Plant Environmental Physiology group

Ecophysiology Techniques Workshop

Lisbon, Portugal 10-15th September 2012

Abstract booklet

Plant Environmental Physiology Group:

The Plant Environmental Physiology Group (PEPg) is a special interest group of the Society of Experimental Biology (SEB) & The British Ecological Society (BES)

Plant environmental physiology is the study of short-term acclimation and long-term adaptation of plants to changing environmental conditions. Our traditional goal has been to integrate leaf and plant- level responses to biotic and abiotic stress under field and laboratory conditions. Increasingly, our focus has been either to set molecular physiology in an ecological context, or to provide a basis for scaling root and shoot level responses to canopy, ecosystem and region in the context of climate change, whether for crops or natural vegetation. Our remit is to:

- Advance and promote the science and practice of plant environmental physiology
- Integrate the plant environmental physiology community and research opportunities within and outside the BES and SEB
- Support, train and liaise with young plant environmental physiologists

The group holds its Annual General Meeting at the BES Annual Meeting in September, and has plans to begin an annual training course in field techniques aimed at postdocs and postgrads in plant environmental physiology. The PEPg is an excellent forum for meeting people working in similar fields, and for socialising as well as general networking. Members interested in holding conferences, meetings, workshops or field meetings can apply through the Group Secretary for BES financial assistance and support for student attendance.

http://plantenvironmentalphysiology.group.shef.ac.uk/

http://www.sebiology.org/plant/physiology.html

http://www.britishecologicalsociety.org/getting_involved/special_interest_groups/index.php

Ecophysiology techniques workshop

The re-introduced Ecophysiology Field Techniques workshop provides a unique opportunity for MSc, PhD students and early career Post-Docs to gain hands-on experience and training in plant physiology techniques in both field and laboratory environments. This meeting will provide an unrivalled opportunity for manufacturers to introduce their latest equipment and provide hands-on training. Through a combination of formal lectures and practical sessions this workshop will provide an invaluable introduction for early stage researchers.

For further information please contact the organiser (Dr Tracy Lawson, email: tlawson@essex.ac.uk) or visit the following websites:
http://www.essex.ac.uk/bs/Pepg_workshop/

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List of speakers and topics:

Speaker Name	Speaker Topic	Affiliation
Prof. Steve Long	Infra-red gas exchange analysis	University of Illinois, USA
Dr Eric Murchie	Chlorophyll fluorescence	University of Nottingham, UK
Prof. Lawren Sack	Hydraulic conductance	UCLA, USA
Prof. Maurizio Mencuccini	Plant water / xylem flow	University of Edinburgh, UK
Dr Jaume Flexus	Mesophyll conductance	University of Majorca, Spain
Prof. Howard Griffiths	Isotope partitioning	University of Cambridge, UK.
Dr Matthew Davey	Environmental metabolomics	University of Cambridge, UK.
Dr Andrew Leaky	Environmental transcriptomics	University of Illinois, USA
Dr Colin Osbourne	Modelling of physiological processes.	University of Sheffield, UK
Dr Justin Mcgrath	Field imaging of growth and leaf development	University of Illinois, USA
Dr Gary Lanigan	Practical setup of Eddy Covariance	Teagasc
Dr Carl Bernacchi	Eddy Covariance measurements	University of Illinois, USA
Dr Tracy Lawson	Chlorophyll fluorescence imaging	University of Essex, UK
Dr Richard Whalley	Soil moisture measurements	Rothamsted Research, UK
Dr Miguel Costa	Thermal Imaging in the field	University of Lisbon, Portugal
Prof Manuela Chaves	History of Quinta Research	University of Lisbon, Portugal
Prof João Pereira	History of Quinta Research	University of Lisbon, Portugal
Dr Bernard Genty	Combined gas exchange and fluorescence	CNRS/CEA Cadarache, France
Prof. Gail Taylor	Transcriptomics/trees	University of Southampton
Dr Hazem Kalaji	Chlorophyll fluorescence	Warsaw, POLAND
Dr. Colin Campbell	Soil moisture measurements	Decagon Devices, USA
Dr Steven Driever	Introduction to measurements of transpiration	University of Essex, UK
Dr Edmund Potter	Introduction to measurements of transpiration	Delta - T Devices

BRITISH ECOLOGICAL SOCIETY

Health and Safety on Field Visits – Handout for participants

A British Ecological Society(BES)-nominated person (or persons) will be in charge of all formal activities associated with the field visit. However, prime responsibility for safety rests with the individual. Act sensibly, responsibly and with consideration for other people at all times. Before undertaking any course of action, the safety of that action should be assessed. If there is any unreasonable degree of risk, that course of action should not be undertaken. This applies both to those in charge of formal field course activities, and to all individuals at all times.

The identity of any qualified first aiders in the group will be made known to everyone. All accidents, injuries, or other mishaps, no matter how trivial, should be reported to the person in charge. Every group should carry a first aid kit. Avoid excessive exposure to adverse weather conditions, including heat, cold, wind, sunlight, glare, damp etc.

Dress sensibly and correctly for the conditions. Carry equipment and clothing to enable you to deal with all eventualities that you might reasonably expect to encounter. If you are not sure what conditions to expect ask before going on the field trip. Fieldwork undertaken during winter months probably carries more risk than that at any other time of year. Weather (and road) condition can change rapidly and unexpectedly. The field trip organiser will check the weather forecast and road conditions and may cancel the trip if there are doubts about the conditions. All participants should wear warm clothes, take hot drinks and observe the normal rules for outdoor activities in the winter.

Ensure that you have all the necessary immunisations, vaccinations and boosters appropriate to the place you are visiting. In the UK this should include tetanus, polio and hepatitis “A”. If appropriate, a briefing will be given on the risks of contracting leptospirosis and Lyme disease, contracted from ticks, together with advice on how to avoid them.

