST – less than 1% of the total value of the projects - support the COST cooperation networks (COST Actions) through which, with EUR 30 million per year, more than 30 000 European scientists are involved in re-search having a total value which exceeds EUR 2 billion per year. This is the financial worth of the European added value which COST achieves.

A “bottom up approach” (the initiative of launching a COST Action comes from the European scientists themselves), “à la carte participation” (only countries interested in the Action participate), “equality of access” (participation is open also to the scientific communities of countries not belonging to the European Union) and “flexiblestructure” (easy implementation and light management of the research initiatives) are the main characteristics of COST.

As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a “bridge” towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of “Networks of Excellence” in many key scientific domains such as: Biomedicine and Molecular Biosciences; Food and Agriculture; Forests, their Products and Services; Materials, Physical and Nanosciences; Chemistry and Molecular Sciences and Technologies; Earth System Science and Environmental Management; Information and Communication Technologies; Transport and Urban Development; Individuals, Societies, Cultures and Health. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

Welcome to Bled

We are glad to welcome you on the final network meeting of COST-Action FA0906 “UV-B radiation: A specific regulator of plant growth and food quality in a changing climate” in Bled, Slovenia.

Bled belongs to the oldest touristic towns in Slovenia. It is located in the a glacial landscape in the transition area between Radovljica depression and eastern foothill of Julian Alps. The islet in the middle of the lake has attracted people since prehistoric times. In the early 20th century it became a fine health resort.

The aim of this Final network meeting is to enhance the European UV research domain, by summarising the outcomes and presenting the achievements of both UV4Growth and the research field as well as to strengthen collaborative interactions across disciplines, connecting different universities and countries, and particularly by stimulating the research environment for Early Stage Researchers (ESRs).

The meeting is co-organized by the Department of Biology, Biotechnical Faculty, University of Ljubljana and Chamber of Agriculture and Forestry of Slovenia, unit Nova Gorica.

We gratefully acknowledge the financial support by COST.

We wish you a productive and enjoyable meeting!

Dr. Marcel A.K. Jansen
Chair FA0906

Dr. Alenka Gaberščik
Dr. Mateja Germ
Local Organisers

Introductory lectures

Historic perspective on plant UV-B research

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Ultraviolet radiation was discovered by Wilhelm Ritter in 1809. In my talk I will try to describe the progress in ultraviolet photobiology, with an emphasis on plants: Finsen's method of curing skin tuberculosis (1896), inactivation of microorganisms (Hertel 1905), nucleic acid as UV target (Gates 1928), photoreactivation of UV damage to plants (Hausser and v. Oehmcke 1933), ozone destruction by nitrogen oxides (Crutzen 1970), weighting function for plant damage (Caldwell 1971), threat to ozone layer by CFCs (Rowland and Molina 1974), publication of evidence for an Antarctic ozone hole (1985), opening for signatures to the Montreal Protocol (1987), start of a long-term field UV enhancement experiment (1991), and the more recent discoveries such as the plant UV-B receptor UVR8 and gene regulation by UV radiation.

Lars Olof Björn
1967 PhD Lund University
1971–1972 Professor of Plant Physiology, Agricultural University of Denmark
1972–2001 Professor of Botany, Lund University
2010 – Professor of Biology, South China Normal University

Rapid changes in UV-shielding in plants: mechanisms, species patterns and physiological significance

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The epidermis in leaves serves as a selective filter of sunlight by removing much of the potentially deleterious ultraviolet radiation (UV; <400 nm) while transmitting most of the photosynthetically active radiation (PAR; 400-700 nm). Plants exposed to UV can increase epidermal UV-shielding by the production and accumulation of UV-absorbing compounds (flavonoids and related phenolics), but the degree to which they can modulate their UV-shielding in response to natural variability in solar UV exposure is poorly understood. Previously, we documented rapid changes in UV-shielding in plants growing in a tropical, high-elevation, high solar UV environment on Mauna Kea, Hawaii, USA. In these studies we observed that epidermal UV-shielding, measured using a non-invasive chlorophyll fluorescence technique (UVA-PAM), changed on a diurnal basis, with UV-shielding increasing significantly from predawn to midday and then declining at sunset. Although modest in magnitude, these patterns could be disrupted by increases in cloud cover and the imposition of artificial shade. Direct measurements of epidermal peels in *Vicia faba* with an integrating sphere have subsequently confirmed that changes in epidermal UV-shielding can occur within 1-1.5 h. As a test of the generality of this phenomenon, we measured UV-shielding at predawn/dawn and midday under clear sky summer conditions in 34 additional species of native and cultivated plants (n=2-15/species) growing in three other locations (Idaho, Utah and Louisiana, USA). Including Hawaii, these locations differ in daily biologically-effective UV irradiances (mean daily UV-B_{BE} = 3.5 – 11.0 kJ m^{-2} d^{-1}) and air temperatures (mean daily T_{air} = 11.8 – 29.0 C). Across all locations, 25 of the 37 species surveyed (67.6%) showed significant ($P<0.10$) increases in UV-shielding from predawn/dawn to midday with the magnitude of these changes ranging from 0.5% in *Typha latifolia* to 31.1% in *Abelmoschus esculentus*. When averaged over species, there was a significant effect of location (ANOVA; $P = 0.05$) with plants growing in Louisiana generally showing larger diurnal changes in UV-shielding than those growing in other locations. No significant differences (ANOVA; $P=0.64$) were found among plants of different growth forms (forb, vine, grass and woody plant). Concurrently, leaf samples in three of these species (*A. esculentus, Phaeseolus vulgaris*, and *Zea mays*) growing in Louisiana were collected and analyzed for whole-leaf UV-absorbing compounds. Diurnal changes in UV-shielding in *A. esculentus* and *P. vulgaris* were associated with significant ($P<0.05$) changes in whole-leaf UV-absorbing compounds. LC-MS analysis indicates that the major UV-absorbing compounds in *A. esculentus* are several glycosides of quercetin. No diurnal changes ($P>0.05$) in UV-shielding or UV-absorbing compounds were detected in *Z. mays*. Although diurnal changes in UV-shielding are highly correlated with changes in both solar UV and PAR, the specific role of these wavebands in driving these responses is as yet unresolved. Additionally, while the diurnal changes in UV-shielding alter both the magnitude and timing of calculated UV exposure of underlying mesophyll tissue, the physiological importance of these differences is not known. Studies are currently underway to further probe the mechanisms of these rapid changes in UV-shielding, determine the drivers of these responses, and assess the adaptive significance of this phenomenon.

Paul W. Barnes is a Professor of Biology and the JH Mullahy Endowed Chair in Environmental Biology at Loyola University New Orleans. Dr. Barnes received his PhD from the University of Nebraska and was a Postdoctoral Research Associate at Utah State University. He has held faculty positions at Loyola, St. Olaf College and Texas State University, and was a Project Leader at the US EPA Environmental Research Laboratory. Dr. Barnes is a plant ecophysiologist whose research has been supported by the NSF, USDA and EPA. He has over 130 published articles and abstracts and has served on advisory panels for the NSF, USDA, EPA and National Academy of Sciences.

Nuclear regulation by UV-B radiation (WG1)

Molecular aspects of regulation by UV-B radiation in plants: zooming out from UVR8

Strid, Å.

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During the four years of the COST action 'UV-B radiation: A specific regulator of plant growth and food quality in a changing climate (UV4growth)', there has been tremendous development in the molecular aspects of UV-B regulation of plant metabolism. Specifically, the three-dimensional structure of the UV-B photoreceptor UVR8 and partial understanding of its function have revealed intriguing biochemical properties. In addition to the central UVR8/COP1/HY5 triad of UV-B signalling, other proteins taking part in UVR8-dependent signalling have been linked to the pathway, such as SPA and FHY3, and the negative regulators RUP1/2 and STO/BBX24. Molecular modelling has also suggested events leading to UV-dependent monomerisation of the UVR8 dimer and interaction with the WD40 domain of COP1. However, it has also become increasingly clear that the UVR8 signalling pathway interacts with other stimulatory pathways to produce an integrated environmentally determined signal that regulates gene expression, metabolism, and morphology, manifested physiologically and in the natural environment. Future research will most likely address the integration of UV-B signalling with e.g. signalling from photoreceptors absorbing radiation in other parts of the electromagnetic spectrum, signalling as a result of oxidative pressure or DNA damage, signalling for regulation of plastid metabolism, trafficking and gene regulation etc. There is also evidence for yet other UV regulated signalling pathways that need extensive and careful examination. Furthermore, the use of molecular information about UV signalling is becoming increasingly useful for applications in horticulture and agriculture and an increasing use of UV regulatory proteins for applications in medicine and biotechnology may also be foreseen.

Åke Strid is Professor of Biochemistry at Örebro University Sweden since July 2000. 1989 he received his PhD degree at Stockholm University and was Assistant Professor at the Royal institute of Technology (Stockholm) until 1994 and then Associate Professor at Gothenburg University. He has published some 100 peer reviewed research papers of which more than half is on UV-B-related topics. He started his studies on UV-B photobiology in 1989 during a Post Doc visit to Prof. Jan M. Anderson's laboratory at the CSIRO-Division of Plant Industry, Canberra, Australia.

What does UVR8 do and how does it do it?

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UV-B wavelengths act as a key regulatory signal to initiate responses in plants. These responses affect plant morphology, physiology, biochemical composition, UV-protection and defence against pests and pathogens. Photomorphogenic responses to UV-B are mediated by the photoreceptor UV RESISTANCE LOCUS8 (UVR8). It is well established that UVR8 regulates the expression of numerous genes that underpin photomorphogenic responses to UV-B. It is now known that UVR8 regulates a range of responses to UV-B, some of which involve interaction with other signaling pathways. UVR8 is a 7-bladed β-propeller protein that exists as a homodimer maintained by interactions between specific charged amino acids at the dimer interface. Specific tryptophan amino acids act as UV-B chromophores for the photoreceptor and photoreception causes rapid dissociation of the dimer into monomers. UVR8 monomers interact with the CONSTITUTIVELY PHOTOMORPHOGENIC 1 (COP1) protein to initiate signalling and hence gene expression. Recent research is providing new insights into the way UVR8 functions to regulate photomorphogenic responses.

Gareth Jenkins is Professor of Plant Cell and Molecular Biology at the University of Glasgow. The focus of his present research is to understand the cellular and molecular mechanisms of plant responses to UV-B, in particular photoreception, signalling and transcriptional regulation mediated by the UVR8 photoreceptor.

Tissue-dependent aspects of UV-B-specific responses controlled by the UVR8 photoreceptor in *Arabidopsis thaliana*

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UV-B RESISTANCE 8 (UVR8) photoreceptor (Rizzini et al. 2011) initiates UVB-specific signalling cascades orchestrating expression of a range of genes resulting in different developmental responses. Despite this broad range of effects, UV-B cannot penetrate deep into the plant tissues UVR8 is expressed uniformly in the model plant *Arabidopsis* (Kaiserli and Jenkins 2007) but the spatial aspects of UVR8 action are not yet elaborated. The aim of our study is to unravel to what extent the cell/tissue specific signalling contributes to UVR8-controlled responses. To this end we created transgenic *uvr8* mutant lines expressing the UVR8:YFP photoreceptor under the control of different tissue-specific promoters. The detailed characterization of these lines including examination of UV-B-dependent photomorphogenesis and observation of UVR8-dependent changes in gene expression profiles has also been performed. We used these transgenic lines to monitor how tissue-specific expression of UVR8 can regulate the nuclear accumulation of the bZIP transcription factor, HY5 (Oravecz et al. 2006). Furthermore, we could analyse the tissue-specific aspects of *HY5* promoter induction using the *HY5:GUS-GFP-NLS* transgene Our results suggest that UVR8-controlled signalling is at least partly mediated in a tissue-autonomous fashion.

References

Rizzini L, Favoury J, Cloix C, Faggionato D, O'Hara A, Kaiserli E, Baumeister R, Schäfer E, Nagy F, Jenkins G, Ulm R (2011) Science 332, 103-106.

Kaiserli E, Jenkins GI (2007) The Plant Cell 19, 2662–2673.

Oravecz A, Baumann A, Máté Z, Brzezinska A, Molinier J, Oakeley EJ, Ádám É, Schäfer E, Nagy F, Ulm R (2006) The Plant Cell 18, 1975-90.

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András Viczián received his MSc degree in biology and geography at the Kossuth Lajos University in Debrecen, Hungary and obtained his PhD at the University of Szeged, Hungary in 2004 After working in several institutes (MPIZ, Cologne, Germany; University of Freiburg, Germany; Instituto Leloir, Buenos Aires, Argentina), recently he is a member of the group of Laboratory of Plant Chrono- and Photobiology at the Biological Research Centre in Szeged His research interests are photomorphogenesis, phytochrome and UV-B signalling in *Arabidopsis thaliana*

Involvement of the eIF2a kinase GCN2 in UV-B responses

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GCN2 (GENERAL CONTROL NONREPRESSED 2) is a serine/threonine-protein kinase that regulates translation in response to stress such as amino acid and purin deprivation, cold shock, wounding, cadmium and UV-C exposure through phosphorylation of the alpha subunit of the eukaryotic translation initiation factor 2 (eIF2) (Lageix et al., 2008; Zhang et al., 2008; Immanuel et al., 2012). The translational regulation of preexisting mRNAs is faster than mRNA transcription and processing. The aim of this work was to investigate the role of GCN2 in responses of broad and narrow band of UV-B radiation. We examined GCN2 activity through analyses of eIF2alpha phosphorylation, determined the response of different T-DNA insertion mutants of *Arabidopsis thaliana* and quantified the expression of known UV-B responsive genes in these mutants upon different conditions of UV-B radiations. Moreover genetic analyses have been initiated with known components of UV-B and stress signalling pathways. Results will be presented that provide new insights into the role of the regulation of translation upon UV-B radiation.

References

Immanuel TM, Greenwood DR, MacDiarmid RM (2012) Funct. Plant Biol. 39, 717-735.

Lageix S, Lanet E, Pouch-Pelissier M-N, Espagnol M-C, Robaglia C, Deragon J-M, Pelissier T (2008) BMC Plant Biology 8, 134.

Zhang Y, Wang Y, Kanyuka K, Parry MAJ, Powers SJ, Halford NG (2008) J. Exp. Bot. 59, 3131-3141.

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Marie-Theres Hauser studied Biotechnology at the BOKU-University of Natural Resources and Life Sciences Vienna, did her PhD at the Max-Planck-Institute of Biochemistry in Martinsried, Germany, Postdoc at New York University, USA and habilitation at the BOKU. She leads the plant genetics group at the Institute of Applied Genetics and Cell Biology. Her research focuses on the molecular genetic analysis of plant development and the effects of abiotic stressors (UV-B, heavy metals, xenobiotics) on development and genome stability.

