P6–GENERAL ENVIRONMENTAL PLANT PHYSIOLOGY

Organised by K. Maxwell for the Plant Environmental Physiology Group

P6.1–Rapid solute accumulation in salt-stressed barley leaves: the 'super'-sink-strength growth zone

W. Fricke, Paisley University; G. Akhiyarova, D. Veselov and G. Kudoyarova, Russian Academy of Sciences, Ufa

The aim of the study was to identify mechanisms through which barley plants can recover leaf growth when suddenly exposed to salinity. Plants at the third leaf stage were exposed to 100 mM NaCl. Leaf elongation rate was reduced immediately, and elongation rates remained close to zero, until about 20–28 minutes, when they recovered suddenly to about 50–60% of the pre-stress level. Significant solute accumulation in leaf tissue was observed already one hour after onset of stress, but clearly succeeded recovery in leaf elongation. This early solute accumulation was confined to the proximal proportion of the leaf growth zone. As stress continued, solute accumulation became more significant and spread, successively, into the distal portion of the growth zone, the adjacent, enclosed non-elongation zone and the emerged part of the leaf. Analyses of cell and bulk leaf extracts showed that chloride constituted a major osmoticum, even within the growth zone. The results suggest (i) that the early, sudden recovery in leaf elongation rate is not related to the accumulation of solutes in cells, and (ii) that the growth zone has an exceptionally high sink strength for solutes – a 'super'-sink strength. Cell developmental gradients in the potential to osmotically adjust exist even within the growth zone. It appears that the ability to extract solutes such as chloride efficiently from the xylem stream passing through the growth zone, is a key feature conferring sink strength to expanding cells and enabling residual leaf elongation in salinized barley.

P6.2–Winter-injury in nitrogen-polluted heather (*Calluna vulgaris*)

S.J.M.Caporn, L.E. Cawley, Y. Lei, M.G. Pilkington, and J.A. Carroll, Manchester Metropolitan University

Elevated nitrogen supply is believed to reduce frost tolerance in higher plants, but the response is complex, with some cases of improved tolerance reported, particularly in early-winter. Field observations suggest that, in general, cold-related damage to heather (*Calluna vulgaris*) in upland regions occurs mainly in late-winter and is not simply a result of direct frost-damage but is due to a particular combination of climatic factors and phenology. Our observations in a nitrogen addition experiment on heather moorland in north Wales found that late winter-injury of this type was greatest in nitrogen treated heather, when compared with water-fed control plants. The injury became obvious during spring in several years but the relationship with environmental conditions and the underlying plant physiological events were never satisfactorily established. The work described here analyses in greater detail several components of winter injury. Firstly, we investigated the relationship between visible injury, bud burst, the extent of frost hardiness and the levels of associated metabolites that could be involved in stress tolerance. Secondly, we examined the water relations of shoots and the possibility that the effect of added nitrogen operates through increasing winter-time dessication. Finally, we explored the possible influence of high light in combination with cold as the ultimate cause of physiological stress and visible injury.

P6.3–Variable resistance to the grassland hemi-parasitic angiosperm, *Rhinanthus minor*, and consequences for community composition

D.D. Cameron and W.E. Seel, University of Aberdeen

The northern temperate hemi-parasitic angiosperm *Rhinanthus minor* grows on a wide range of host species in traditional hay meadows and semi-natural grasslands. We found that the composition of newly sown meadow plots was influenced by the parasite within a single growing season. Significant parasite-induced reductions in the biomass of all grass species were recorded, whilst legume biomass was highly variable and most forbs showed no significant response to the presence of the parasite. This resulted in the contribution made by grasses to the total community biomass declining relative to uninfected swards, that made by legumes remaining the same and that made by forbs increasing. Parasite-infected plots effectively became more forb rich.

Using SEM, TEM and LM techniques, we discovered variation in both the structure of parasite haustoria formed on the different host species, and in the degree of parasite-induced deformation of host root cells. The parasite successfully entered host xylem vessels of grasses and legumes, but did not invade the xylem of forbs. In forbs, areas of cell fragmentation and/or dark staining were clearly visible at the host-parasite interface. The appearance of the host-parasite interface differed between species combinations.

We propose that the community level effects are due to differential host resistance, which in part, is expressed at the haustoria/root interface. A number of different

defence mechanisms may be responsible for resistance in the different host species.

P6.4–Biophysical control of leaf extension at low temperature

A.D. Farrell, J.C. Clifton-Brown, M.B. Jones, University of Dublin; and, A.D. Tomos, University of Wales, Bangor

The productivity of plants in cool climates can be limited more by leaf expansion than by photosynthesis. This is due to the reduced rate at which leaves expand to intercept radiation during canopy closure.
We have investigated the biophysical inhibition of cell expansion at lowered temperatures in *Zea mays*. Seedlings were placed with their leaf extension zone at 21, 14 or 7 °C, while the root system and mature leaves were kept at 21 °C. Turgor pressure in the growing cells was measured directly with a pressure probe.
The effect of temperature on the extension properties of tissue from the leaf extension zone was examined with a range of extensiometer techniques.
The lower temperatures resulted in a marked reduction in leaf extension rate while turgor pressure remained constant. A model of growth control based on the thermal responses in the cell walls is presented and the implications for plant productivity are discussed.