Any unreasonable behaviour, including failing to comply with a reasonable request, shouting and verbal or physical abuse, will not be tolerated. Warnings will probably not be given in such cases.

The BES takes every step to ensure the health and safety of all participants on field trips and site visits. However, accidents do sometimes happen and in these circumstances the BES can accept no liability for any accident or damage to or for loss of property caused as a result of participation in the event. Please note that this clause does not affect participants statutory right and does not purport to exclude the BES's liability for any injuries occurring whilst acting in accordance with BES instructions.

Flash talk abstracts

Screening tomato germplasm based on physiological traits for drought tolerance

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28 accessions of tropical tomato liens were screened in mini-lysimeter for drought tolerance based on physiological traits. The response to drought by determinate, semi-determinate and indeterminate genotypes was very distinct. Among the determinate type, AVRDC breeding lines CL5915-93D4, and CLN1621L, CLN2413D, and CLN2498E x CA4 accumulated good dry matter yield including fruits but could not lead to fruit maturity under droughted conditions. Among the indeterminate, LA1310 showed very high level of drought tolerance through its very dynamic control of leaf area and stay green property. This line hold promise for further evaluation and including it in the breeding program to confer drought tolerance in cultivated tomato genotypes.

The *GPC-B1* transcription factor and the control of grain composition in wheat

Philippa Borrill[1], Cristobal Uauy[1,2] and Alison Smith[1]

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The *GPC-B1* gene is a *NAC* transcription factor which affects grain nutrient concentrations in wheat (*Triticum aestivum* and *T. turgidum*), and hence the end use and nutritional value of the grain. It has been shown that reducing expression of *GPC* genes using RNAi decreases grain protein, iron and zinc concentrations. These changes are related to a delay in the senescence of the flag leaf, leading to the suggestion that *GPC-B1* controls remobilization of nutrients from this leaf to the developing grain. Interestingly the down-regulation of *GPC* genes does not alter grain yield indicating a de-coupling of protein, micronutrient and carbon loading into the developing grain. We aim to discover how the import of protein, micronutrients and carbon is separately controlled using *GPC-B1* as a tool. A diverse range of germplasm resources have been assembled including RNAi and TILLING mutant lines. The effect of delayed senescence on photosynthesis and carbon assimilation is being examined, with particular emphasis on the fate of photosynthate assimilated during this extended green period. Furthermore, whilst certain nutrients are decreased in the grain of *GPC* RNAi lines, others are increased and it is possible that the route of transport may be a partial explanation, therefore tracer studies are being undertaken into xylem and phloem transport.

Localization-functional relationship of phenylpropanoids: new evidence for an old issue

Cecilia Brunetti, Martina Di Ferdinando, Susanna Pollastri, Francesco Ferrini, Alessio Fini, Massimiliano Tattini

University of Florence, Viale delle Idee 30, Sesto Fiorentino, Italy.

We reported here the inter- and intra-cellular distribution of individual phenylpropanoid classes in response to changes in light irradiance. We have performed HPLC-DAD-MS analysis coupled with fluorescence microspectroscopy and multispectral fluorescence microimaging (wide-field and confocal laser scanning microscopy). Our analysis offer conclusive evidence for the multiplicity of functions served by flavonoids in photoprotection.

Effect of *Cistus ladanifer* encroachment on tree water relations

Caldeira MC[1], David TS[2], Lecomte X[1]

[1] School of Agriculture, Technical University of Lisbon; [2] Instituto Nacional de Recursos Biológicos I.P.Technical University of Lisbon, School of Agriculture, Technical University of Lisbon, School of Agriculture, Lisbon, Portugal.

Cistus ladanifer is a native stress-tolerant shrub expanding in the cork oak woodlands. Our hypothesis is that shrubs compete with the trees for water, reducing C assimilation in trees growing in invaded plots. Leaf gas-exchange, leaf water-potentials and sap-flow are being measured in trees and shrubs in invaded plots and compared to paired plot where shrubs have been removed. Trees growing in invaded plots show a higher reduction in leaf water potentials and leaf C assimilation than non-invaded trees supporting the competition hypothesis.

Drought affects differently gas exchange of leaves located in sun than in shade

FJ Cano[1], A Gascó[2], R López[1], L Gil[1] , I Aranda[2]

[1]Unidad Docente de Anatomía, Fisiología y Genética Forestal, E.T.S.I. Montes, Universidad Politécnica de Madrid (UPM), Ciudad Universitaria s/n, 28040 Madrid. Spain.
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In recent years, many studies have focused on the limiting role of leaf internal conductance (g_i) to photosynthesis (A_n) under water stress, but no studies have characterized their effect during drought on leaves developed in sun or in shade. We conducted A_n/C_i curves in four deciduous tree species, in the

field, in the early summer of years: 2009 (very dry) and 2010 (wet) to remove ontogenetic effects.

Effect of climate change on the gross primary productivity (GPP) of rich limestone grasslands

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Grasslands are one of the dominant forms of land use worldwide and they play an important role as carbon sink. In the United Kingdom, pastures represent approximately a 49% of the land cover, and within this group limestone grasslands (LG) represent an important ecosystem due to the exceptional diversity of rare plants. In order to explore the possible effects of climate change in LG, a long-term climate manipulation experiment was established in Buxton, Derbyshire, UK. The selected grasslands have been subjected to variations in winter temperature (+ 3 ˚C) and in summer rainfall patterns (exclusion or supplement of rain) for almost 20 years. The site has been thoroughly studied in terms of the species turnover, genetic variability and soil microscale variations as possible mechanisms responsible for the resilience of the system. Nevertheless, there is no information about the photosynthetic capacity of this species or how the productivity of the ecosystem is affected by the treatments. Hence, by using a flux measurement technique we explore the variation on Net Ecosystem Exchange (NEE) and ecosystem respiration (Reco) along the treatments and, we examine what are the key drivers in the variation of the Gross Primary Productivity (GPP) among treatments. We believe that exploration of the feedback mechanisms between soil, plant and atmosphere is critical information for making sense of climate change effects on plant communities and links to the carbon cycle. Keywords: limestone grasslands, climate change, gross primary productivity.