Genome-wide analysis of the mutagenic effects of UV-B in *Arabidopsis thaliana*

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DNA is the main storage molecule for genetic information for all living organisms and therefore its sequence and integrity need to be protected. On the other hand, as an unavoidable consequence of the requirement for light, all plants are exposed to UV irradiation. Due to its relatively high energy content, UV-B irradiation can damage macromolecules. At the level of DNA, UV-B mainly causes non-native bonds between di-pyrimidine bases (pyrimidine dimers) that hinder transcription and replication. Unrepaired, pyrimidine dimers can lead to fixed mutations. However, it is unknown how many UV-B induced mutations are generated in plants and transmitted to their offspring under natural conditions.
To address this, we grew *Arabidopsis thaliana* wild-type plants, as well as selected mutants in the UV-B signalling, DNA damage repair and flavonoid production pathway, in UV-B free and three different solar-like UV-B regimes in the sun simulator facilities of the Helmholtz Zentrum Munich. In total, 125 plants of different treatments, genotypes and generations were whole-genome sequenced and the mutation rates estimated. Our data shows that natural-like UV-B increases mutation rates already in wild-type plants, but more strikingly in mutants impaired in the DNA damage repair, revealing the importance of pyrimidine dimer repair for genome stability. Flavonoids play only a minor role in shielding plants against accumulation of mutations. Furthermore, our data suggest a non-random distribution of UV-B induced mutations in the genome and potential for their preferential accumulation in specific developmental stages, which will be further analyzed.

Thomas Piofczyk studied biology at the Ruhr-University Bochum, where he graduated and obtained his Diploma in biology in the department of plant physiology. Since 2010 he is a PhD student at the Max Planck Institute for Plant Breeding Research, working on plant molecular responses to UV-B radiation.

Photoreceptor control of bending towards UV-B

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[4] *Lumilab, Department of Solid State Sciences, Faculty of Sciences, Ghent University, B-9000 Ghent, Belgium*

In order to attain favourable conditions for photosynthesis, plants have developed mechanisms to orient their growth towards incoming light. Blue and UV-A light serve as cue for the phototropin photoreceptors to sense light direction. Our experiments on etiolated *Arabidopsis* seedlings demonstrate that the phototropins also perform this function in the UV-B range of the spectrum. In addition, we found a novel phototropic response to UV-B that is phototropin-independent and mediated by the UV-B photoreceptor UVR8. The UVR8-mediated bending towards UV-B is slower than the phototropin-mediated response and does not depend on many of the downstream components of the canonical phototropin-directed signalling pathway. Genetic and pharmacological assays indicate that the phytohormone auxin is indispensable for the UVR8 mediated bending. These data together with transcriptome data suggest that UVR8 may regulate UV-B phototropism by repressing auxin responses on the illuminated side of the elongating hypocotyl. We conclude that plants use the full short wavelength spectrum of sunlight to efficiently reorient photosynthetic tissue with incoming light, relying on both phototropin and UVR8 photoreceptors.

Filip Vandenbussche obtained his PhD degree in Biotechnology at Ghent University in 2004. Since then, he has been working for the Research Foundation Flanders (FWO), and is currently an assistant professor at Ghent University. His scientific work in plant physiology and molecular biology has been mainly focused on hormonal interactions and cross-talk with light signalling in the development of *Arabidopsis* seedlings. Today he extends this work into the field of UV-B.

UV-B mediated inhibition of plant shade-avoidance

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Upon detection of an encroaching canopy, many plants initiate a suite of elongation responses, collectively termed the ‘shade-avoidance response’. Vegetative shade lowers both the level of blue (B) light and the ratio of red to far red (R: FR) light, as sensed by the cryptochrome and phytochrome photoreceptors, respectively. It is assumed that the shade-avoidance developmental pathway is switched off by both high levels of B light and a high ratio of R: FR light acting as indicators of direct sunlight. Here we show that UV-B light, acting through the UV RESISTANCE LOCUS 8 (UVR8) photoreceptor, acts a potent inhibitor of shade-avoidance. We demonstrate that UVR8 antagonizes auxin and gibberellin signalling and we determine how UVR8 signalling interacts with the more established phytochrome and cryptochrome pathways in order modulate growth and development under sunlight.

References

Casal J (2012) The Arabidopsis Book 10, 1–19.
Heijde M and Ulm R. (2012) Trends Plant Sci. 17, 230–237.

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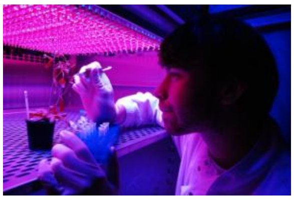

Scott Hayes graduated from the University of Southampton in 2010 with a degree in Biochemistry. He is now a final year PhD student at the University of Bristol, under the supervision of Dr. Kerry Franklin.

UV-B post-harvest irradiation induces fruit anthocyanin accumulation in an anthocyanin-rich tomato line

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The influence of post-harvest UV-B irradiation on flavonoid accumulation was tested in fruits of the tomato line SA206-1-2-2 (with the anthocyanin fruit Aft gene), characterised by purple spots on fruit surface, and its wild type, cv Roma. Fruits, harvested at mature green stage, were daily irradiated with UV-B (1 h a day, 6.08 kJ m^{-2} d^{-1}) until red ripe stage. Skin and flesh were separated and stored at -80°C until use. UV-B treatment induced different effects on flavonoid concentration, depending on genotype and tissue investigated. The concentration of total skin flavonoids increased in Roma following UV-B irradiation, while it decreased in SA206-1-2-2. In the flesh, flavonoids underwent a decrease in both genotypes. A similar trend was shown by antioxidant activity. Naringenin was the most affected flavonoid in Roma skin, being about 3-fold higher in UV-B-treated fruits. Interestingly, in SA206-1-2-2 line, which is constitutively richer in flavonoids than Roma, UV-B radiation induced a decrease in rutin concentration but led to a marked increase in petunidin, delphinidin and malvidin skin concentration, indicating a metabolic shift towards antocyanin synthesis in response to UV-B irradiation.

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Supported by grant No. COST-Action FA0906-UV4growth.
We are indebted with Prof. Gian Piero Soressi for providing the tomato seeds.

Antonella Castagna graduated with honor in Biological Sciences, she obtained her PhD title at the University of Pisa, where she presently works at the Department of Agriculture, Food and Environment. She is involved in researches on plant responses to abiotic stresses aimed to clarify the primary targets, the signaling mechanisms and the kinetics of damage and defense responses. Another field of research deals with the study of nutraceutical compounds and the possibility to promote their accumulation in fruits and vegetables by eco-friendly approaches (as UV-B radiation).

Progress towards the identification of alternative ultraviolet-B signaling pathways in *Arabidopsis*

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Ultraviolet radiation (UV) is an intrinsic part of sunlight, which acts as an environmental signal regulating the growth and development of plants throughout their life cycle. Even though UV-B is <0.5% of total solar radiation reaching the earth’s surface, it has the potential to induce stress and photomorphogenic responses in plants. To identify the signal transduction pathways other than the UVR8 mediated pathway, we have developed a few homozygous *Arabidopsis* transgenic lines by introducing the promoters of UV-B-regulated genes such as those encoding the receptor like protein kinase, *RPK1*; a light harvesting chlorophyll a/b-binding protein, *LHCB1*3*, and a small subunit of ribulose-1,5-bisphosphate carboxylase (*rbcS1*) individually with the *luc+* reporter. Transgenic lines carrying single locus transgene were characterized for the expression of both endogenous UV-B responsive mRNA and transgene expression. Two of these lines showing similar pattern with LUC imaging and mRNA expression for each promoter were selected for EMS mutagenesis. Development and characterization of mutants with altered bioluminescence to UV-B is currently under way in order to identify and characterize the genes involved in the UV-B signaling pathways of *A. thaliana*.

Acknowledgement

Supported by the Carl trygger Foundation for Scientific Research and Örebro University's Faculty for Business, Science, and Technology.

Selvaraju Kanagarajan works as a Postdoctoral Fellow at the Örebro University Sweden since May 2013. He received his PhD degree in 2005 from the Tamil Nadu Agricultural University, India. He has published 12 peer reviewed research publications in the fields of plant molecular biology, biochemistry and molecular genetics.

The recombinant production and characterization of UVR8 c-terminal peptides 397-423 and 397-440

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UV RESISTANCE LOCUS8 (UVR8) is a photoreceptor involved in UV-B-mediated light perception in plants. Through the interaction with CONSTITUTIVELY PHOTOMORPHOGENIC1 (COP1), UVR8 (and COP1) is responsible for regulating more than 100 genes and subsequent UV regulated photomorphological development in plants. Recently, the X-ray crystal structure was solved for the dimeric form of the central UV-absorbing part of UVR8 giving important clues into the mechanism of its UV-B photoperception. However, still little is known about the UVR8-COP1 interaction and the interaction with the regulatory proteins RUP1 and RUP2. Our goal is to characterize UVR8-derived C-terminal peptides thought to be important for both these interactions (Cloix et al. 2012, Wu et al. 2013). To conduct heteronuclear NMR, peptides need to be enriched with NMR-active isotopes. For doing so we utilize both *E. coli* and cell-free based expression systems. Here we report on the expression, isolation and the preliminary characterization of the UVR8 derived C-terminal peptides a.a. 397-423 and 397-440.

References

Christie JM, et al. (2012) Science 335, 1492-1496.
Cloix C, et al. (2012) Proc. Natl. Acad. Sci. USA 109, 16366-16370.
Wu M, Eriksson LA, Strid Å (2013) Theor. Chem. Acc. 132,1371.

Daniel Farkas received a PhD in protein biochemistry from the University of Gothenburg (Gothenburg, Sweden) and currently I am working as a Postdoc in Åke Strid's research group at Örebro University (Örebro, Sweden). My research interests concerns the biophysical characterization of UVR8 and its interactions.

UV-B-induced metabolic changes (WG2)

UV-B – an essential regulator of the secondary plant metabolism

Schreiner, M.[1,*], Hanschen, F.[1], Hauser, M.T.[2], Hideg, É.[3], Kocsis, M. [3], Martínez Abaigar, J.[4], Mewis, I.[1], Neugart, S.[1], O'Brien, N.[5], Ranieri, A.[6], Rohn, S.[7], Schödl-Hummel, K.[8], Winkler, J.B.[9], Zrenner, R.[1], Jansen, M.A.K.[10]

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Epidemiological studies have revealed an inverse association between a high consumption of fruit and vegetables and a lower risk of chronic diseases. This protective effect is mostly due to secondary metabolites present in plant tissues. During the last decade, it has become increasingly clear that UV-B radiation is an important regulator of plant secondary metabolism. Low, ecologically-relevant UV-B levels trigger distinct changes in the accumulation of, among others, phenolic compounds, carotenoids and glucosinolates. Fundamental understanding of plant UV-B perception and responses opens up new opportunities for crop manipulation. Thus, targeted low dosage UV-B radiation treatments as emerging technology may be used to generate fruit and vegetables enriched with secondary plant metabolites for either fresh consumption or as a source for functional foods and nutraceuticals, resulting in increased consumption of these health-promoting substances. The presentation will summarise the historic perspective of UV-B-induced metabolic changes, and will present a vision of future opportunities in research and horticultural enterprises.

Monika Schreiner obtained her Master of International Agricultural Development and her PhD at the Technical University Berlin. She worked as a Postdoctoral Scientist at the Leibniz-Institute of Agricultural Engineering Bornim before becoming the head of Department Quality at the Leibniz-Institute of Vegetable and Ornamental Crops Großbeeren Erfurt and Professor at the Leibniz University Hannover.
Major research interest are the study of secondary plant metabolites and their functions; elicitor application, genotypic and ecophysiological effects on secondary plant metabolism.

The effects of different UV-B irradiations on plant growth, antioxidant compounds and postharvest quality of broccoli florets

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The depletion of ozone and enhanced solar ultraviolet-B (UV-B) irradiance may have adverse impact on plant organisms. In this study, the impact of UV-B radiation on plant growth, biochemical changes, antioxidant activity and postharvest quality of broccoli florets during long term storage was studied. The broccoli florets were grown under different levels of UV-B radiation in the soilless system in a greenhouse. For this purpose, three different dosages, 2.2, 8.8 and 16.4 kJ/m^2, of UV-B radiation were applied to the sprouts of broccolis. Harvested broccoli florets were stored at 0^{o}C in modified atmosphere packaging (MAP) for 60 days. The supplementary UV-B radiation during plant growth of broccoli florets significantly decreased the total yield, head size and beta caratone but increased ascorbic acid and antioxidant activity. The amount of chlorophyll A, chlorophyll B and total chlorophyll decreased during the storage. During storage, CO_2 concentrations increased and O_2 concentrations decreased inside the MAP. MAP significantly reduced weight loss after both cold storage and shelf life. Storage of pomegranates in MAP also reduced decay and maintained visual appearance compared to control fruit.

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Prof. Mustafa Erkan received his B.Sc in Horticulture at Ege University İzmir, Turkey in 1987. Then he moved to Akdeniz University to pursue his M.Sc. and Ph.D. in Postharvest physiology. Some of his on-going projects are Dynamic Controlled Atmosphere Storage of Apples and other pome fruits, Effects of UV-B irradiation on metabolic changes of broccoli and Palistore packaging and transportation of different fruits and vegetables Prof. Erkan organized several postharvest symposiums including the 10th International Controlled and Modified Atmosphere Research Conference and the 6th International Postharvest Symposium with the attendance of 800 participants. Prof. Erkan currently teaching several courses including Postharvest Physiology and Good Agricultural Practices at Department of Horticulture at Akdeniz University and chairing the graduate school of Akdeniz University since 2011.

Ambient UV exclusion influences phenolic composition and gene expression in berry skins of Tempranillo grapevines

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We tested the influence of ambient UV exclusion on phenolic composition and gene expression in berry skins of Tempranillo grapevines, the most emblematic variety used for red wine production in Rioja (Spain). We applied 3 UV treatments (no filter, Ambient UV; UV-transmitting filter, FUV+; and UV-blocking filter, FUV-) in a completely randomized block design since 7 June 2012 (just before flowering) until harvest (7 September). Among the 41 individual phenolic compounds analyzed, only one hydroxybenzoic acid (protocatechuic), one hydroxycinnamic acid (p-coumaric) and 8 flavonols (2 kaempferols, 4 quercetins and 2 isorhamnetins, all of them glucosylated), significantly increased in Ambient and FUV+ in comparison with FUV-. With respect to gene expression at the transcriptome level, we identified an activation of phenylpropanoid and terpenoid aromatic precursors metabolism in the presence of UV, together with the up-regulation of UV protective genes like a Photolyase and a Dicyanin. In conclusion, UV ambient levels considerably determined the phenolic composition and gene expression of Tempranillo berry skins. This opens the possibility of manipulating UV to modify berries (and possibly wine) characteristics.

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Gonzalo Soriano has a degree in agricultural engineering and currently is a PhD student at the Universidad de La Rioja (Logroño, Spain). He is mainly interested in the organismic and molecular effects of UV radiation on bryophytes, but he also collaborates in studies on the effects of UV on grapevine physiology, secondary metabolites production and gene expression, from the plant to the wine.