BSBEC-BioMASS – Optimising biomass yield of short rotation coppice (SRC) willow and *Miscanthus* for biofuel production

CUNNIFF, J.[1], SHIELD, I.[1], BARRACLOUGH, T.[1], CASTLE, M.[1], CERASUOLO, M.[1], PURDY, S.[2], JONES, L.[2], MADDISON, A.[2] DONNISON, I.[2] & KARP, A.[1]

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BSBEC-BioMass is part of the BBSRC Sustainable Bioenergy Centre (BSBEC) and is aiming to improve SRC willow and *Miscanthus* yields for biofuel production. Three routes are being investigated: extending canopy duration and improving cold tolerance, maximising carbon fixation by altering architecture, and optimising allocation of above and below ground biomass.

Water use and yield of two contrasting sugarcane genotypes in response to drought stress

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High biomass yielding cultivars (energy-cane) may be good candidates for bio-energy production in marginal areas. However, a better understanding is required of how much water would be used and of their tolerance to drought. The aim of the study was to compare water use and yield of an energy-cane cultivar (04G0073) to that of a conventional sugarcane cultivar (N19). The cane was planted on 05Oct2011 on a rainshelter facility at Mount Edgecombe (29° 42' 24.5585"S, 31° 02' 45.1735"E), South Africa. Half the plots received adequate water throughout, while the other half received no irrigation after 10Feb2012. Volumetric soil water content was measured with a neutron water meter, daily sap flow was recorded using the non-intrusive heat-balance method, and leaf water potential (ψL) was measured periodically with a pressure chamber from 10Feb2012 until the final harvest on 05May2012. Crop transpiration rate estimated from sap flow observations compared well with transpiration estimates from soil water balance determinations. Under well-watered conditions, 04G0073 transpired at a much higher rate than N19. The average ratio between sap flow derived transpiration and the Penman-Monteith sugarcane reference evaporation was 0.90 and 1.49 for N19 and 04G0073, respectively. N19 reduced transpiration rate much sooner (at a higher soil water content) than 04G0073 during the development of stress events. This resulted in 04G0073 depleting the root zone more rapidly than N19. It maintained similar ψL to that of N19 under stressed conditions, despite experiencing lower soil water contents. 04G0073 yielded 8% more biomass than N19 when well-watered. Drought stress reduced biomass yield of 04G0073 by 50%, compared to 25% of N19. We conclude that the energy-cane cultivar 04G0073 uses significantly more water than sugarcane cultivar N19 and this enables it to produce higher biomass yields. However, it also depletes available soil water quicker, which leads to larger yield reductions than N19. This information is useful for determining the feasibility of growing energy cane in marginal areas.

Two novel Arabidopsis mutants with increased starch degradation rates

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In the Arabidiopsis leaf, starch is turned over in a diurnal manner. During the day, around half of the photoassimilate is used to produce starch. At night, when photosynthesis is not possible, starch is broken down to provide energy for growth and metabolism in the dark. The rate at which starch is degraded does not change during the night. It is timed in a way that reserves run out precisely at dawn. However, the rate of starch degradation is flexible and can reset at dusk. If a plant is subjected to an unexpectedly early night, starch degradation is still linear but slows down. In that way the reserves once again last until dawn although the night is longer. It was discovered that the circadian clock provides the timing mechanism for this adjustment. My aim is to find the link between the circadian clock and starch degradation. Using a forward genetic screen, I identified two mutants that are not able to adjust their starch degradation rates. One of the mutants has a point mutation that knocks out a gene of unknown function. Data from our collaborators indicates that the encoded protein is located inside the starch granule. The rate of starch synthesis is also affected in the mutant. We speculate that the starch turnover phenotype may result from alterations in granule structure or composition that increase the susceptibility to enzymatic attack. The second mutant carries a point mutation in BETA-AMYLASE 1 (BAM1) that results in an amino acid substitution in the protein. Mutant BAM1 has an increased affinity for its binding partner, the granule-bound protein LSF1. The two proteins form a complex at the starch granule surface, which may facilitate starch degradation by BAM1. Therefore, the extent of complex formation between these proteins could be a means by which starch degradation rates are controlled. The novel phenotypes of these two mutants will help us to understand the control of starch degradation from new and different perspectives.

Trees. urban environment and "landscape ecophysiology"

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Trees living in the urban environment must cope with a variety of abiotic stresses. Furthermore. global change will modify environmental variables (i.e. temperture, rainfall), which is likely to affect the survival and growth of urban trees, as well as the benefits they provide. Ecophysiological tools are useful to develop new criteria for sustainable urban arboriculture, inlcuding species

selection (based on stress tolerance criteria), nursery hardening and preconditioning, and care after planting.

Water use efficiency of productivity by hybrid poplar clone *Populus nigra* x *P. Maximowiczii* in conditions of Czech-Moravian Highlands

Milan Fischer[1, 2], Abhishek Mani Tripathi [1], Miroslav Trnka[1, 2], Matěj Orság[1 , 2], Lenka Bratošová[1, 2], Michal Marek [1], Zdeněk Žalud[1, 2]
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The relation between water loss and carbon uptake can be described with so–called water use efficiency (WUE). We investigated stand WUE of productivity by hybrid poplar clone *Populus nigra* x *P. Maximowiczii* in conditions of Czech-Moravian Highlands based on measuring actual evapotranspiration and the aboveground woody biomass increment.

Rapid response to selection of leaf eco-physiological traits under manipulated [CO_2] and temperature conditions in *Brassica napus*

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Current knowledge of evolutionary trajectories under environmental change is poor. A controlled selection experiment was performed under elevated [CO_2] and temperature conditions to reveal inter-generational alterations of immediate eco-physiological responses. The results imply adaptive changes in the trade-off between C-uptake/ transpiration; and the pattern of nitrogen allocation within leaves.

Ozone and soil salinity interactions in Mediterranean woody species

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Soil salinity is common in coastal areas where sea water can penetrate the water table, especially in summer, and sea spray deposits salt on leaves and soil, especially in winter (Greaver and Sternberg, 2010); additionally soil salinity is increasing in agricultural areas where maquis species are often used as field delimiters and are part of a landscape unit. O_3 is another recognized oxidative stress and its concentrations are increasing worldwide as the result of higher NOx emissions mainly in coastal areas where urbanization increases (Martinez et al., 2007). Soil salinity and O_3 are oxidative stress that often coexist in coastal areas and may can occur simultaneously, potentially altering water use strategies of vegetation and affecting species fitness. The objectives of this work were, thus, to: i) determine the response mechanisms of two evergreen species, *Quercus ilex* L. and *Arbutus unedo* L., to soil salinity in terms of stomatal control, compartmentalization, and pigment concentrations; ii) determine how these mechanisms are altered in the presence of tropospheric O_3.

Ecophysiological responses of anisohydric mulberry to summer drought at a hot semi-arid steppe experimental site of southern India

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Mulberry (*Morus spp*. L), a well-known perennial woody tree crop has been recently introduced to the non-traditional moriculture belts, located in the hot semi-arid steppe agroclimatic regions of southern India where seasonal summer drought, together with high air temperature and excessive solar irradiance exert large constraints on survivability, growth and yield. We examined important ecophysiological responses, including leaf gas exchange characteristics, soil and leaf water status, stomatal sensitivity and photosytem-II (PS-II) efficiency in water-stressed mulberry stands in order to understand the physiological basis of drought tolerance in this tree species. The study was conducted during year 2009 (the study site recorded excessively hot dry summer in this year) for three months (April to June) comprising peak summer months of the study zone. Mulberry trees (genotype V1, *M. indica*), grown in short rotation coppice (SRC) system, were subjected to two irrigation regimes: control plot received a regulated full-rate irrigation (weekly 2-3 times) and drought-stressed plot received a regulated deficit irrigation (irrigated only once in a fortnight). Water-stressed mulberry trees exhibited anisohydric behaviour manifested as large declines in leaf water potential (ψL), more conspicuously during midday (12:00 to 13:00 solar hour) that established a potential gradient between leaves and roots and allowed

considerable rate of photosynthetic CO_2 fixation. Intense drought and high solar irradiance of the experimental site also exerted apparent photoacclimatory changes in the PS-II of drought-exposed stands. OJIP kinetics of PS-II showed mechanisms that were associated to photoprotection and restoration of PS-II efficiency. Further, analyses of stem wood hydraulic architecture revealed interesting vessel characters of intermediate trait values which were associated with optimization of hydraulic conductance as well as conferring safety from cavitation under soil moisture stress conditions. The research findings improved the understanding of anisohydric functionality of trees in hot semi-arid steppe agroclimates.

GHG Balance and Carbon Mitigation Potential of Bioenergy Crops

Zoe M Harris, Dr Mathew J Tallis and Prof Gail Taylor

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Globally all nations have an obligation to supply food, energy and fuel for an increasing population whilst also looking to reduce greenhouse gas emissions. This is particularly complicated in the UK as we have a limited land capacity which hinders our ability to be completely self-sufficient whilst striking a balance for using land for food and land for fuel. Bioenergy crops are proposed as one of the means by which we can supply a renewable and more sustainable source of energy but we do not yet fully understand the effect of changing land to bioenergy crops. My project aims to assess the effects of a land use conversion from grass land (ex-set aside) to SRC willow as a dedicated bioenergy crop on soil carbon and greenhouse gas emissions. I will do this using an array of techniques which include gas sampling, soil sampling and use of an eddy covariance flux tower. My PhD forms part of a network of sites all over the UK each looking at different land use conversions and the work from our combined effort will form part of a publicly accessible tool for land use managers to assess the environmental impacts of converting land to bioenergy crops.

O_3 and NOx interactions with tree foliage: a field study with shoot chambers

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O_3 and nitrogen oxides (NOx) are reactive trace gases, air pollutants and key elements of tropospheric chemistry. One of the processes underlying the atmospheric balance of O_3 and NOx is their interaction with vegetation. O_3 and NOx are removed, absorbed, and NOx potentially also emitted to/from the