UV-B alters plant volatile emissions

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Climate change projections include less precipitation and prolonged dry periods for regions like the Mediterranean, the South-West U.S. and Australia. As a consequence, UV-B doses will increase in these agriculturally important regions. Besides damaging membranes, proteins and DNA, and a negative effect on plant growth, UV-B seems to enhance plant defenses against herbivores. Field studies indicated that presence of UV enhances herbivore resistance (Caldwell 2007) and part of the signaling pathway of jasmonic acid, an essential hormone in herbivore defense, is indeed induced by UV-B (Demkura 2010). In this project, we study effects of UV-B on the emission of Volatile Organic Compounds (VOCs), known to play an important role in attracting herbivores as well as their enemies. We use a custom-made setup with a Proton Transfer Reaction (PTR)-MS to look at the kinetics of VOC emissions during exposure to UV-B. Our results show that in tomato plants UV-B induces volatile emissions in different phases; immediately upon exposure, after one or two hours (delayed) and only after exposure had stopped (late). The 'late' class includes monoterpenes, a group of volatiles known to be essential in plant-herbivore interactions. To investigate whether these compounds are newly synthesized or UV-damage products, we study the expression of damage-induced genes as well as genes involved in herbivore-induced signal transduction and terpene biosynthesis. Recently, UVR8 was identified as the UV-B receptor in *Arabidopsis thaliana* (Rizinni 2011). Future experiments using *Arabidopsis* and its uvr8 mutant may provide important evidence as to how UV-induced VOC emissions responses are regulated. Furthermore, these studies will identify how UV responses interact with VOC responses to other light signals, especially reduced red:far-red ratio's that were recently found to affect VOC emissions as well.

References

Caldwell MM, Bornman JF, Ballaré CL, Flint SD, Kulandaivelu G (2007) Photochem. Photobiol. Sci., 6, 252-266.

Demkura PV, Abdala G, Baldwin IT, Ballaré CL (2010) Plant Physiol., 152, 1084-1095.

Rizzini L, Favory JJ, Cloix C, Faggionato D, O'Hara A, Kaiserli E, Baumeister R, Schäfer E, Nagy F, Jenkins GI, Ulm R (2011) Science 332, 103-6.

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Paulien Gankema studied Biology at VU University in Amsterdam, specialized in several aspects of plant-environment interactions during her Masters. After a first internship in plant-insect interactions and a second internship in the tropics on the plant-mycorrhiza symbiosis, she started her PhD in Utrecht with Ronald Pierik, in the Plant Ecophysiology group. In this project, focusing on UV-B and plant volatiles, she built a setup to measure volatiles with GC and PTR-MS, working transdiciplinary with scientists from the Institute for Marine and Atmospheric Research.

Effects of enhanced ultraviolet radiation and C:N stoichiometry on changes in metabolic profiles of different barley varieties

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Metabolomic profiling represents a new tool to ascertain the plants response to biotic or abiotic stresses. Generally, biosynthesis and accumulation of metabolites especially polyphenols in plants is induced by enhanced UV radiation and nitrogen deficiency. However, the spectrum of polyphenols, their localizations, and dynamics of synthesis/degradation may be altered by UV:PAR ratio and C:N stoichiometry. The main objective of our work was to study how changes in UV:PAR ratio (modulated by UVA+UVB lamps and plastic filters) and N supply influence metabolic profiles in barley varieties with different sensitivity to oxidative stress. Metabolomic profiling (HPLC-MS) accompanied by physiological measurements covered a wide spectrum of secondary and primary metabolites. Significant differences in constitutive metabolomic profiles, particularly phenolics, were observed between barley varieties. High UVA and UVB doses increased synthesis of galangin, luteolin, chrysin etc., particularly in sensitive Barke variety. On the contrary, high N supply reduced concentration of sinapic acid, homoorientin, apigenin etc., particularly in resistant Bonus variety. Such decrease in phenolics related to reduction of photosynthetic parameters induced by UV radiation.

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This work is part of the research supported by grant LD12030 (MSMT, CR).

Michal Oravec studied Chemistry and Environmental Chemistry at the Masaryk University, Brno (CZ) and obtained his PhD. Dissertation thesis was focused on determination of selected organic pollutants in components of the environment. Currently he works as a junior researcher in the Metabolomic laboratory of Global Change Research Centre Academy of Sciences Czech Republic. The main focuses of his work are metabolomic profiling in different plants and effects of environmental factors like draught and UV/PAR radiation, etc. on changes in metabolic profiles of plants.

Seasonal UV radiation and low water availability effects on the phenolic content and antioxidant activity of polar extracts from leaves of the Mediterranean species *Arbutus unedo* (Ericaceae)

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This study evaluates UV radiation and low water availability effects on the phenol content and antioxidant activity (DPPH scavenging) of *Arbutus unedo* leaves aiming to improve their exploitation as a source of bioactive constituents. The study was carried out in the field on naturally growing plants submitted to 95% UV-B reduction (UVA), 95% UV-A+UV-B reduction (UV0) or near-ambient UV levels (UVA+UVB), in conjunction with 2 water regimes (natural rainfall or 30% reduction). Total phenol (TPP), flavonol (TFLAVO), flavanol (TFLAVA) contents, levels of 8 phenols and DPPH scavenging were measured for 4 consecutive seasons. A seasonal effect on TPP, TFLAVO and TFLAVA was observed, with TFLAVA being also negatively affected by ambient UV exposure. Regardless of the water regime, leaves under UVA plots had a ~1.45-fold higher theogallin content than UV0 ones, while those exposed to UVA+UVB had the highest quercitrin content. DPPH scavenging was higher by ~5% and ~10% in leaves under UVA or UVA+UVB, respectively, compared to UV0 plants. Finally, the reduction in water availability decreased the quercetins/kaempferols ratio. Present findings contribute to understand UV and water availability impacts on naturally growing *A. unedo* plants, as well as to develop crop manipulation strategies.

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Nikolaos Nenadis is a Lecturer of Food Chemistry and Technnology (Laboratory of Food Chemistry & Technology, School of Chemistry, Aritotle University of Thessaloniki). His research is mainly focused on natural phenolic compounds, the examination of their structure-antioxidant activity relationship experimentally and with the aid of quantum chemical calculations, as well as their characterization in plants with potential interest for the food industry.

An essential UV-B threshold for the formation of phenolic acids and flavonoid glycosides in *Vitis vinifera*

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Phenolic compounds in *Vitis vinifera* leaves accumulate in response to enhanced UV-B radiation (UVR 280-315 nm). In 'Pinot noir' leaves the response of phenolics to latitudinal climate changes (temperature, global radiation, UVR) should be determined. 'Pinot noir' leaves were harvested at veraision in 5 European locations (Florence, Girona, La Rioja, Pécs, Vienna). Climate data were recorded from budbreak to veraison. Phenolic acids and flavonoids were analysed with HPLC-MS^n. The main phenolic acid in leaves of 'Pinot noir' was caftaric acid (90%), the main flavonoid glycoside was quercetin-3-glucuronide (75%). The time range (93-119 d) from budbreak to veraison fluctuated greatly over the different locations. The average temperature and global radiation varies from 17.0-22.1 °C and 12.8-23.5 MJ m^{-2}, respectively. However, changes in average UVR were quite slight (3.2-4.0 kJ m^{-2}). Concomitantly to these low UVR differences, the phenolic acid and flavonoid profile of 'Pinot noir' leaves was comparable at the locations. The induction of UVR absorbing compounds seems less sensitive until a threshold for synthesis of phenolic acids and flavonoids is reached under relative high UVR. This production threshold results in a constant profile of phenolic acids and flavonoids.

References

Jansen MAK, Hectors K, O'Brien NM, Guisez Y, Potters G (2008) Plant Sci 175, 449–458.

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Supported by grant No. COST-Action FA0906-UV4growth (Trans-European Wine-Leaf Experiment).

Susanne Neugart studied nutritional sciences at the Friedrich Schiller University Jena and obtained her PhD at the Technical University Berlin. She was awarded for her PhD thesis from the German Society for Quality Research on Plant Foods. Currently she works as a junior research group leader in the Leibniz-Institute of Vegetable and Ornamental Crops Grossbeeren/Erfurt e.V. The main focuses of her work are structure elucidation of flavonoid glycosides in different species and their response to different environmental factors such temperature and radiation dependent on the structure.

“Double Maturation Raisonnée” (DMR) – opportunity to use advantages, but not disadvantages of UV-B irradiation in wine production

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To improve wine quality, a new practice called “Double Maturation Raisonnée” (DMR) has been developed. DMR is a technicque, where a cut of an one-year fruitful cane at the technological ripening stage of the grape is applied. DMR has been tested in a field trial in two consequtive years on four grapevine varieties, cultivated in sub-Mediterranean environmental conditions. Grape quality has been monitored by periodical FTIR, and for red varieties the phenolic maturity, based on Glorie methods, has been analysed as well. The results show that biochemical changes were not significantly related to water loss from berries, as expected and also previously reported. On the other hand, DMR minimised the total acid drop, usually present after full technological maturity. The results obtained have actually an important technological value for wine producers from that region, since warmer weather conditions during the recent years caused a rapid decrease of acids at the final stage of the maturation, what negatively affected wine stability, as well as its organoleptic properties. Furthermore, also the synthesis of phenolic compounds was affected by DMR, again yielding beter organoleptic properties and more stable wine, promising higher wine quality.

References

Corso M, Zilotto F, Rizzini FM, Teo G, Cargnello G, Bonghi C (2013) Plant Sci 208, 50 - 57.

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Tjaša Jug studied organic chemistry at University of Ljubljana and achieved hers PhD at University of Nova Gorica, School of Environmental Sciences. Then she has left the research, starting to work as a laboratory manager at Agricultural and Forestry Institute of Nova Gorica, supervising wine and soil analysis. Few years ago she has started with research again, dealing mostly with practical aspects, useful for farmers (plant nutrition, humic substances, grape ripening, aromatic compounds in grape, wine, fruits, milk, cheese, data evaluation...).

Dynamics in epidermal flavonoid accumulation in different *A. thaliana* genotypes under UV-B exposure – feasibility of non-invasive measurements using Multiplex®

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The importance of flavonoids for plant growth and development and their role as e.g. antioxidants (ROS scavenging) or UV-absorbing sunscreens has long been recognized. The dose dependent triggering of flavonoid accumulation under ultraviolet-B radiation (UVB, 280-315 nm) is an important factor for the understanding of the dynamics in epidermal accumulation of flavonoids as stress protectors. Determination of dynamics by 'classical' methods such as HPLC or mass spectrometry demands a high number of samples due to their destructive character. Methods based on the optical properties of the flavonoids in the UV and visible spectral regions allows for non-destructive and real-time determination of flavonoid content of leaves. The use of these methods in *A. thaliana* plants, however, is often restricted due to leaf and rosette size. In this presentation we will present results from measurements with the Multiplex® (FORCE-A, France) in different genotypes which will be compared to HPLC determined values of flavonoid and anthocyanin accumulated values. Correlations between these values depending on genotype and UV-B dose will be estimated and advantages and restrictions of the instrument in studying *A. thaliana* will be discussed.

Jana Barbro Winkler studied biology at the Christian-Albrechts-University in Kiel where she graduated at the Botanical Institute and obtained her PhD at the Institute of Polar Ecology. Since 2000 she is working at the Research Unit for Environmental Simulation at the Helmholtz Zentrum München. Her main research interest is the effect of changing environmental parameters on the physiological performance of plants.

ROS specific antioxidant responses to UV

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Ultraviolet (280-400 nm) is an important region of solar spectrum regulating several aspects of plant physiology, including antioxidant capacities. The aim of the present study was to compare UV inducible changes in antioxidant capacities directly neutralizing reactive oxygen species (ROS). Two experiments were performed: (i) within a controlled environment (CE) using supplemental UV irradiation and (ii) in the vineyard applying UV screening plastic filters on grapevine leaves. Tobacco plants in greenhouse were irradiated with low doses of supplemental UV-B. After one week, leaves had approximately 15-20% less photosynthetic activity than controls kept under PAR only. All ROS specific antioxidant capacities increased, but the plants' ROS defence was most focussed on H_2O_2 neutralizing. Grapevine leaves kept under UV-B deprived sunlight for 21 summer days had slightly higher photosynthesis per stomata and lower antioxidant capacities than controls kept under UV transparent cellulose-diacetate. These results show that ROS antioxidants participate in acclimation to UV and also emphasise differences between responses to UV under CE and natural conditions. *In vitro* experiments with monochromatic UV demonstrated the possibility of H_2O_2 photocleavage by UV-B to hydroxyl radicals, which explains why peroxides and $^{\bullet}OH$ neutralization are in the frontline of defence against UV in CE and are also important in acclimation to solar UV.

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Gyula Czégény is PhD student in the 2nd year at University of Pécs, Faculty of Sciences, Institute of Biology, Department of Plant Biology. His main research area is the investigation of plant responses to UV-B stress, including detection of reactive oxygen species (ROS) examine of ROS specific antioxidant and UV screening pigment capacities and changes in photosynthesis. His supervisor is Professor Éva Hideg.

Differences in plant chemistry and crop growth under specific wavelengths of the UV region

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UV radiation regulates a multitude of plant chemistry processes and morphogenesis (Johansen et al., 2011). Potted peppers and eggplants were exposed from seed to supplemental UV (weighted towards UV-A) and separately to UV-B radiation. Effects on plant chemistry and growth (stem height, leaf area and dry weight) were monitored over 7 and 12 weeks for pepper and eggplants, respectively. At intervals leaf material was also harvested and analyzed for secondary metabolites, soluble carbohydrates, amino acids, proteins and photosynthetic pigments. Both species responded to UV with shorter stems, but also with lower leaf area. In pepper, there were higher leaf secondary metabolites, amino acids, total content of protein and sucrose in response to UV. For eggplants, leaf area and chemistry were unaffected by UV exposure. In a separate experiment specifically investigating UV-B impacts, similar responses were observed on peppers. For the former, dry weight and leaf area were reduced and phenolic and protein/amino acid contents increased. Our results demonstrate consistent but species-specific effects showing that pepper is sensitive to UV but eggplants appear more tolerant. Effects and direction of response was similar for both UV (weighted towards UV-A) and UV-B radiation.

References

Johansen NS, Vänninen I, Pinto DM, Nissinen AI, Shipp L (2011) Ann. App. Biol. 159, 1-27.

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Beatriz Dáder is a 3rd year PhD student under the supervision of Prof. Alberto Fereres and Dr. Aránzazu Moreno. She studied Agricultural Engineering in Madrid (Spain) and joined Dr. Fereres' lab at Institute of Agricultural Sciences (ICA-CSIC) in 2010, where she works in the integration of physical and biological means of pest control and associated viruses on horticultural crops. During summer 2013, she was awarded with a STSM and a grant from the Spanish Government to work in collaboration with Dr. Dylan Gwynn-Jones' laboratory for 5 months in Aberystyth (UK).