foliage. As a part of an extensive research effort, the research group of Ecophysiology in the Department of Forest Ecology (University of Helsinki) has studied the interactions of O_3 and NOx with forest vegetation in non-controlled field conditions for more than 15 years at the SMEAR II station in Juupajoki, Central Finland (Hari & Kulmala, 2005). The results have contributed to our present knowledge of the air-foliage exchange of these gases (for example Altimir et al. 2006, Raivonen et al. 2009). Currently we aim to clarify further the relative importance of the major controlling factors in the deposition and emission of O_3 and NOx, focusing on the evaluation of the role of biogenic volatile compounds (BVOC) in the deposition of O3 and the role of NO_3^- (on needle surfaces and as nutrient) in the emission of NOx. We are also working to refine our understanding of chamber effects. Several types of non-steady-state shoot-scale chambers have been used in our studies. The current chamber type is built as a sliding box that encloses the shoot only for the short time needed to make a measurement and otherwise allows the shoot to experience all occurring ambient conditions, including wind and rain. Gas fluxes are determined from concentration changes during chamber closure using a mass balance equation. Altimir, N., Kolari, P., Tuovinen, J.-P., Vesala, T., Bäck, J., Suni, T., Kulmala, M. and Hari, P. 2006. Foliage surface ozone deposition: a role for surface moisture? Biogeosciences, 3: 209–228. Hari, P. & Kulmala, M. 2005. Station for Measuring Ecosystem-Atmosphere Relations (SMEAR II). Boreal Environment Research 10: 315–322. Raivonen, M., Vesala, T., Pirjola, L., Altimir, N., Keronen, P., Kulmala, M. and Hari, P. (2009). Compensation point of NOx exchange: Net result of NOx consumption and production. Agric. For. Meteorol. 149(6–7): 1073–81.

Carbon storages and fluxes on different levels

Alisa Krasnova

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Carbon storages are distributed within the ecosystem on several organisational levels ranging from leaf tissues to the whole stand. Freshly taken up carbon is stored into sugars and starch and further distributed over the tree organs (leaves, stem, and roots). Partly, the use of stored carbon leads to time lags between the uptake from photosynthesis and the release by respiration. Furthermore, the annual cycle of tree phenology lead to movements of stored compounds inside leaf tissues to leaf litter and by that contributing to soil respiration. Ecosystem scale flux measurements such as Eddy covariance integrate the sources and sinks of carbon within the ecosystem.

The effects of CO_2 and water deficit on leaf development and plant growth in seedlings of *Theobroma cacao*

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Seedling of Theobroma cacao were grown for five months at ambient and elevated CO_2 (380 and 700 ppm, respectively). The elevated CO_2 treatment represented predicted global CO_2 concentration by 2100. Photosynthetic rate of plants grown at elevated CO_2 was twice that of ambient grown plants, which translated into greater plant height and fresh weight in the elevated treatment. Quantum efficiency also increased significantly in response to elevated CO_2, while light compensation point decreased. Stomatal density increased in response to elevated CO_2. Cocoa seedlings responded positively to an increase in CO_2 concentration. The effect of CO_2 was quite similar to that seen in other plant species.

Comparison of photosynthetic parameters in a collection of Portuguese common bean traditional varieties: settling the basis for drought resistance studies

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Photosynthetic capacity of sixty Portuguese bean (*Phaseolus vulgaris* L.) landraces was studied. Net CO_2 assimilation, stomatal conductance and transpiration were measured with IRGA. Chlorophylls and carotenoids concentrations were spectrophotometrically determined. Relative water content and specific leaf areas were also taken into consideration on the landraces comparison. Results will be discussed.

Cistus monspeliensis L. under warming treatment: a positive effect ?

Dario Liberati
University of Tuscia, DISAFRI, University of Tuscia, Viterbo, Italy

A microclimate manipulation, aimed at increasing air temperature, was carried out on a shrubland located in the north west of Sardinia (Italy); the

physiological, morphological and phenological responses of the dominant species *Cistus monspeliensis* suggest a positive effect of this treatment.

Cracking radish and the effects of irrigation

Rachel Lockley, Dr Jim Monaghan, Dr Ivan Grove

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Root splitting in radish (*Raphanus sativus*) is a fundamental problem for growers with losses ranging between 5 and 30%. Despite both economic and technical requirement for knowledge in this area the causes of root splitting in radish have yet to be fully explained and there is a lack of information and scientific investigation in this area. The aim of this project is to investigate the causes of root-splitting and provide growers with recommendations of best practice growing and storage conditions for the main commercial types of radish. This project will also evaluate different cultivars for their resistance to splitting and establish the physiological characteristics of particular radish which are most resistant to splitting. Previous studies of splitting in radish, carrot, kohlrabi and potato suggests that both pre and post-harvest conditions may have significant effects on splitting. Initial investigations in this project will concentrate on pre-harvest factors; primarily the effect of soil water content and the timing of irrigation stress. Radish is a short duration crop with high growth rates and therefore the correct use of irrigation and an adequate water supply is thought to be fundamental to successful radish growth. To test this radish plants will be grown in pots in the glasshouse and exposed to a range of soil moistures at defined growth stages. Initial studies into irrigation frequency compared plants irrigated to the same gravimetric water potential daily, every other day, every 4 days and every 8 days. Initial results have shown irrigation has a significant effect on water content ($P=0.017$) and weight ($P=0.027$) at harvest which demonstrates that irrigation does affect the radish composition. However, these early investigations showed irrigation frequency did not have a significant effect ($P=0.912$) on splitting. Further investigations will be carried out to determine the role of irrigation and soil moisture content on root-splitting. In addition to the investigations into the pre-harvest factors the project will also be investigating post-harvest factors such as the effect of storage relative humidity and temperature on splitting. Experiments will also investigate cultivar differences to establish which are most resistant to splitting under different conditions. The cultivars will be investigated physiologically, using sectioning & staining methods and scanning electron microscopy (SEM), to identify traits which make them more resistant to splitting. Once key traits in the resistant plants have been identified this can be used to screen new cultivars. It is hoped this this research work will lead to a greater understanding of the physiological basis of splitting, allowing growers to grow radish with less waste.

Quantifying C3-C4 gradients within Alloteropsis semialata

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Alloteropsis semialata is unique in having subspecies of C3 and C4 photosynthetic pathways, as well as apparent intermediate forms. I am characterising the distribution of anatomic, cytogenetic and 13C isotopic variations throughout this species' range and using GIS to understand how this variation is arranged across environments.

Turbocharging Photosynthesis: Integration of Carbon Concentrating Mechanism components from Algae into Higher Plants

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Plant productivity for food and biomass relies on carbon assimilation through photosynthesis. This process is typically limited by the low operating efficiencies of the primary carboxylase, Rubisco. In C3 crops, such as wheat and rice, Rubisco constitutes up to 50% of protein in leaf mesophyll cells to compensate for these inefficiencies. Even with this major investment, oxygen competes with CO_2 at the Rubisco active site resulting in the requirement for re-assimilation of carbon and nitrogen lost through the photorespiratory salvage pathway. This condition is exacerbated by diffusive resistances to CO_2 uptake within the leaf. Various photosynthetic carbon concentrating mechanisms (CCMs) have evolved to increase the CO_2 supply to Rubisco and suppress photorespiration. CCMs exist in some vascular plants (i.e. C4 and CAM species), and efforts are under way to introduce the C4 pathway into C3 crops such as rice, to hopefully increase photosynthetic CO_2 assimilation and hence yield. However, the C4 pathway relies on complex inter- and intra-cellular organisation and co-ordination. As an alternative, many unicellular algae, such as *Chlamydomonas reinhardtii*, possess a biophysical CCM that enhances CO_2 concentrations in the chloroplast, aggregates Rubisco activity, and constrains CO_2 leakage. Key components of the algal CCM have been identified, including inorganic carbon transporters and specific carbonic anhydrases. We are developing a novel insertional mutagenesis screen to identify additional CCM elements. In parallel, we are expressing components of the CCM from *Chlamydomonas* in *Arabidopsis* photosynthetic cells, thereby providing a mechanism to enhance photosynthesis and potentially improve productivity in C3 crops.

Physiological parameters in lichens as a tool for bioindication of environmental stress

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Lichens are well known as reliable indicators of atmospheric pollution. Physiological parameters (e.g. membrane damage, Fv/Fm, Performance Index), showed to respond to environmental stress as heavy metals pollution, nitrogen excess, climatic changes. Results of field and lab experiments are presented.

Effect of substrate treatments on physiological performance of Mediterranean shrubs in a revegetated quarry

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Soil quality is a major problem in Mediterranean quarries restoration. I will present the physiological results (e.g. water potential, Fv/Fm, etc.) of a field experiment performed in a limestone quarry at Outão (Portugal), to test different types of substrate improvement in the performance of three native woody species.

Leaf temperature and photosynthetic performance in chickpea

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The responses of photosynthetic rate and leaf conductance to leaf temperature were evaluated in two contrasting chickpea genotypes (Elixir and FLIP03-46C) grown under field conditions (Elvas, Portugal). Photosynthetic performance was assayed with leaf temperatures ranging from 24ºC to 40º C under controlled VPD. Technical constraints and physiological implications are discussed.

The importance of seed size in the origins of agriculture

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Seed size may correlate with a suite of functional traits (including seed yield and growth rate) favouring some species as crops over others. This hypothesis was tested for thirty-three plant species and results are discussed in the context of natural selection and human agency in the emergence of agriculture.

Combining molecular and physiological analyses to reveal the differential response of the genus Alnus under a polymetallic exposure

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Three local clones belonging to the genus *Alnus*, 1 *A. incana* and 2 *A.glutinosa* were selected and grown hydroponically exposed to a combination of Cd, Ni and Zn. Physiological measurements, proteome and carbohydrate analyses provided evidence for both inter- and intra-specific variability to face with this polymetallic constraint.

Characterization of vegetation functional response to spatio-temporal changes in soil properties though integration of remote sensing techniques with SVAT model.

Suvarna Punalekar.

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Floodplain meadow ecosystems are sensitive to changes in hydrological regime. The complete understanding of their complexity can be achieved by integration of field and remote sensing data (for different spatial and temporal

scales) and SVAT models. The FUSE project aims to understand the soil-vegetation-atmosphere interactions over biodiversity rich Yarnton meads, UK. The project involves monitoring soil physicochemical parameters like soil moisture and temperature at multiple depths, chemical compositions, water potential. Simultaneously the vegetation biophysical parameters like LAI, chlorophyll, stomatal conductance, leaf N and P would also be measured using both in situ and remote sensing methods. The radiative transfer and energy balance would be modelled using physically based SCOPE model. SCOPE will further be updated with subsurface soil and ground water modules.

Using a process-based model to predict water use in olive

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A process-based stomatal model was used in a hedgerow olive orchard under deficit irrigation for understanding the mechanisms behind the control of transpiration. The hydromechanical model fitted our canopy conductance data (estimated from sap flow data) satisfactorily and allowed us to analyze the physiological parameters obtained.

Comparing drought stress tolerance of two Jatropha curcas ecotypes.

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Jatropha curcas is a plant well adapted to semi-arid climates .The focus of our work is to explore the mechanisms of this tolerance. We are studying, at the ecophysiological and molecular levels, the behaviour of two different ecotypes (from arid and tropical regions) when submitted to drought.

Xylem hydraulic conductivity: Methods for improving it measurement

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In xylem hydraulic conductivity (*K*) measurements, a non-zero flow is typically observed at a pressure gradient = 0. Not considering this "passive" flow (F_0) can lead to significant errors in *K* determinations. We will evaluate different methods for considering the F_0 to improve the accuracy in *K* measurements.

Effect of foliage development on the tree transpiration

Josef Urban, Emilie Bednářová, Vladimír Gryc, Štěpánka Řehořková, Sabina Truparová, Kristýna Slovíková, Roman Plichta

Mendel University in Brno, Faculty of Forestry and Wood Technology

Sap flow was measured on six trees in the mature European beech forest. Simultaneously, LAI development, PAR transmittance and phenological phases were recorded. In this presentation, correlation among those characteristics is presented.