Pinot Noir grapevine skins along a latitudinal gradient in Europe: the other side of Grapevine Ultraviolet Network (GUN)

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GUN (Grapevine Ultraviolet Network) emerged as one of the collaborative pan-European projects within the COST Action FA0906 UV4growth, focusing on the relationship between UV and not only grapevine leaf physiology, but strategically also grape composition and wine quality. Thus, GUN integrally covers the whole grapevine cycle and economic value from the field to the table. In this context, Pinot Noir grapes have been sampled in 2013 in 11 localities of Spain, France, Italy, Hungary, Austria, Slovenia, Czech Republic and Germany. This represents a latitudinal gradient of 14º (36º-50º) and a linear distance of around 1500 km. Grapes were harvested from 31 July to 22 October in the different localities, sampling 3 maturity stages (densities) in each locality. Grapes of the intermediate density, thus having a similar maturity, were analyzed. Brix degrees varied between 19.1 and 23.7, and grape weight between 1.1 and 2.0 g, but these variables were not significantly correlated with latitude. Grape skins were obtained and freeze-dried in each locality, and essential compounds for wine quality, such as phenolics and norisoprenoids precursors, are being currently analyzed. Preliminary results, and their relation to UV and other environmental factors, will be presented.

Acknowledgement
Supported by the COST Action FA0906 of the European Union.

Encarnación Núñez-Olivera graduated and gained her PhD in Biology (Universidad de Extremadura, Spain), where she was Assistant professor. Afterwards, she was Associate profesor and permanent professor at the Universidad de Zaragoza and Universidad de La Rioja. Since 2010, she has a post as Professor (Catedrático) of Plant Physiology at the Universidad de La Rioja. She mainly teaches Biology and Plant Physiology. Her research is focused on the ecophysiology of bryophytes (mosses, liverworts and hornworts) and grapevine in relation to UV radiation, with a particular interest in secondary metabolism.

Coordinated regulation of the flavonoid biosynthesis by UV-B radiation in an autochthonous grapevine cultivar

Végh, B.É.[1,*], Mátai, A.[1], Csepregi, K.[1], Czégény, G.[1], Teszlák, P.[2], Hideg, É.[1], Jakab, G.[1,2]

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Ultraviolet radiation can influence plant stress tolerance through regulation of the accumulation of different secondary metabolites. The aim of the present study was to analyse UV inducible changes in polyphenol biosynthesis of a given grapevine genotype under field conditions. Two years old grapevine cuttings of the autochthonous grape cultivar, Olaszrizling were grown in pots in a natural environment and horizontally trained vines were covered by filters to modify the spectral composition of light reaching the leaves surface. Leaves under UV-B deprived sunlight had lower UV-absorbent capacities than controls kept under UV transparent cellulose-diacetate and the two light conditions also resulted in small differences in leaf metabolites and antioxidant capacities. In agreement with this observation biosynthetic and regulatory genes of the flavonoid pathway showed altered expression pattern. Our results show that, similarly to other species, a coordinated regulation of the flavonoid pathway is necessary for the avoidance of light stress and successful acclimation to UV and also indicate genotype specific differences. Therefore, further characterization of local varieties may help growers exploiting the genetic capacity of autochthonous cultivars.

Acknowledgement
Supported by the Hungarian Scientific Research Fund (OTKA K-101430).

Brigitta É. Végh is a PhD student in the 2nd year at University of Pécs, Faculty of Sciences, Institute of Biology, Department of Plant Biology. Her main research area is the investigation of grapevine responses to UV-B stress, including examination of genes involved in antioxidant and developmental responses to UV and high light exposure. Her supervisor is Professor Gábor Jakab.

Changes in grapevine leaf phenolics and antioxidants in response to a decrease in solar UV – *in situ* experiments with UV filters in the vineyard

Csepregi, K.*, Czégény, G. , Hideg, É.

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Our study is part of a research program aimed at the acclimation of grapevine leaves to sunlight. A plastic filter was used to reduce solar UV radiation and a UV transparent cellulose diacetate filter as control. Both were >90% transparent to PAR, but leaves under the plastic filter experienced only 15% of 315-400 nm UV-A and 55% of 290-315 nm UV-B as compared to controls. Adaxial sides of individual grapevine (*Vitis vinifera*, conc. Gohér) leaves on the East side of an East/West oriented vineyard were covered with the filters during August 2013. UV-minus leaves (under the partially UV filtering plastic foil) and UV-plus leaves (under the more UV transparent cellulose diacetate) were compared after 21 days. UV-plus leaves featured 10% lower Fv/Fm and more non-photochemical quenching than UV-minus leaves, indicating that ambient UV in the vineyard in combination with high (1900-2000 µmol m^{-2} s^{-1} maximum) PAR was stressing the leaves to some extent. Differences in antioxidant capacities and phenolic contents emphasize the role of these compounds in acclimation to solar UV.

Acknowledgement

This research was realized in the frames of TÁMOP 4.2.4. A/2-11-1-2012-0001 „National Excellence Program – Elaborating and operating an inland student and researcher personal support system". The project was subsidized by the European Union and co-financed by the European Social Fund. Experiments were supported by Hungarian Scientific Research Fund (OTKA K-101430).

My name is Kristóf Csepregi, I am 3rd year PhD student at the University of Pécs. In my PhD work I examine the adaptation of grapevine leaves to natural sunlight and the role of polyphenols in this process. In addition to phytochemistry we measure antioxidant capacities. I study various Hungarian cultivars and also participate in the trans-European grapevine experiment within COST UV4growth.

Role of apoplastic GGT1 in plant's response to UV-B radiation*

Trentin, A.R.[1], Pivato, M.[1], Ebinezer, L.B.[1], Giaretta, S.[1]Prasad, D.[2], Fabrega-Prats, M.[1], Masi, A.[1]

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In *Arabidopsis thaliana*, γ-glutamyl tranferase1 (GGT1)-an apoplast localized protein is a crucial enzyme in GSH catabolism in the intercellular spaces. UV-B radiation has several detrimental effects on plant's metabolism, with plasma membrane being the most damaged due to this oxidative stress. Ascorbate and GSH are two widely studied non-protein anti-oxidants with crucial roles in scavenging ROS species and in turn alleviating oxidative stress. We investigated the levels and redox states of these antioxidants in total leaf and apoplast extracts from both the genotypes in response to a 8^{h} UV-B irradiation. Upon UV-B irradiation, ascorbate was accumulated irrespective of the genotypes both in total leaf extracts and apoplastic fluids. Reduced ascorbate was always detected in total leaf extracts, while its oxidized form was exclusively detected in the apoplast extracts. GSH content was constitutively higher in total leaf extract of ggt1- mutant in contrast to wt, indicating an impaired GSH degradation pathway in the mutant. However, in the apoplastic fluids, GSH accumulated only in response to UV-B radiation indicating its role in maintaining redox balance in the intercellular spaces. Recent proteomic investigation evidenced a constitutive up-regulation of proteins related with antioxidants defense and stress response in leaves of ggt1- knockout mutants. In conjunction with these observations, we speculate that ggt1- mutants have an impaired GSH degradation pathway, which renders the plant incompetent to adapt to such oxidative stress. This highlights that GGT1 has several crucial roles in redox signalling and scavenging free radicals generated due to oxidative stress.

Antonio Masi, Ph.D., Assistant Professor
PhD in Photobiology in 1996 at the University of Padova; he carried out research in the field of Plant Physiology, in Bern (Switzerland), UC Berkeley (USA), Cornell University (Ithaca-NY, USA).
He has been involved in the following research areas: effects of UV-B radiation in crops; plant sulphur metabolism; oxidative stress and antioxidants in plants; comparative plant proteomics; functional genomics studies on the significance of glutathione metabolism in plants, by means of Arabidopsis mutant lines.

Development of trans-European wine-leaf experiment (Grapevine Ultraviolet Network)

Organizers: Schödl-Hummel, K. (local), Hideg, É. (scientific)
20 participants from 8 COST participating countries

University of Natural Resources and Life Sciences Vienna (BOKU)
Tulln, Austria, October 28-30, 2013

Grapevine Ultraviolet Network (GUN) uses the unique potential of COST Action UV4growth and unites European vine research laboratories engaged in UV-related topics. In 2012, we collected Pinot Noir grapevine leaves from 5 sites in 5 countries and these samples were analyzed in participating laboratories for metabolite contents including flavonoid-glycosides, phenolic acids, tocopherols and carotenoids; as well as for antioxidant capacities and UV absorbing properties. These studies were completed during 2013 and results were discussed at our meeting in Tulln. As preliminary analyses, correlations were sought between local meteorological parameters (with special emphasis on but not restricted to solar UV conditions) and metabolites. To expand this study, leaves and berry skins were collected from 11 locations (5 identical with the ones used in 2012 and 6 new sites) in 8 countries during the summer of 2013. Leaf studies were complemented with on site photosynthesis measurements and morphological studies. Leaf extracts from this second collection are being analyzed to confirm and possibly extend results based on the 2012 experiment. Leaf and berry skin results are reported at this meeting (see abstracts by Susanne Neugart and Encarnacion Núñez-Olivera, respectively) and will also appear in a joint journal publication. GUN members also wrote a popular science text on positive, exploitable effects of UV-B in vineyards which is being translated into six languages for publications in national journals.

Reported by: Éva Hideg, ehideg@gamma.ttk.pte.hu, University of Pécs, Hungary

Organismal responses to UV-B radiation (WG3)

UV-B organismal effects in a context of global change: facts and faces

Martínez Abaigar, J.

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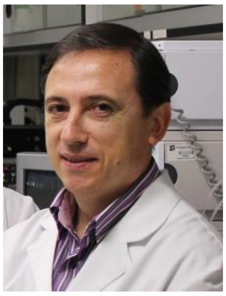
Much work has been done in recent years with respect to the effects of UV-B radiation on photosynthetic organisms, from unicellular algae to flowering plants. Mechanistic organismal responses affecting morphology, architecture, DNA integrity, gene expression, photosynthesis, secondary metabolites, oxidative processes, etc., are considerably well-known and should be put in the context of the new perception of UV-B as a regulation factor triggering a global physiological response in the plant rather than a univocal stressor. Starting from this perspective, some gaps and new challenges for the most immediate future will be identified. In particular, we must develop new strategies to face the assessment of field realistic studies (conducted especially in zones either exposed to strong ozone reduction or naturally receiving high UV-B irradiances), biotic interactions, ecosystem effects and new environmental situations resulting from the (still uncertain) interaction of global changes affecting not only UV-B itself but also temperature, cloudiness, N deposition, etc. In addition, innovative applied aspects of UV-B exposure and manipulation must arise from the basic knowledge accumulated. International collaborative, rather than competitive, research will be essential to succeed in these exciting challenges.



Javier Martínez Abaigar
Graduated and gained PhD in Biology (Universidad de Navarra), assistant professor (Universidad de Navarra, 1985-88), associate professor (Universidad de Zaragoza, 1988-92) and permanent professor (Universidad de La Rioja, 1992-present). Professor (Catedrático) of Botany at the Universidad de La Rioja since 2009. My research is focused on: 1) the ecophysiology of bryophytes (mosses, liverworts and hornworts) and grapevine in relation to UV radiation; and 2) the use of mosses as pollution biomonitors. 26 peer-reviewed papers on UV. Past president of the Spanish Bryological Society.

Effects of UV-B radiation on plant morphology; from generic stress to specific regulation

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UV-B induced morphological responses are commonly reported, but major questions remain concerning the phenotype, regulatory mechanisms, possible function and consequences for fitness. UV-induced changes include thicker leaves, shorter petioles and stems, increased axillary branching and altered root-shoot ratio. It is likely that these morphological changes are underpinned by more than one mechanism; at low UV-B doses through an UVR8 mediated response, and at high UV-B doses through a generic stress-induced morphogenic response (SIMR). Various hypotheses have focussed on the protective function of UV-induced morphogenesis, proposing shading and decreased leaf penetration of UV-B. However, these ideas remain largely unproven, while not giving weight to potential trade-offs in photosynthetic light capture and changed plant competitive abilities. UV-B effects on plant morphology need to be re-appraised in the context of both their function and ecological consequences. To facilitate this, future research will need to disentangle the seemingly contradictory interactions that occur at the threshold UV dose where regulation and stress-induced morphogenesis overlap and where responses may, or may not, have a functional role and/or fitness cost.

Marcel Jansen is a plant-ecophysiologist with interests in the functional plasticity of plants under stress, including UV-B, organic pollutants and nano-materials. Research centres on elucidating the molecular-physiological mechanisms underlying adaptation and acclimation responses of plants. UV-B research centres on the mechanism, and ecological role of UV-B induced morphogenic changes, including possible trade-offs in terms of plant fitness, and horticultural applications. Marcel chairs the COST Action UV4Growth.

Messages go against the phloem: Ramets use UV-B to signal pre-emptive activation of photoprotection in their parents

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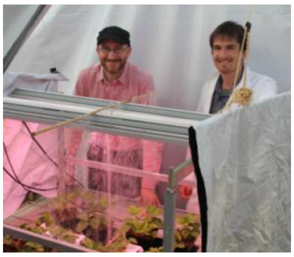
Plants obtain information from the light environment around them and use it to make decisions about where to grow and how to optimise their photoprotection. The spectral quality of sunlight changes under plant canopies with location and time of year. These changes are perceived by understorey species. We utilised coloured spectra generated by specially designed LEDs (Valoya Oy) in combination with fluorescent UV-B tubes to test the response of strawberry (*Fragaria vesca*) plants and their ramets to different greenhouse light environments. We determined how the UV-B protective mechanisms between the mother plants and ramets are regulated; and how the spectral composition of PAR and UVB affects plant morphology and metabolism, to estimate the ecological impact of this factor in nature. Ramets seem to be used as pioneers by parent plants relaying back information about their surroundings! Parent plants growing in no-UV with their ramet in UV has similar epidermal phenolic content to plants with both parent & ramet in UV, but more phenolic compounds than plants grown entirely under no-UV: evidence that a signal is transduced from ramets to plants. This finding is particularly interesting given that the flow of water and assimilates would mostly go in the opposite direction to the signal.

Acknowledgement
This work is supported by the Czech Institute of environmental technologies (J.N., J.K.), CZ.1.05/2.1.00/03.0100, the European Social Fund and the State Budget of the Czech Republic Grant OPVK BioNetwork (J.N.), CZ.1.07/2.4.00/31.0025 and by University of Ostrava - SGS/2014 (J.N., Z.M.), and by Academy of Finland Research Fellowship decision no. 266523 (T.M.R.). We thank Saara M. Hartikainen and Pedro J. Aphalo for their help and advice.



Jakub Nezval is an early stage researcher in the final stages of his PhD at the University of Ostrava. He specialises in photochemistry and photobiology and his major research focus is the effect of UV radiation and high light on photosynthetic pigments and secondary metabolism in crop plants. This presentation is the outcome of a collaborative exchange study visit to Helsinki University in summer 2013 to investigate light induced signalling.