Do particular leaf traits maximize the cooling potential of green roofs?

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We are investigating how leaf traits such as leaf colour, thickness and pubescence, as well as water deficit, influence green roof's potential for summertime cooling of surrounding air, and that of a building. Several types of plant canopies were analyzed both in a controlled environment and outdoors. Measurements of substrate moisture content, leaf stomatal conductance, leaf thickness, leaf area index, leaf visible reflectance, canopy temperature, air temperature 10 cm above canopy, substrate temperature bellow canopy and four component radiation were made.

Poster Abstracts

Deciphering the molecular mechanisms underlying abiotic stress adaptation in legumes: combining plant physiology with "Omics" approaches

Susana Araújo[1], Luis Alfaro Cardoso[1] and Pedro Fevereiro[2]

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Understanding what are the molecular mechanisms underlying abiotic stress adaptation in legumes is still a challenge. We are addressing this question using two legumes *Medicago truncatula* and *Phaseolus vulgaris.* Using different experimental platforms in these plants, it is expected to provide candidate genes to be used in innovative improvement strategies.

Measuring stomatal response of Eucalyptus (*Eucalyptus sp.*) grown at different concentration of carbon dioxide (CO_2) and temperature, Western Sydney, Australia.

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Atmospheric carbon dioxide (CO_2) increase is a major concern for areas of global forests. CO_2 is known to influence plants' physiological functions by reducing the stomatal conductance (g_s) and possibly affecting forest water balance. The objective of this study was to investigate the effect of growth under elevated CO_2 concentration ($[CO_2]$) and/or temperature on the primary short-term stomatal CO_2 response, stomatal dimensions and hydraulic conductance in Eucalyptus globulus grown in whole-tree chambers. In order to compare g_s CO_2 responses among treatments, leaves from *E. globulus* trees were exposed to four levels of $[CO_2]$ until g_s stabilization. Although leaves in all treatments exhibited stomatal closure responses to increased $[CO_2]$, this response was significantly reduced in leaves growing in elevated $[CO_2]$, showing that stomata of *E. globulus* do acclimate to growth $[CO_2]$. The stomatal CO_2 response of plants grown in elevated temperature did not differ from that in plants grown in ambient temperature. Anatomical and hydraulic measurements were also analyzed and there were no significant effects of CO_2 or temperature treatment on stomatal density or size or hydraulic conductance. In order to preserve plant species and their ecosystems, it is crucial to understand the impacts of higher $[CO_2]$ and temperatures of a near-future climate on plant water use. This study indicates that while stomatal CO_2

responses have the potential to cause water savings under elevated [CO_2], this potential is reduced by stomatal acclimation to prevailing growth [CO_2] and is unlikely to be present during conditions when g_s is constrained by plant hydraulics.

Temperature acclimation of mitochondrial respiration in the light, a study on fast-growing Eucalyptus in Australia

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Very little work has undertaken an examination of mitochondrial respiration in the light (R_{light}) and its relationship to mitochondrial respiration in the dark (R_{dark}). This ongoing study aims to answer if *Eucalyptus globulus* acclimates to warmed treatment and if R_{dark} and R_{light} have different temperature dependencies.

Effect of Low Temperature during the Night in Young Sweet Pepper Plants: Stress and Recovery

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The optimization of the use of heating in greenhouses should be an energy saving target in the cultivation of sweet pepper plants, from both an environmental and economical point of view. The first step is to understand the effect of low temperatures on this crop. While the effect of low temperature has been studied in plants exposed to light, there are few studies about the effect of cold in the dark, which is a more realistic situation in greenhouses. The objective of this work was to study the effect of low temperatures during the night in sweet peppers and to assess some of the physiological consequences on the following [warm] day. Therefore, we subjected sweet pepper plants of two cultivars to 5 or 7 cycles of 12/12 h warm light (500 µmol m^{-2} s^{-1} PAR, 21°C) and cold dark (6 °C). After the treatment, several measurements were performed in leaves (first in the dark and cold, and one hour after light was switched on): chlorophyll fluorescence (spot and imaging) and measurements of biomass. Our results show a decrease in the efficiency of photochemistry (Y(II)) in photosystem II during the dark, cold period related to a stimulation of photoprotection mechanisms in the photosynthetic apparatus. The area surrounding the nerves had higher potential efficiency of PSII photochemistry than the rest of the leaf surface.

However, 1 hour after rewarming in light conditions, leaves had recovered high values of Y(II). In addition, fully expanded leaves increased their Specific Leaf Area and Fresh to Dry Weight ratio during this period. This may indicate that, during the recovery period, dry weight decreased due to redistribution of assimilates to expanding leaves and/or the leaf water content increased. These results support two possible explanations for the cause of the decrease of Y(II) during cold nights: low temperature (1) leads to accumulation of assimilates in leaves leading to feedback inhibition of photosynthesis, and/or (2) decreases plant hydraulic conductance and, therefore, leaf water content. The fast recovery of this crop after several cold nights might open possibilities for new strategies of energy saving in greenhouses. However, more studies should be done to make sure that other plant processes affecting crop yield/quality are not influenced by low night temperatures.

Development of a drought stress matrix using exemplary *Lablab purpureus* L.

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Gottfried Wilhelm Leibniz Universität Hannover, Institute of Botany, Germany

Due to climate change genotypes of crop plants tolerant to water stress are needed. Application of our stress matrix should reliably identify tolerant genotypes. Methods include PAM Imaging, conductance measurement, thermal imaging photography, and fresh and dry weight determination.

Thermal imaging as a tool in detecting variation in drought stress response in perennial ryegrass (*Lolium perenne*) genotypes

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Thermal imaging can be used to detect early plant stress due to detection of reduced stomatal conductance, prior to any change in the water status of the plant. Imaging technologies have the potential to rapidly assess large numbers of plants – a huge advantage over most techniques for assessing plant physiological behaviour. Modern crop genetic improvement programmes require phenotypic information on numerous genotypes, often under a range of environmental conditions. In this experiment thermal imaging was used to detect variation between different genotypes of perennial ryegrass (*Lolium*

perenne L.) in response to drought stress. The experiment was carried out in a temperature-controlled greenhouse between May and July 2012. Eight genotypes were compared when exposed to complete drought (no irrigation), severe drought (irrigation to replace 30% evapotranspiration), mild drought (irrigation to replace 60% evapotranspiration), and full irrigation. Thermal images were captured twice a week, from which an index of stomatal conductance and a crop water stress index were obtained. Soil moisture content, relative water content, electrolyte leakage and biomass and leaf extension were also measured. Preliminary results indicate stomatal closure in response to drought, but also differences in stomatal conductance between genotypes.

Diversifying selection of cavitation resistance across an insular pine range

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Drought is one of the most powerful selection forces in Mediterranean ecosystems. Under current climate warming scenarios tree populations are likely to face increasing selective pressure to adapt to dryer environmental conditions through changes in key traits to supply leaves with enough water to reproduce and survive. *Pinus canariensis* inhabit in an archipelago where migration is limited, phenotypic plasticity and some degree of local adaptations in xylem traits will confer an adaptive potential for this species to successfully adapt to xeric conditions.

Responses of leaf hydraulic conductance to drought in grapevine (*Vitis vinifera*).

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Hydraulic conductance has been characterized as a key parameter regulating gas exchange. Some studies have reported how leaf hydraulic conductance or petiole hydraulic conductivity are changing along the day. Garnacha and Tempranillo are two grapevine varieties contrasted according to the water stress response. In order to characterize the response to water stress we performed vulnerability curves using the rehydration kinetics method (Brodribb and Holbrook 2003) to see how leaf hydraulic conductance is changing under water stress conditions and well water conditions on the two varieties. Results show distinct responses of leaf hydraulic conductance to water stress in the two varieties studied.

Evolution of Stomatal Responses to ABA and CO_2

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Stomata regulate CO_2 uptake and water loss in vascular plants by controlling the aperture of microscopic pores. The most ancient, and non-vascular, plant lineage to form stomata is the mosses which have a ring of stomata around the base of their sporophyte structures. We have recently demonstrated that the apertures of these moss stomata close in response to ABA and use a similar mechanism to that of vascular plants, involving the protein kinase OST1. Recent work by others has shown that the vascular plant stomatal aperture response to CO2 also requires OST1. Here we present evidence suggesting that signalling components similar to OST1 and ABI1 are functional in ancient plant stomatal responses to both ABA and CO2. Expression of moss genes homologous to vascular plant OST1 or ABI1 was able to restore ABA- and CO2-induced stomatal aperture responses to vascular plants lacking these components. Our experimental evidence suggests that stomatal ABA and CO2 signalling responses both evolved before the last common ancestor of mosses and flowering plants over 410 million years ago.

Effects of elevated atmospheric humidity on leaf gas exchange: A case study in hybrid aspen.

Aigar Niglas, Arne Sellin

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Leaf gas exchange characteristics were measured on hybrid aspen saplings grown in ambient and elevated atmospheric humidity. The trees grown in higher humidity had higher stomatal conductance, lower water-use efficiency

and relative stomatal limitation to photosynthesis compared to control plants, while the treatment did not affect plant photosynthetic parameters.

Screening for Salt and Water Stress Tolerance in Pepper Accesions Based in Germination Rate for using as Rootstocks.

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Grafted technique could enable plant breeder to combine desired shoot characteristic with a good root characteristic. Specific stages throughout the ontogeny of the plant such germination and seedling stages should be evaluated during the screening for obtain plants tolerance. The propose of our work was to evaluate the behavior of 7 pepper genotypes during germination under salinity and water stress

Ecophysiological adaptations of the herbaceous understorey of Mediterranean evergreen oak woodlands to different frequencies of precipitation

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Two water treatments were applied to herbaceous understorey by varying the frequency of irrigation events without changing the total amount of water received by plants. Gas exchange, water status, chloroplastic pigments, antioxidant compounds and protein oxidation were analyzed to understand adaptation of the herbaceous plants to the future fluctuations in Mediterranean climate.

The aboveground biomass allocation in the hybrid poplar clone (*Populus nigra x P. Maximowiczii*) grown as a short rotation coppice

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Short rotation coppice cultures based on Populus spp. are considered as an alternative source of bio-energy produced from arable land in the central

Europe. The aim of our poster is to provide allometric equations describing the relationships between the main biometric parameters (diameter at breast height and tree height) and the aboveground biomass allocation into stem/branch/leaves.

Using next generation sequencing to understand plant acclimation and adaptation to the changing environment

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Next generation sequencing (NGS) is a new technique which has created exciting opportunities in the field of genetic analysis. Massively parallel genomic DNA and RNA sequencing offers considerable advantages beyond the use of gene expression microarrays. These new technologies have yet to be employed to any great extent in Environmental Biology but they are amenable to now address how plants and ecosystems show phenotypic plasticity in response to the changing environment and whether this results in adaptive change and evolution. Plant genomic responses to predicted climate change and altered soil biodiversity are two areas that can now be unravelled in a way not previously possible. NGS allows for in depth analysis of plant species with no previous information required, enabling rapid evaluation of any of novel plant acclimations and adaptions and also enabling abundance and diversity in soil systems to be quantified. Here we discuss the advantages of different NGS techniques and also the potential pitfalls you can incur when using the technology. We will especially focus on species which lack a reference genome and discuss how NGS is enabling us to address how these species are now amenable to study.