Epidermal UV screening outdoors is regulated by solar blue light

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Both visible light and UV radiation have been shown to affect phenolic compound synthesis and accumulation in plants. Here we demonstrate that solar blue light stimulates epidermal flavonoid biosynthesis in the absence of solar UV radiation. We grew lettuce (*Lactuca sativa* cv. Lollo Rosso “Revolution”) outdoors, in Finland, under six types of filters differing in their spectral transmittance. These filters were used to 1: attenuate UV-B and green; 2: attenuate UV-B and UV-A; 3: attenuate UV-B, UV-A and blue light; 4: attenuate UV-B, UV-A, blue and red (shade conditions); and **5**: as a near ambient control not attenuating any of these wavebands. After 25 days growth, half of the seedlings under each treatment were moved to full sunlight for 8 days. Attenuation of blue light significantly reduced the content of flavonoids in leaf adaxial epidermis. This reduction was significant also after 2 days and had almost disappeared after 8 days exposure to full sunlight. Effect of UV radiation on epidermal flavonoids was not observed. Plant growth was slower under UV and shade conditions. These results show that solar blue light is likely the main regulator of phenolic compound synthesis and accumulation, whereas growth is affected by high UV or low PAR conditions in lettuce plants that germinate and develop outdoors in Finland.

References

Ibdah M, Krins A, Seidlitz HK, Heller W, Strack D, Vogt T (2002) Plant Cell Environ. 25,1145–1154.

Götz M, Albert A, Stich S, Heller W, Scherb H, Krins A, Langebartels C, Seidlitz HK, Ernst D (2010) Protoplasma 243, 95-103.

Morales LO, Tegelberg R, Brosché M, Keinänen M, Lindfors A, Aphalo PJ (2010) Tree Phys. 30, 923-934.

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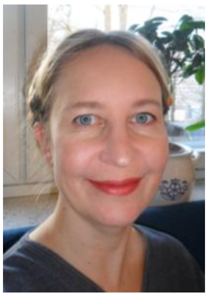

Sari Siipola studied in Lapland as an artisan in traditional Sami handcrafts. Later she studied environmental sciences in the University of Helsinki and eventually changed her major to plant biology. Her minor was scientific communication. Sari Siipola graduated from her master studies in 2011 and continued with her PhD studies in the beginning of 2012. Her research covers effects of different light conditions and UV radiation on plant physiology, growth and morphology.

Aphid and whitefly performance is directly affected by UV radiation on horticultural crops

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It is widely known that UV radiation directly plays a major role on insect fitness and indirectly affects their success via changes in plant chemistry (Vänninen et al. 2010). In this study, we hypothesize that UV is central to the trophic relationships between the two key pests *Myzus persicae* and *Bemisia tabaci* and their hosts pepper and eggplant. Crops were grown from seed in the presence and absence of UV radiation to target and understand how it influences insect success via population growth. At a 10- and 4-true leaf stage for peppers and eggplants, respectively, plants were infested by aphids and whiteflies. Insect pre-reproductive period, offspring and growth rates were calculated as well as host plant chemistry. UV exposure increased aphid population growth in parallel to pepper leaf proteins and amino acid content. Conversely, for eggplants and whitefly, UV radiation had negative effects on insect performance with longer pre-reproductive period and a lower larval number. Our results demonstrate species-specific responses highlighting direct negative effects on whitefly and indirect positive effects of UV radiation on aphids via plant chemistry.

References

Vänninen I, Pinto DM, Nissinen AI, Johansen NS, Shipp L (2010) Ann. App. Biol. 157, 393-414.

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Alberto Fereres, born 1959. Professor of the Spanish Research Council (CSIC) at ICA-CSIC, Madrid, Spain. MSc, Purdue University, Indiana, USA (1989). Doctorate in Agricultural Engineering, Polytechnic University (1988). Post-doctoral visiting scientist at University of California, Riverside (1989). Published more than 140 scientific papers and 20 book chapters on biology and ecology of aphids, aphid-virus-plant interactions, insect probing and feeding behavior, host plant resistence to insects and pest management of insect vectors of plant diseases.

UV4quality: UV radiation as a tool for improving crop quality

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[3] Copenhagen University, Department of Plant and Environmental Sciences, Højbakkegård Allé 9, DK-2630 Taastrup, Denmark

In the north, vegetables are produced in greenhouses under light limiting conditions. Under such conditions, plants tend to be stragglier (Valladares and Niinemets 2008) and contain low levels of phytochemicals (Jansen et al, 2008). As a consequence, sturdiness, flavour and odour of produce are often sub-optimal. UV radiation can compensate for morphogenic and metabolic consequences (Schreiner et al. 2012) of low light levels and supplementary UV may be used for this purpose in commercial production. Together with two horticultural companies, we use UV lamps to increase phytochemical content and increase sturdiness of seedlings. The anticipated outcome is an increased quality of the produce. At the same time, we obtain scientific information about the functioning of plant UV photobiology. We primarily analyse UV-treated plants for growth parameters and phytochemical content, generating data on trade-offs between growth, stress and acclimation. We also analyse UV-treated plants for morphological changes to understand fundamental aspects of growth regulation. The research will lead to increased quality in greenhouse crops, improving taste and odour, and sturdiness and resistance towards handling and transport.

References

Jansen MAK, Hectors K, O'Brien NM, Guisez Y, Potters G (2008) Plant Sci. 175, 449-458.
Schreiner M, Mewis I, Huyskens-Keil S, Jansen MAK, Zrenner R, Winkler JB, O'Brien N, Krumbein A (2012) Crit. Rev. Plant Sci. 31, 229-240.
Valladares et al. (2008) Annu. Rev. Ecol. Evol. Syst. 39, 237-257.

Acknowledgement

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Irina Kalbina
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Involvement of gibberellin in UV-B-induced responses and control of flavonoid content in pea

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A daily period of temperature drop is commonly used to control shoot elongation in northern greenhouse industry to reduce the use of plant growth retardants. Since this is not sufficient in warmer periods, exposure to UV-B in addition to temperature drop is of considerable interest. Generally, interactive effects of UV-B and temperature are not well understood. The present study aimed to shed light on the role of gibberellins in interactive UV-B-temperature effects using pea as a model plant. UV-B alone or in combination with temperature drop reduced the levels of active GA_1, and the combined treatment was highly efficient in reducing elongation growth. The *GA3-oxidase-1* mutant *le* was less sensitive to UV-B-induced damage than the wild type (WT). Also, both WT and *le* were less sensitive to damage when UV-B was provided together with diurnal temperature drop. The *le* mutant had higher levels of specific flavonoids than the WT, but there were no consistent differences in flavonoid contents between plants subjected to UV-B only and when combined with temperature drop. After UV-B exposure less cyclobutane pyrimidine dimers (CPD) were present in *le* than in the WT, and in both genotypes temperature drop reduced the UV-B-induced CPD formation. In conclusion, GA appears to play a role in UV-B-induced responses and control of flavonoid content in pea.

Jorunn E. Olsen is professor of plant physiology at Department of Plant and Environmental Sciences at the Norwegian University of Life Sciences. Her main area of interest is plant developmental physiology with respect to climatic responses, emphasizing light and temperature sensing and signaling. The main processes studied in recent years have been thermoperiodic control of shoot elongation in herbaceous model plants and control of bud dormancy-related processes in trees. Currently also interactive effects of UV-B and temperature on plant morphology are investigated.

Response of two species of buckwheat to combination of UV radiation and selenium

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[2] Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenija

The impact of UV radiation and the addition of selenium (Se) on Tartary and hybrid buckwheat was investigated. We also examined a distribution and speciation of Se in both species. Experimental plants were exposed outdoors to four treatments regarding the quantity of UV radiation (ambient or reduced) and added Se (naturally accessible or foliary treated with Na selenate). The content of pigments and UV absorbing compounds, transpiration rate, photochemical efficiency of PS II, respiratory potential and the biomass of plant parts were measured. Irrespective of the buckwheat species UV radiation reduced the transpiration rate and respiratory potential, while it increased the potential quantum yield of PS II and the content of anthocyanins. Added Se lowered the content of chlorophyll *a* and carotenoids and also reduced the potential quantum yield of PS II, while it increased the effective quantum yield of PS II and transpiration rate. The added Se alleviated negative effects caused by UV radiation since it increased transpiration rate. UV radiation had positive impact on Tartary buckwheat while it had a negative impact on hybrid buckwheat. Content of Se in seeds of Se-treated plants were at least 15 fold higher comparing to non treated ones.

References

Breznik B, Germ M, Gaberščik A, Kreft I (2005) Photosynthetica 43, 583-589

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Aleksandra Golob graduated at the Biotechnical Faculty, University of Ljubljana in 2011. Since November 2011, working as a young researcher at the Department of Biology, Biotechnical Faculty, University of Ljubljana, under the supervision of Asst. Prof. Dr. Mateja Germ. Her research objectives are to evaluate the impact of UV radiation on biochemical, physiological and morphological responses of various crops.

Prickle hairs enhance reflectance of UV radiation in graminoids

Klančnik, K.[1,*], Vogel-Mikuš, K.[1], Kump, P.[2], Vavpetič, P.[2], Pelicon, P.[2], Gianoncelli, A.[3], Jezeršek, D.[3], Gaberščik, A.[1]

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In graminoid plant species silicon (Si) substitutes carbon as a structural element, affects water and energy balance and mitigates stress by binding and co-precipitating metal ions. In the present study we investigated the role of silicified structures in reflecting UV radiation in species *Phragmites australis*, *Phalaris arundinacea*, *Molinia caerulea*, *Deschampsia cespitosa* and *Carex elata*. We examined the total amount of Si and silica phytoliths contents, biochemical and morphological leaf properties and measured reflectance spectra. In addition localization of silicon at tissue and cellular levels was performed by micro-PIXE and by LEXRF element distribution mapping. The results of the mapping showed that the majority of Si is concentrated in the epidermal layer including prickle hairs. In the latter in some plant species Si was co-localised with aluminium. Redundancy analysis showed that the length of prickle hairs explained up to 66% of variability of the reflectance spectra in the UV range. We conclude that the length of prickle hairs significantly contributes to UV-radiation balance in graminoids.

References

Björn LO, Li S (2011) App. Phys. Lett. 99, 024104.
Klančnik K, Vogel-Mikuš K, Gaberščik A (2014) J. Photochem. Photobiol., B Biol. 130, 1–10.

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Katja Klančnik graduated in Biology at Biotechnical Faculty in 2009. Since 2010 she is a PhD student at the University of Ljubljana in the program Biology of Plants. Under the supervision of Dr. Alenka Gaberščik, Katja's current research is mainly focussed on understanding leaf optical properties in relation to different leaf or stand traits.

Response of phenolic compounds and xanthophylls in barley leaves to different spectral composition of photosynthetically active radiation and its relation to efficiency of photoprotective processes

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Recently, it was found that, in addition to high PAR level (HI), blue light can stimulate accumulation of both phenolic compounds and photoprotective carotenoids. However, particularly the information on impact of blue light on composition of phenolic compounds and efficiency of photoprotective processes mediated by both carotenoids and phenolics is scarce. Therefore, composition of soluble leaf phenolics and photosynthetic pigments was examined in leaves of barley grown under blue (450 nm; B), red (640 nm; R) and green (530 nm; G) and white light (W) at PPFD 240 µmol m^{-2} s^{-1}. As expected B plants revealed pronouncedly higher content of phenolic compounds as compared to R and G plants. However, extent of B-light induced stimulation of specific phenolic acids and flavonoids differed from response to HI. The efficiency of UV-shielding was higher in B plants as compared to R and G ones, but to less extent than expected on the basis of phenolics analyses. B plants revealed a higher content of xanthophyll cycle pigments together with reduced content of lutein, but a half efficiency of light-induced thermal energy dissipation in comparison with R plants. The role of observed B-light induced accumulation of phenolic compounds and xanthophyll cycle pigments will be discussed.

References

Agati G, Tattini M (2010) New Phytologist 186, 786-793.
Jenkins GI, Long JC, Wade HK, Shenton MR, Bibikova TN (2001) New Phytologist 151, 121-131.
Schellenberger-Costa B, Jungandreas A, Jakob T, Weisheit W, Mittag M, Wilhelm CH (2013) J. Exp. Bot. 64, 483–493.

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Vladimír Špunda is a member of Physics Department, Faculty of Science, University of Ostrava since 1991. He is a guarantee of Biophysics Programme at the Faculty. Vladimír´s long-term research interests are chlorophyll *a* fluorescence in photosynthesis research, biophysical plant ecophysiology, acclimation of photosynthetic apparatus of higher plants to environmental factors (radiation and its spectral composition, temperature, CO_2 concentration), application of optical spectroscopy techniques for studies of organization of photosynthetic apparatus.

UV-B and water availability interact to shape flavonoid profiles through transcriptional regulation

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Previous research showed a great influence of UV-B on grape composition. The aim of this study was to characterize the effects of the interaction between UV-B radiation and water deficit, framed within the predicted climate change scenario, on flavonoid biosynthesis and grape quality. Fruit bearing cuttings were exposed to 0, 5.98 and 9.66 kJ m^{-2} day^{-1} of supplemental biologically effective UV-B radiation and subjected to two water regimes (well watered and cyclic drought), under glasshouse-controlled conditions. UV-B increased flavonoid biosynthesis and strongly modified the spectrum of flavonols. Water deficit did not affect total skin flavonoid concentration, but increased the amount of 3'4'5' substituted and methylated flavonoids. A clear interaction between UV-B and water deficit was observed in the concentration of 3' methylated flavonols at maturity. Concomitantly, gene expression was up-regulated in key steps (*FLS1* and *UFGT*) by UV-B, leading to increased anthocyanin and flavonol skin content. Changes in flavonoid composition were explained to a large extent by the transcript levels of *F3'H*, *F3'5'H* and *OMT2*. This study contributes to improve our knowledge of the processes leading to the constitution of fruit flavonoid profiles shaped by environmental conditions, which may have a positive impact on fruit composition.

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Johann Martínez-Lüscher is graduated in Biology at the University of Navarra (Spain) and obtained his M.S. degree at the University of Southern Denmark. At the moment he is in his last year of PhD Thesis at the University of Navarra (Spain) and the University of Bordeaux (France), focused on the effect of UV-B in interaction with climate change factors on grapevine photosynthetic performance and grape quality. Part of his recent research has been performend at the Institute of Grapevine and Wine Sciences (ISVV) in Bordeaux. His major research interest is the assesment of the impact of climate change factors on grapevine using multidisciplinary aproaches.

Targets of UV-B irradiation on the photosynthetic performance in *Oryza sativa* L.

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Considering the importance of rice as a key worldwide staple food crop, the UV-B targets in the photosynthetic metabolism were investigated. *Oryza sativa* L. cv. Safari plants were submitted to UV-B irradiation (1 h per day, between 8 and 14 days after germination, with a ten narrow-band, λ 311 nm) that resulted in a total biological effective UV-B (UVB_{BE}) of 2.975 kJ m^{-2} day^{-1}. One day after the end of the UV-B treatment, reductions higher than 80% in net photosynthesis (P_n), stomatal conductance (g_s) and photosynthetic capacity were found. Furthermore, several fluorescence parameters (F_o, F_v/F_m, $F_{v'}/F_{m'}$, ϕ_e, q_P and q_E) and the thylakoid electron transport were also severely depressed, whereas the de-epoxidation state of xanthophylls and the lipoperoxidation of chloroplast membranes were increased. Notably, the leaves developed after the end of irradiation showed a much smaller impact for all these physiological parameters. The results showed a global impact of UV-B in the photosynthetic performance in irradiated leaves, but revealed also a low impairment extent in the leaves entirely developed after the end of the irradiation, reflecting a remarkable recovery capability of the plant, what could constitute an advantage under occasional UV-B exposure events.

References

Ramalho, JC, Lidon FC (2011) J. Photochem. Photobiol. B: Biology 104, 457–466.
Lidon, FC, Ramalho JC (2011) J. Agronomy and Crop Science 198/2, 130-144.
Lidon, FC, Reboredo, FH, Leitão, AE, Silva, MMA, Duarte MP, Ramalho (2012) Emirates J. Food Agriculture 24/6, 546-556.

Fernando C. Lidon
Prof. of Faculty of Sciences and Technology (FCT), New Univ. of Lisbon (UNL), Portugal since 1988. Graduated from Univ. of Évora (Biology, 1984) and Faculty of Sciences of the Univ. of Lisbon (Biochemistry, 1988), Ph.D. (UNL, 1994 and ECE-Wisconsin/USA, 1998), Aggregated Prof. by the Univ. of Evora (2013). Author of more than 150 peer reviewed publications and 7 books. Currently supervises 12 M.Sc., 2 Pos-doc and 4 PhD students at the FCT/UNL. Present research topics include: Food phytotechnology linking plant responses to oxidative stress and acclimation to solar UV radiation.

The UVR8 response to daylight

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UV-B light can be both a photomorphogenic trigger changing gene expression, growth response and chemical composition of the cell and a stress signal to plants. Therefore it is vital that plants are able to respond appropriately to UV-B light. UV RESISTANCE LOCUS8 (UVR8) is the only known UV-B photoreceptor in plants. UVR8 can respond to very low fluence rates of UV-B light and once UV-B is absorbed by UVR8 transcriptional responses are triggered, which not only provides the plant with a degree of protection from the damage ultraviolet light can cause but also plays a photomorphogenic role. Controlled environment rooms differ significantly from the natural environment. When constructing a model for the mechanism of UVR8 action it is important to consider how UVR8 functions in a natural solar environment, when exposed to a range of temperatures, photosynthetically active radiation (PAR) and UV-B light. Data will be presented on the conversion of UVR8 dimer to the active monomer in natural daylight.

Kirsten Findlay obtained her BSc (Hons) from The University of Edinburgh in 2011. She is currently a PhD student under the supervision of Prof. Gareth Jenkins at the University of Glasgow. Her research includes work on both the structural properties and environmental action of the UV-B photoreceptor UVR8.

Response of pepper plants (*Capsicum annuum* L.) to step-changes in their UV environment

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This study focuses on responses of pepper plants to step changes in their UV environments and the underlying mechanism of such responses. Initial propagation of lettuce seedling under high UV environment expressed exploitable benefits in later growth (Elfadly et al. 2012). Similar responses were observed here with pepper plants under field and controlled environments. Films that are transparent to UV radiation may be desirable for improving crop quality (Tsormpatsidis et al. 2010). In the field studies, plants were propagated under either UV transparent or blocking films and then switched to the other environment in the cropping stage. Crop yield was increased in UVT/UVO plants. Under CE experiments, plants showed rather unexpected responses to transient UV-B exposure in cell division that has long term consequences for leaf expansion. UV+/ UV- plants showed progressive leaf growth which is novel and surprising and interestingly, is consistent with leafy crop (Wargent et al. 2011). Mechanistically, there was a significant correlation between change in epidermal cell number and leaf area of UV+/UV- plants compared with UV-/UV- which shows the systemic effect of early exposure to UV-B on meristematic tissues that are not directly exposed to incident radiation.

I am Eslam Elfadly, lecturer of Horticulture at Alexandria University, Egypt. I gained my PhD from Lancaster University, UK with focus on protected cropping under state-of-the-art spectral filters on aspects of commercial production of pepper and lettuce under hot climates as well as the underlying mechanisms of plant responses to UV-B radiation. Currently, I am a visiting researcher at Lancaster Environment Centre, Lancaster University, UK with an interest of investigate the physiological responses to UV radiation and leaf structure on model crop species.

Ecophysiological consequences of UV-B radiation and ozone on Brassicaceae – Role of UV-B reception on plant resistance traits

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UV-B mediated changes on secondary metabolites in Brassicaceae were investigated along with consequences for plant resistance against insects and pathogens in comparison to ozone. In our first experiments with *Brassica oleracea* var. *italica* (broccoli) and *Arabidopsis thaliana* we found that ecological relevant low to moderate UV-B doses elicited especially the accumulation of 4-methoxy-indol-3-ylmethyl glucosinolate, 4-methylsulfinylbutyl glucosinolate, and camalexin. Contrary to the observed accumulation of defense metabolites and mostly increased resistance against insects, pre-exposure of A. thaliana and broccoli to 1 – 2 kJ m^{-2} d^{-1} UV-B resulted in a higher susceptibility to infection with *Alternaria brassicicola* and *Botrytis cinerea*. The UV-B mediated effects were further investigated by including the *A. thaliana* mutants uvr8-6, Ari12-2, and ncbpc. Ozone in different concentration as a second ROS inducing factor was included in the study to evaluate effects on secondary metabolite accumulation. Consequences of UV-B and ozone application on the performance of *Spodoptera exigua* and *B. cinerea* will be presented in the light of UV-B reception.

Inga Mewis received her diploma and PhD. from Free University Berlin, Germany and was external working at Technical University Munich and Central Luzon State University, Philippines. After her postdoctoral fellowship at Pennsylvania State University, USA, she worked as research associate and lecturer at Humboldt-University Berlin, Germany. Now she is working in the Department of Quality at IGZ, Germany. Major research interests are secondary plant metabolites and how they mediate ecological interactions with herbivores, and how they are influenced by abiotic factors such as UV-B.

A foot in both camps: how does ivy optimise foraging when faced with contrasting UV-environments?

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Ivy (*Hedera helix*) is an understorey forest species with a conservative functional strategy. It responses very steadily to changes in its environment and keeps its leaves for several years. Consequently, decisions on where to grow have long term consequences for its success. We replicated the type of changes in light quality that ivy might encounter in the forest understorey by manipulating light in a greenhouse with coloured LEDs and UV-B tubes. Ivy runners were placed at the frontier between different UV environments and given the choice of growth direction towards or away from the UV environment. Ivy responded strongly over several weeks investing greater leaf area in the low UV environment and increased pigmentation in the adjacent leaves receiving UV. However, the response of leaves on stems with alternate leaves in UV and no-UV treatments differed from that of stems receiving all UV or no UV, indicating that signals were transferred and resources reallocated along those branches in a mixed light environment. These results help us understand how understorey plants like ivy forage for resources in the dynamic spectral environment of the forest understorey, where the UV to visible light changes both temporal and spatially.

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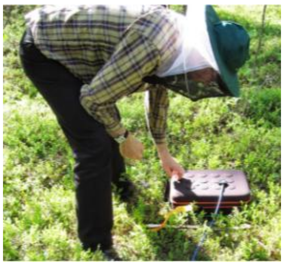

Matthew Robson is recently appointed Academy of Finland Research Fellow at Helsinki University, initiating the research group: Canopy Spectral Ecology and Ecophysiology (*Can*SEE). He has more than 15 years experience researching the effects of solar UV-B radiation on ecosystems throughout the world, obtaining his PhD guided by Martyn Caldwell in Utah. Matt's research aims to understand how signals from the solar spectrum are ultilised by organisms and scale to ecosystems.

Transcriptomic response of the aquatic plant *Elodea nuttallii* to mercury and ultraviolet radiation

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Enhanced UV radiation can have either negative or positive effects on plants: elements of plant metabolism can be damaged and oxidative stress can be generated. On the other hand exposure of plants to UV can induce defence mechanisms of plants which help them tolerate other stresses. Our project aims to investigate the influence of enhanced UV radiation on the response of the aquatic plant *E. nuttallii* to interacting stresses. In the present work we exposed *E. nuttallii* to UV (0.55 Wm^{-2} UVBE) for 6 h and to Hg for 24 h or to both for combined treatment. We analysed Hg content, oxidative stress response, effect on pigment content, as well as the transcriptome. UV radiation decreased Hg uptake in shoots as compared to plants exposed to Hg alone. Pigments tended to decrease in response to UV and Hg, and a cumulative effect of combined treatment was observed. Looking at oxidative stress enzymes, we observed an opposite effect of combined treatment: peroxidase activity was significantly decreased by UV and Hg treatments alone, whereas a combination of both abolished this effect. Results of RNA-Seq confirmed results obtained from analysis of pigments and stress response. In conclusion, we were able to show that UV exposure influences accumulation and tolerance to Hg.

Nicole Regier gained her PhD in plant biology from ETH Zurich in 2010. Her research interest currently focuses on heavy metal bioaccumulation mechanisms in aquatic ecosystems. She is using the recently developed high-throughput DNA sequencing tools to analyse the organismal responses on the gene level. One aspect of her work covers the investigation of the combined effects of multiple stressors including high UV radiation on aquatic plants.

The effects of UV radiation on arthropod pests: A review of publications from 2009 to 2013

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Insects and mites use optical cues for host finding and flight orientation. They often use UV radiation for take-off, orientation and navigation. Absence or reduced UVA often lead to lower infestation levels, slower dispersal rates and lower incidences of insect borne diseases. There are additional reports that covering crops with plastics or screens containing UV-blocking additives provides protection against pests and diseases compared to standard cladding materials. The attraction of insects to host plants and to traps was enhanced by moderate UV reflection. Direct exposure of arthropods to UVA often induces avoidance behaviour and elicits stress response. The preference of some pests to reside on the abaxial side of leaves or inside plant apex is to avoid solar UV among other factors. Direct exposure of arthropods to UVB also induces avoidance behaviour and is often damaging or lethal to some life stages. Solar UVB often elicits stress response in host plants, which indirectly reduce infestation by canopy arthropods. Jasmonate signaling plays a central role in the mechanisms by which solar UVB increases resistance to insect herbivores in the field. Thus, UV radiation affects the agroecosystems by complex interactions between multiple trophic levels.

David Ben-Yakir
Studied Entomology at the University of California in Davis and at the Oklahoma State University. Since 1989 I serve as a research entomologist at the Agricultural Research Organisation in Israel. I have collaborated with researchers and industries in developing novel, photo selective crops' covers. I demonstrated that whiteflies are repelled by reflective, UV-blocking nets, and appear to be "arrested" by yellow nets. I keep studying the visual and behavioral responses of pests to light and shapes with the aim of using optical manipulation as a component of IPM.

UV-B radiation alters interactions between photosynthesis and secondary metabolism in variegated *Plectranthus coleoides*

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This study is based on the results obtained from the experiments conducted within two Short Term Science Missions (STSMs) in the Research Unit Environmental Simulation, Helmholtz Zentrum München during 2011 and 2012. Our aim was to investigate the effects of realistic UV-B doses on photosynthesis and secondary metabolism in variegated leaves. Variegated *Plectranthus coleoides* plants were exposed to UV-B radiation (0.90 W m^{-2}) under two photosynthetic active radiation (PAR) intensities (LL: 395 and HL: 1350 µmol m^{-2} s^{-1}) for nine days in the sun simulators at the Helmholtz Zentrum München. In the green leaf portions, UV-B radiation stimulated photosynthetic rates in *P. coleoides* at both PAR intensities and doubled the size of plastoglobuli whereas the contents of photosynthetic pigments were slightly increased at HL. The concentrations of phenylpropanoids, catechins and hydroxybenzoic acids, were preferentially accumulated in green leaf portions, independently on radiation regimes. A hallmark of UV-B induced changes in plant metabolism, the induction of flavonoid pathway, was evidenced in *P. coleoides* by accumulation of apigenin and cyanidin glycosides in the whole leaf at both background PARs. UV-B induced accumulation of apigenin and cyanidin glycosides was more pronounced in the white leaf portions, compared to green one. Moreover, we observed differential response of H_2O_2 scavenging system to high PAR and UV-B in relation to tissue type. Alteration of linear electron flow, provoked by acclimation to UV-B at HL was associated with decreased ascorbate redox state and APX activity. In summary, UV-B radiation stimulated CO_2 assimilation and increased fixed carbon flow into photosynthetic pigments, phenylpropanoids and flavonoids/anthocyanins which might be important for photoprotection of photosynthetic machinery under high light intensity.

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Marija Vidović
2008: Graduated in Biochemistry, Faculty of Chemistry, University of Belgrade, Serbia 2008: PhD student in Biochemistry, Faculty of Chemistry; 2008–2010: Scholarship of Ministry of Science, Republic of Serbia; 2010: Research Assistant, Institute for Multidisciplinary Research, University of Belgrade, Serbia; 2008 (3 months): Research fellowship at Faculty of Agriculture, University of Padua, Italy 2011 and 2012 (2 months): two COST STSM grants, Helmholtz Zentrum München, Neuherberg, Germany 2012 (1 month): Institute of Plant Sciences, University of Graz, Austria.

Effects of covering materials differing in UV-transparency on the nutritional value of tomato grown in high tunnels

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UV radiation is considered to be stimulative for accumulation of secondary metabolites, especially flavonoids, terpenoids and vitamins, which increase nutritional and pharmacological value in vegetable crops (Jansen et al., 2008). However, in glasshouses and polytunnels widely used in agriculture most of UV radiation is excluded. Tomatoes (*Solanum lycopersicum*), high-value crop commonly grown in the polytunnels, were planted at three small farms in central Serbia using six commercially available plastic covering materials differing in the photosynthetic active radiation (PAR):UV-A:UV-B ratio. The aim of our work was to estimate the correlation of the level of flavonoids and vitamins accumulation in tomatoes with different UV-transmitting covering materials. The phenolic profile and carotenoid content from the tomato fruit, grown under different PAR:UV-A:UV-B ratio was compared. The content of epidermal flavonoids in the leaves of tomato was measured by a non-destructive real time method (Dualex 4 Scientific). The content of epidermal flavonoids increased up to 50% in plants grown under covering materials with higher UV-A and UV-B transparency levels while synergistic effects of PAR and UV radiation on flavonoid accumulation were observed.

References

Jansen MAK, Hectors K, O'Brien NM, Guisez Y, Potters G (2008) Plant Sci. 175, 449–458.

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This research was supported by the Ministry of Education and Science, Republic of Serbia (Project No. 43010 III).

Predrag Kolarž was born in 1971 in Belgrade; BSc degree obtained in 1998. and PhD in 2010, both at Faculty of Physics, Belgrade, Serbia.
Current position: Research assistant professor in the Laboratory for Atomic Collision Processes, Institute of Physics, Belgrade. Scientific work is based on measurement and analysis of ionizing and nonionizing radiation sources in the environment. Different techniques and types of radon and air ion measurements and also UV radiation are important points of interest through different projects.

Among- and within-genus variability of the UV-absorption capacity in saxicolous mosses

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We explored the influence of genus, species and environmental factors on the UV-absorption capacity and individual UV-absorbing compounds (UVAC) of 23 sun-exposed saxicolous mosses belonging to the genera *Andreaea*, *Grimmia* and *Racomitrium*, differentiating the soluble (SUVAC, mainly located in the vacuoles) and insoluble (WUVAC, bound to the cell wall) UVAC. We also calculated the total UV-absorbing compounds (TUVAC) and the ratio between WUVAC and SUVAC. All the physiological variables (SUVAC, WUVAC, TUVAC and WUVAC/SUVAC) were significantly affected by both the genus and the species, which clearly reflects the influence of genetics on the levels and compartmentation of (UVAC). This suggests that UVAC are strongly constitutive in the mosses studied. SUVAC was the physiological variable better correlated with environmental variables determining UV levels, such as altitude, latitude and slope, and thus it is a highly UV-responsive variable. In contrast, WUVAC was hardly correlated with environmental variables. However, *p*-coumaric acid, an individual compound extracted from the insoluble fraction of *Andreaea* samples, did show positive and significant correlations with both altitude and UV levels, which suggests its importance as UV biomarker.

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Laura Monforte has a degree in Environmental Sciences and currently is completing her PhD at the Universidad de La Rioja (Logroño, Spain). She is mainly interested in the effects of UV radiation on bryophytes (mainly mosses and liverworts) and other green organisms under an evolutionary perspective. In addition, she studies phenolic compounds which could serve as UV biomarkers in the field.

Molecular basis of plant response to UV-B radiation

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In the project we test an idea that induced mutagenesis due to unrepaired DNA lesions, here the UV-B photoproducts, is underlying UV-B impact on plant phenotype. We use recently described approach (Kamisugi et al. 2012) using moss *Physcomitrella patens* protonemata culture having 50 % of apical cells and thus mimicking actively growing tissue, the most vulnerable stage for induction of mutations. After UV-B irradiation we selected, isolated and analyzed by sequencing numerous clones (Holá et al. 2014) mutated in adenosine phosphotrasferase gene (APT) of various repair deficient background (pplig4, ppku70, pprad50, ppmre11). The mutagenic effect in these repair deficient lines will be finally related to number of UV-B photo adducts detected by comet assay. So far we participate in the project only 7 months, nevertheless we have already (end of November 2013) several surprising observations: notably UV-B is a very strong mutagen in all tested *Physcomitrella* lines when compared to previously studied ionizing radiation mimicking Bleomycin or alkylation mutagen MMS and all so far all identified mutations in exons are substitutions, no insertion, no deletions, even the short ones. We hope to complete the whole story by final UV4G meeting.

References

Kamisugi Y et al (2012) Nucl. Acids Res. 40(8), 3496-3510.
Holá M et al (2014) BioMed Research International (in press)

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Interactive effects of UV radiation and drought on the accumulation of phenolic compounds and photosynthesis in selected species of the mountain grassland ecosystem

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The aim of our experiment was to investigate the interactive effects of UV treatment and drought on the changes in accumulation of phenolic compounds and photosynthetic parameters in selected herb (*Hypericum maculatum*) and grass (*Agrostis tenuis*) of a mountain grassland ecosystem. The experimental plots were manipulated during the whole vegetation season using roof constructions enabling exclusion/transmission of incident precipitation and UV radiation, respectively. Based on *in vivo* fluorescence measurements, UV and drought treatments had a similar effect on the accumulation of UV-screening compounds. UV exclusion resulted in their slight reduction, particularly under ambient precipitations. The HPLC-MS analyses revealed that combined UV and drought increased particularly synthesis of sinapic acid in *A. tenuis*, while luteolin and quercetin were synthetised in *H. maculatum*. The presence of UV radiation reduced the negative effect of drought on light-saturated CO_2 assimilation rate (A_{max}). The reason of the alleviating effect of UV radiation on the response to drought stress is likely the increase in water use efficiency which was found in both species studied.

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Barbora Veselá received her M.Sc. in Systematic biology and ecology at the Masaryk University, Brno (CZ) and currently she's a PhD student at Mendel University in Brno. Her study is focused on drought stress and how spectral composition of light induces protective mechanisms in plants. She works in Laboratory of Plant Ecological Physiology of Global Change Research Centre Academy of Sciences of the Czech Republic.

Parallel factor analysis of fluorescence of epidermis and leaf extracts soluble of phenolics

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It is well known that UV-radiation or high level of photosynthetically active radiation considerably enhance accumulation of UV-absorbing phenolic compounds (PC) in epidermis that lead to increased efficiency of epidermal UV-shielding. Some groups of PC such as hydroxycinnamic and hydroxybenzoic acids are fluorescent and are responsible for the most epidermal blue-green fluorescence (BGF) in vivo (Morales et al. 1994). Therefore fluorescence spectroscopy as a sensitive and simple technique is useful tool for studying fluorescent PC both *in vivo* and *in vitro*. In this study we try to characterized epidermal (in vivo) and soluble free leaf PCs (*in vitro*) fluorescence with parallel factor analysis (PFA), which is used for analysis of simple mixtures in different science fields (Stedmon and Bro 2008). Detailed mapping of the fluorescence properties of PC fluorescence produced excitation emission matrices (EEMs), which are well suited for PFA. Using PFA sets of EEMs obtained from barley leaves grown under different light conditions several components fluorescing in blue-green and UV regions, with clearly different emission and excitation spectra, were distinguished. Same analysis were performed for 40 % methanol extracts of soluble leaf PCs and compared with HPLC analysis.

References

Morales F, Cerovic ZG, Moya I (1994). Biochim. Biophys. Acta, 106, 127–133.
Stedmon CA, Bro R (2008) Limnol. Oceanogr.: Methods 6, 572–579.

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Václav Karlický is an early stage researcher at the University of Ostrava. He specialises in biophysics and plant physiology and his major research focus is the effect of UV radiation and high light on photosynthetic apparatus using fluorescence spectroscopy.

UV-B irradiation impact on the chloroplast lamellae in *Oryza sativa* L.

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UV-B irradiation, although might prompt eustress, can also arrest plant growth, namely through photosynthesis inhibition. Following this assumption, UV-B specific targets in the chloroplast lamellae were investigated. *Oryza sativa* L. cv. Safari was UV-B irradiated (1 h per day, between 8 and 14 days after germination, with a ten narrow-band, ʎ 311 nm) resulting in a total biological effective UV-B of 2.975 kJ m^{-2} day^{-1}. One day after UV-B irradiation ending, the levels of isoprenoids and galactolipids diminished, while lipids peroxidation increased. Following grana disorganization, the levels of chloroplast polypeptides having 72/69, 69/65, 33/32, 28/26, 22/20 and 18/16 kDa decreased, but the proportion of the 49/46 kDa polypeptides increased. Yet, the chloroplast lamellae of leaves grown after UV-B exposure (at the 28th day) revealed a general recovery and a higher stacking of thylakoids, as confirmed by Transmition Electron Microscopy. The results showed a global impact in the thylakoid lipids matrix and protein patterns in UV-B irradiated leaves, but revealed a notable recovery of the photosynthetic apparatus in the leaves developed after plant irradiation ending, what could constitute an advantage under occasional UV-B exposure events.

References

Ramalho, JC, Lidon FC (2011) J. Photochem. Photobiol. B: Biology 104, 457–466.
Lidon, FC, Ramalho JC (2011) J. Agronomy and Crop Science 198/2, 130-144.
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Professor and director of the College of Education Almeida Garrett (ESEAG) COFAC / Lusophone University Group, Portugal, since 1997. Graduated from the Faculty of Sciences of the University of Lisbon (Chemistry, 1988), Ph.D. form University of Lisbon (Chemistry, 1996). Author of more than 57 peer reviewed publications and 3 books. Currently supervises students in undergraduate and M.Sc's courses in the areas of environment, food and health, chemistry, and teaching of experimental sciences. Present research topics include: Food technology linking plant responses to oxidative stress and acclimation to solar UV radiation.

Effect of shading, plastic cover, and UV-block on plant phenology and insects visiting *Lobularia maritima* L. Desv. (Cruciferae)

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The objectives of this study were to test the effect of shading, plastic cover, and UV-block on the phenology of *Lobularia maritima* L. Desv. (Cruciferae) and its visitation by insects. Four different cover treatments were compared: shading net on top of plastic transparent to UV, plastic transparent to UV, plastic opaque to UV, and no cover. Rectangular tunnels (57 cm high x 75 cm wide) were set up in rows following a North-South direction. Cover was provided on the top of the tunnel, on the top 35% of the eastern side of the tunnel, and on the top 61% of the western side of the tunnel. Each tunnel was 3 m long and covered a total of 13 plants of *L. maritima*, from which only the 5 middle plants were sampled. Each treatment was replicated 4 times. Plants were transplanted to the field on 15.10.2013, when more than 50% if the plants were flowering. Plant phenology was assessed on 31.10.2013, 20.11.2013, and 20.11.2013 by calculating the percentage of plants containing visible fruits. There were no differences in plant phenology among the plants under the different treatments. Insect sampling was conducted weekly over a period of 5 weeks (from 21.10.2013 to 20.11.2013). The insects sampled included *Aleyrodes proletella* L. (Hemiptera: Aleyrodidae), *Brevicoryne brassicae* L. (Hemiptera: Aphididae), *Chaetocnema tibialis* Illiger (Coleoptera: Chrysomelidae), *Empoasca* spp*.* (Hemiptera: Cicadellidae), *Lygus* spp*.* (Hemiptera: Miridae), *Pieris rapae* L. (Lepidoptera: Pieridae), *Trialeurodes vaporariorum* Westwood (Hemiptera: Aleyrodidae), *Phyllotreta variipennis* Boieldieu (Coleoptera: Chrysomelidae), an unidenfied alticinid species of beetle (Coleoptera: Chrysomelidae), and an unidentified species of thrips (Thysanoptera). Significant differences between treatments were found for *A. proletella* and *Empoasca* spp.. *A. proletella* was found in higher densities under the shading net on top of plastic transparent to UV treatment than under the other cover treatments, while *Empoasca* spp. was found in higher densities under the plastic transparent to UV treatment than under the other cover treatments. Our study shows that shading and plastic covers, including those made of UV-blocking material, could have different effects on insect densities depending on the insect species. This experiment will be repeated next spring when we expect additional insects to be available.

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Francisco Rubén Badenes Pérez was born in Xàtiva, Valencia, Spain. After studying Agricultural Sciences at the Universidad Politécnica de Valencia, he worked as a technician and as a social worker. He later studied Plant Protection and Pest Management at the University of California, Davis, focusing on monitoring and management of San Jose scale using reduced-risk insecticides and biological control. He continued his studies in Entomology at Cornell University, conducting his PhD research on trap cropping and diamondback moth. After conducting postdoctoral research for Cornell University and USDA, he worked as a group leader in Insect Ecology at the Max Planck Institute for Chemical Ecology. He now works as a scientist at the Institute of Agricultural Sciences in Madrid.

Effects of enhanced UV-B and temperature in growth of different genders and genotypes of *Populus tremula*

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The European aspen (*Populus tremula* L.) is a dioecious species and among the most widespread broadleaved trees throughout the Eurasian boreal and temperate forests. Often females of woody species have allocated more resouces to reproduction, while males have been more growth and maintenance oriented. Although the climate change is a major threat to woody species, there are only a few studies addressing the sensitivity of dimorphic species to combined levels of UVB and temperature interactions. In this experiment we examined whether six different genotypes and their sexes of *P. tremula* differ in their growth and pest susceptibility under different climate change scenarios in field conditions. We have established a modulated UV-B and temperature field in the Botanical Garden of the University of Eastern Finland. The natural solar UVB-radiation was enhanced by 31% and the temperature was enhanced by 1,5 C°. The length and basal diameter of the longest shoot of each plant was measured six times during the growing season. At the end of the growing season above ground biomass, leaf area, rust abundance and herbivore damages of the plants were measured. Our preliminary results showed that temperature increased aspen biomass, diameter, height and leaf area and there seems to be more differences between genotypes than between sexes. UVB is regarded to be as a stress factor, because it supressed the temperature-enhanced biomass increase, especially in females. Temperature decreased rust damages in both sexes and increased herbivore damages only in males, though clonal variation was moderate.

References

Cippollini ML, Wigham DF (1994) American Journal of Botany 81, 65-75.
Obeso JR (2002) New Phytologist 155(3), 321-348.
Xu X et al. (2010) Tree physiology 30(12), 1489-1498.

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Efficient PSII repair in the cyanobacterium Synechocystis PCC 6803 requires the cry-DASH cryptochrome*

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The decade long study of cry-DASH cryptochromes resulted in no conclusive function to which they could be associated. This indicates a protein with diverse roles. Since we showed that the homologue of the Synechocystis cry-DASH (Syn-CRY), a DNA photolyase, is involved in PSII repair, we examined whether Syn-CRY participates in the same process to some degree? We found that the absence of Syn-CRY renders the *Synechocystis* cells increasingly sensitive to not only UV-B but also high intensity PAR. However, unlike its homologue, Syn-CRY is not involved in UV-B damaged DNA repair, nor does it affect the transcription of genes, indispensable for PSII repair. Nevertheless, its lack does interfere with the accumulation of D1 protein, the structural backbone of PSII, as well as other, mostly cytoplasmic proteins, such as PilA1 and bicarbonate transporter SbtA. We concluded that Syn-CRY is required for efficient restoration of Photosystem II activity following UV-B and PAR induced photodamage. Its effect, unlike that of DNA photolyase, is not exerted through DNA repair, but most likely effects either D1 translation by inhibiting CO_2 transport and fixation, or PSII assembly through the putative involvement of PilA1 in Chl binding.

References

Vass IZ, Kós PB, Sass L, Nagy CI, Vass I (2013) Photochem. Photobiol. 89 384–390.
Takahashi S, Murata N (2006) Biochim. Biophys. Acta 1757 198–205.
He Q, Vermaas W (1999) Plant Mol. Biol. 39 1175–1188.

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István Zoltán Vass is a PhD student in the Molecular Stress- and Photobiology group of the Plant Biology Department, within the Biological Research Center of the Hungarian Academy, in Szeged, Hungary. He has been involved in studies regarding UV-B stress effects and the repair of the occuring damages, in cyanobacteria.

UV-B and climate change (WG4)

UV radiation as a modulator of plant defense and biogeochemical cycles

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UV radiation is a minor fraction of the daylight spectrum. Research efforts over the past three decades have thoroughly characterized the effects of the UV-B (280-315 nm) component. In this talk, I will address the following points. A) Whereas UV-B has modest effects on the growth of terrestrial plants, it is a strong positive modulator of plant immunity. The mechanisms that mediate this effect of UV-B are becoming increasingly well understood. Agricultural intensification, which involves increased planting density and canopy leaf area indexes, may lead to reduced plant exposure to the beneficial effects of UV-B radiation, resulting in reduced plant defenses against pest and diseases. B) Changes in UV resulting from changes in climate or land use may have more important consequences on terrestrial ecosystems than those derived from ozone depletion. This is because the resulting variations in UV may affect a greater range of ecosystems, and will not be restricted solely to the UV-B component. Several processes that are not very sensitive to UV-B can be strongly affected by UV-A radiation (315-400 nm). One example is the physical degradation of plant litter (photodegradation), which has important direct and indirect effects on carbon sequestration in terrestrial ecosystems.

References

Ballaré CL. 2014. Light regulation of plant defense. Annual Review of Plant Biology 65: doi: 10.1146/annurev-arplant-050213-40145.

Ballaré CL, Mazza CA, Austin AT, Pierik R. 2012. Canopy light and plant health. Plant Physiology 160, 145-55.

Austin AT, Ballaré CL. 2010. Dual role of lignin in plant litter decomposition in terrestrial ecosystems. Proceedings of the National Academy of Sciences of the United States of America 107, 4618-22.

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Changes in understorey plant phenology reflect the under-canopy light environment along a European forest gradient during bud burst

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During leaf flush in the spring, the spectral quality of light reaching forest understorey layers changes. Recent advances in the portability and accuracy of array spectroradiometers enable us to better characterise the natural light environment and to assess seasonal changes in the relationship between UV and visible light. We investigate whether UV-radiation is utilised by plants to signal changes in the light environment producing a regulatory photomorphogenic response: thereby studying the association between changes in irradiance and in the development, chlorophyll and flavonoid content of understorey plants. The growing season for forest trees starts later with increasing latitude along a north-south transect from Madrid to Finnish Lapland, meaning that late-emerging plants are subject to increasing visible and UV radiation doses and an increasing UV-B:visible ratio during the period of bud burst. This temporal increase in the relative UV-B received was correlated with increasing flavonoids in understorey plants in both a site- and species specific manner. This result improves our knowledge of light-signal perception and response in forest plants, and has implications for ecosystem processes particularly under climate-driven changes in phenology.

References

Augsperger CK, Chesseman JM, Salk CF. (2005) Light gains and physiological capacity of understorey woody plants during phenological avoidance of canopy shade. Functional Ecology 19, 537-546.

Brown MJ, Parker GG, Posner NE. (1994) A survey of ultraviolet-B radiation in forests. Journal of Ecology 82, 843-854.

Robson TM, Klem K, Urban O, Jansen MAK. (2013) Re-interpreting plant morphological responses to UV-B radiation. Submitted to Plant Cell and Environment UV special issue.

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Saara Hartikainen recently started her PhD in Plant Ecology at Helsinki University with Matthew Robson studying the effects of changes in the solar spectrum along a latitudinal gradient on plants in the forest understorey. Since 2011, she has been working with Pedro Aphalo's UV-group and attended the UV4growth meeting on Phytochemistry in Cork. Her MSc researched the relationship between floristic composition and soil type in the Amazonian rainforest in Peru and she previously studied the migration of exotic tree species from plantations in Finland.

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Long-term field study with dark-leaved willows reveals that genders differ in their tolerance to UV- and temperature enhancements

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Males of dioecious trees are expected to grow faster, to be less defended and be more vulnerable to herbivores than females. Our aim was to study the effect of 3-year exposure to modulated UV and temperature enhancements on males and females of field-grown *Salix myrsinifolia.* We measured growth, insects attack frequency, and used graphic vector analysis to investigate allocation to phenolic compounds. Enhanced UV-B and UV-A induced the synthesis of leaf flavonoid and condensed tannins but in females only, a process that was facilitated by warming. Insect damage didn't differ between genders and was not significantly affected by any of the treatment. Increase in UV- had only small effect on the growth of *S. myrsinifolia*, unlike temperature which significantly increased all growth parameters. Females tended to have bigger leaf area than males, differences that was again stronger under elevated temperature. Under enhanced UV-B, males had significantly smaller diameter and were generally shorter than females which, along with females' increase in phenolics are suggestive of females' greater tolerance to UV-B when compared to males. From our results, we suggest that in the long-term, genders of *S. myrsinifolia* might respond differently to future climate change.

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Effects of solar UVB, temperature and sample processing on phenolic content in *Sphagnum lindbergii* after 7 years of field experimentation

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The content of phenolic compounds has been often used by researchers as an indicator of UV-triggered changes in plants. *Sphagnum lindbergii*, a species from a subarctic peatland, was grown under manipulated UVB and temperature *in situ* to test the effects of this manipulation on the phenolic content. Further, the content of both methanol-soluble and cell wall bound phenolics was measured spectrophotometrically and the concentration of the individual compounds in the samples was evaluated by HPLC. The effect of UVB and temperature manipulation on these variables was subtle, and the role of temperature regime in regulating plant phenolic content seemed to be more important than that of UVB. Additionally, we studied how various methods of extraction and storing of the plant material affected the phenolic content. Storing did not affect the bulk absorbance of methanolic extracts, but differences in sample processing (freeze-drying, air-drying, extraction of the insoluble fraction) led to significant differences in the bulk absorbance of both fractions, as well as in the content of some individual compounds. Thus, results can be very much influenced by the sample processing methods applied.

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Anna Hyyryläinen is a postgraduate researcher at the department of biology at the University of Oulu (Finland), studying the effects of solar UVB and temperature on peat mosses. During Bachelor and Master studies at Vilnius University (Lithuania) she focused on bryoflora and population biology of *Marchantia polymorpha*. In 2007-2009 she participated in ECOREIN project (The Ecological and Socioeconomical Responses of Global Change on Reindeer Pastures). In 2009-2012 she was a visiting researcher in Finnish Forest Research Institute (Rovaniemi).

Effects of ultraviolet radiation and rainfall reduction on carbon and nitrogen levels in the soil of a Mediterranean shrub community

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In Mediterranean ecosystems, changes in UV radiation and water availability are expected as a consequence of climate change. Our study evaluates how these changes may affect carbon and nitrogen levels in the soil of a shrub community located in Girona (NE of the Iberian Peninsula). We studied 18 plots subjected to a 95% reduction in UVB+UVA (UV0), a 95% reduction in UVB (UVA) or to near-ambient UV radiation (UVBA); in conjunction with two water availability conditions (natural rainfall or 30% reduced rainfall). Soil humidity and respiration were analysed for 4 consecutive seasons. Soil pH, electric conductivity, organic carbon, organic matter, total nitrogen and enzymatic activity of β-glucosidase and protease were measured in 2-3 different seasons and at 2 depths. As expected, soil humidity was greater in plots under natural rainfall, with UVA plots showing, in general, the highest humidity values among UV treatments. UVA plots had also the highest soil respiration levels, although this effect was dependent on water availability. At the same time, UVA and UV0 plots showed higher soil pH than UVBA ones, having also, in autumn, higher values of β- glucosidase activity. Overall these results suggest that UV radiation affect physical and chemical soil properties, with UVA and UVB showing contrasting effects.

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Laura Diaz is a PhD student at the University of Girona (Spain). She is working on plant ecophysiology in the frame of the research group "Soils and vegetation in the Mediterranean". In particular, she is studying soil and plant responses to changes in UV radiation and water availability.

Trans-European Arabidopsis experiment 2013-2014

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A large-scale European experiment was initiated in the spring of 2013 on the latitudinal growth response of the *Arabidopsis thaliana uvr8-2* mutant and its corresponding wildtype at 29 European sites. Due to unfavourable weather conditions samples from 10 sites could be evaluated for growth characteristics, 7 and 3 for flavonoid and glucosinolate content, respectively. This study represented the first multi-site investigation of *A. thaliana* growth and UV-B related secondary metabolite production over such a large geographical gradient under real outdoor conditions. It was hypothesised that the *uvr8-2* plants would show lower growth rates compared to the control Landsberg *erecta* (wildtype). Rosette growth did not relate to latitude with no observable patterns in the rosette widths of control (wildtype) and *uvr8-2*. Localised climate effects appeared to have a stronger influence than latitude. Chemical analysis of Sinapoyl-glucoside revealed no significant differences between the two genotypes studied. However, analysis of total flavonoid glycosides revealed that particular quercetin and kaempferol glycosides were consistently higher in the wildtype compared to *uvr8-2*. Also in respect to the glucosinolate profile *uvr8-2* had a tendency of lower aliphatic and indole glucosinolates mainly due to depressed 3-hydroxypropyl glucosinolate and 3-indolylmethyl glucosinolate concentrations, respectively. This experiment represents an important platform and foundation for an expanded experiment in 2014 that will have more statistical power and will benefit from identification of error sources and challenges that were faced in 2013.

Marie-Theres Hauser leads the plant genetics group with the focus on the molecular genetic analysis of plant development and the effects of abiotic stressors (UV-B, heavy metals, xenobiotics) on development and genome stability.

Technical groups (TGs)

What's in a name? That which we call UV-B may be something else

Aphalo, P.J.

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What we call UV-B, is very frequently not just UV-B. The names we use for treatments, lamps, filters, many times hide part of the reality. If we are not aware of this, then we can easily misinterpret the results from our experiments. Is an “UV-B” lamp really a source of just UV-B radiation? Does an erythemal sensor really measure radiation weighted according to the CIE erythemal BSWF? Do all so called “neutral density (N.D.)” filters attenuate equally all wavelengths? I will give examples, both from actual experiments, and simulations. The simulations have been calculated using the suite of R packages that I am developing for calculations related to photobiology. Examples of cases to be analysed or discussed: 1) effects of radiation emitted by UV-B lamps on phytochrome photoequilibrium; 2) the use of imperfect erythemal sensors for controlling modulated systems; 3) the use of broad band sensors calibrated under one radiation source to measure irradiance under a source with a different emission spectrum; 4) using broad band sensors to measure irradiance under sources with narrow emission peaks (e.g.\ LEDs).

References

Aphalo PJ, (2013-) Photobiology packages for R. http://r4photobiology.wordpress.com/

Aphalo PJ, Albert A, Björn, LO, McLeod A, Robson, TM, Rosenqvist, E (eds.) (2012) Beyond the visible: A handbook of best practice in plant UV photobiology. COST Action FA0906 UV4growth. Helsinki: University of Helsinki, Department of Biosciences, Division of Plant Biology, 176 pp.

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Pedro José Aphalo

Agricultural Engineer, and M.Sc., University of Buenos Aires, Ph.D., University of Edinburgh. In Finland since 1991. I have been interested in the role of information in plant responses since my M.Sc. thesis, and in parallel also interested in electronics and software development. These two activities have influenced each other: studying system analysis in relation to computer programming and control systems was behind my early interest in looking at plants as control systems. My knowledge of eco-physiology has influenced the design of software and instruments used in my lab.

UV in horticulture – how can our research be used?

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The research on UV effects on plants during the last 30 years has been initiated by the concern of the effects of ozone depletion. Our perception of UV have gradually changed from a potentially serious stressor in ecology and plant production, to a light signal that may put the plants at “low-alert” to cope with other stresses as well (Hideg et al. 2012). UV has effects on plant morphology as well as biochemistry in terms of pigmentation and secondary metabolites, and therefore also potentially beneficial effects on human health. In the vast horticultural production of vegetables and ornamentals in greenhouses in Europe UV is excluded by the cover materials – most glass and plastic materials. Therefore, a potentially valuable tool to improve plant quality and healthy metabolites is missing. TG2 on dissemination arrange a Stakeholder Meeting on UV in horticulture in Odense, Denmark, 9-11 March 2014. Academics, growers and hardware producers will attend. We will discuss what we know about UV effects on plants, which of these effects that are desirable to use in plant production, which UV technologies (UV transparent plastic and UV lamps) that can be implemented in greenhouse production, and what knowledge that is missing. This talk will summarize the outcome of the discussions.

References

Hideg E, Jansen MAK, Strid Å (2013) Trends in Plant Science 18: 107-115.

Eva Rosenqvist has worked at Danish Institute of Agricultural Sciences, specializing in dynamic climate control in greenhouses based on the ecophysiology of photosynthesis, to minimize the energy use for heating and supplementary light. Her PhD at Copenhagen University is in light acclimation and photoinhibition of photosynthesis. She has worked on stress responses of numerous climate parameters within the framework of greenhouse production, but also on regeneration of forest trees and phenotyping of heat stress in wheat.

UV4Growth & agriculture: turning photobiology into commercial reality

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Opportunities now exist to regulate the UV environment during both pre-harvest and post-harvest phases of food production, providing life-cycle control of plant secondary metabolism for consumer health, crop plant stress resilience, resistance to pest and disease attack, and post-harvest food quality, all of which are valuable facets of consumer food acceptability, and ultimately, food security. Our understanding of the responses of crop plants to differing UV regimes has expanded in recent years, using a combination of modified field-scale experiments and controlled environment approaches. However, limited 'deep' integration of scientific studies into applied systems, and typically limited communication between university-based researchers and agri/hort industry are just two roadblocks to high-value uptake of such new knowledge. In order to drive this understanding into application, UV4Growth has stimulated a range of stakeholder and dissemination activities. In a series of meetings during the Action, researchers have explored opportunities with horticultural players from France, Denmark, UK, Ireland, Finland and Egypt. Here we will present an overview of this exploration of commercial opportunities stemming from UV photobiology, and discuss the progress during FA0906 regarding stakeholder engagement and research application.

References

Wargent JJ, Jordan BR (2013) New Phyt. 197, 1058–1076.

Jason Wargent is a plant physiologist and Senior Lecturer at the Institute of Agriculture & Environment, Massey University, New Zealand. His research is focused on understanding and exploiting fundamental and applied plant responses to UV radiation. In 2013 he was appointed as an adjunct Professor within the International Institute of Agri-Food Security, Curtin University, Australia, and he has recently established a technology 'spin-out' initiative focused on developing novel horticultural plant lighting treatments.

All you wanted to know about UV radiation and plants

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UV radiation (UVR) has an essential role in plant biology, yet is under-recognised in contemporary science teaching. Because of strong links with major topics in the curriculum, such as evolution, global environmental change and plant ecology, UVR could become integrated in modern school science teaching if engaging support materials were available. To address a shortfall we produced a teaching resource that would be suitable for students of around 16 years age. Our aim was to facilitate pupil learning and aid teachers wanting to deliver classes on this topic. Within the resource, we present information on UVR and the electromagnetic spectrum, and the relationship between sunlight, photosynthetic energy and UVR. The impact of UVR to plants is described, including that to plant tissues and the effect of DNA damage within the cell nucleus. The mechanisms plants use to repair, or protect from UVR damage (including UVR8) are also discussed, and wider ecological significance of UVR is explained; particularly the energetic compromises plants strike in producing protective pigments and developing adaptive morphology. Furthermore, the ecological role of UVR in attracting insect pollinators and in improving food crops for human nutrition is detailed. We will describe further practical experiments that can be used for school demonstrations, thereby ensuring the effects of UVR to plants becomes an engaging part of modern science teaching.

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Alan G. Jones is a postdoctoral research associate at Aberystwyth University, working in Dylan Gwynn-Jones' research group. His NERC funded research investigates Global Change drivers, including UV-B, on Arctic high-latitude shrub communities. Alan gained his PhD from Imperial College London studying atmospheric nitrogen deposition and heathland ecology in the UK. At the University of Tasmania, Australia, he contributed to research on eucalyptus forest degradation and wildfire cycles. Alan specialises in studying the mechanisms of plant-soil interactions, to understand how external drivers of ecosystem change affect plant biology.

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