P6.5–Determining photo-respiratory fractionation and effects on carbon isotope discrimination in *Senecio* species

G.J. Lanigan, J.S. Gillon, N.R. Betson, and H. Griffiths, University of Cambridge

The effect of photo-respiration on instantaneous photosynthetic discrimination was studied by measuring gas-exchange characteristics and stable isotope composition concurrently, on leaves of three *Senecio* species of contrasting life-form (*S. squalidis*, *S. cineraria* and *S. greyii*). The rate of photo-respiration was manipulated by altering the O_2 partial pressure (pO_2). Observed discrimination (Δ_{obs}) decreased relative to modelled discrimination (Δ_i) at higher pO_2, indicating a greater input from ^{13}C-depleted photo-respiratory CO_2. These effects were observed to be species-specific, with a minimal effect of elevated pO_2 on Δ_{obs} of *S. greyii*. The observed photo-respiratory fractionation factor (f) was initially estimated for all three species (assuming that all the photo-respired CO_2 retro-diffuses), with $f = +2.5‰$ for S. squalidis/cineraria and $f = +0.7‰$ for *S. greyii*. However, when the model incorporated the proportion of photo-respiratory CO_2 re-fixed, the estimates of f increased to $f = +9‰$ (*S. squalidis/cineraria*) and $f = +11‰$ (*S. greyii*). Photo-respiratory discrimination, therefore, had an observable impact on Δ_{obs}, suggesting that, in environments promoting increases in the relative rate of photo-respiration (eg. arid/semi arid regions), this may impact on the isotopic composition of CO_2 in air, and also on leaf organic material.

P6.6–Oxygen isotope composition of phloem sap water and sugar in relation to leaf water in *Ricinus communis*

L.A. Cernusak, S. Chin Wong and G.D. Farquhar, Australian National University.

We collected phloem sap from 10 week old *Ricinus communis* plants grown in a temperature and humidity controlled glasshouse and measured the oxygen isotope enrichment of the phloem sap sugar and water relative to source water. Leaf water oxygen isotope enrichment was measured for leaves of the same plants. Phloem sap was collected both from leaf petioles and from the base of the stem. The oxygen isotope ratio of phloem sap water from both petiole and stem base was enriched compared to source water; enrichment values ranged from 2.2 to 7.2‰, with an average of 5.0‰ for the petiole and 4.2‰ for the stem base. Observed leaf water enrichment over source water ranged from 15.7 to 21.4‰, and was well correlated with the ratio of ambient to intercellular vapor pressures ($r = -0.94$, $P < 0.001$, $n = 8$). Phloem sap sugar oxygen isotope ratios did not differ between petiole and stem base ($P = 0.84$, $n = 7$), and were enriched relative to source water by values ranging from 36.4 to 41.2‰. Leaf water and phloem sap sugar enrichment over source water were well correlated ($r = 0.90$, $P = 0.002$, $n = 8$), with the difference between the two ranging from 19.8 to 22.7‰. Results will be discussed in the context of models relating the oxygen isotope ratio of plant organic matter to leaf water enrichment.

P6.7–Season-long photosynthetic and isotopic characteristics of two contrasting successional species

N.R. Betson, G.L. Lanigan, K. Maxwell and H. Griffiths, University of Cambridge

During the development of temperate broadleaved forests, two distinct successional groups of plants are clear. Fast growing, shade intolerant pioneer ‘early successional’, species colonise a region, making way for slower growing, shade tolerant ‘late successional’ species. This study focuses on the determinants of isotopic composition in Birch (*Betula pendula*—early successional, light demanding) and Beech (*Fagus sylvatica*-late successional, shade tolerant). There are two distinct

shoot phenologies associated with the different successional groups. Fast growing, pioneer species continue to produce leaves throughout the season with maximum photosynthetic activity (A_{max}) being reached slightly before full leaf expansion (FLE) and then decreasing. 'Flush' type shoots are generally associated with the slower growing, late successional species that flush most of their leaves at the start of the season over a short time period. A_{max} is attained at FLE and then maintained throughout the growth season until shortly before senescence. The last decade has seen an exponential growth in the use of stable isotopes of carbon and oxygen signals derived from plant material and atmospheric CO_2 to reconstruct past climate as well as modelling future climate change. Understanding the mechanisms controlling these signals for contrasting ecotypes and biomes is important and the study of contrasting growth and developmental patterns of the two phenological patterns under different light regimes provides a system to model real-time isotope signals as contributing to the more long-term organic signal.

P6.8–Mechanisms responsible for the variable response of plant respiration to temperature

O.K. Atkin, E.M. Covey-Crump and A. Armstrong, University of York

In addition to being a vital component of plant metabolism, plant respiration (R) also represents a major source of CO_2 release into the atmosphere. Annual respiratory CO_2 release depends in part on the sensitivity of R to the short- and long-term changes in temperature. Here, we discuss the mechanisms responsible for the variable Q_{10} (the proportional change in R with a 10 °C increase in temperature) values and degrees of acclimation exhibited by plants. Using plots of reduced ubiquinone vs. O_2 uptake in isolated mitochondria, we show why Q_{10} values vary with measurement temperature. Our analysis also demonstrates that any treatment that alters the availability of respiratory substrate affects the Q_{10}; we show that high Q_{10} values occur in tissues where respiratory flux is substrate-saturated/enzyme capacity-limited. The degree of acclimation is also highly variable amongst plant species. This variability is due, in part, to some studies exposing *pre-existing* roots/leaves to a new growth temperature whereas others compare roots/leaves that *develop* at different temperature. In most cases, maximal acclimation requires that new leaves and/or roots be developed following a change in growth temperature. The mechanisms underlying the higher degree of acclimation exhibited by newly developed tissues will be discussed.

P6.9–Circadian regulation of stomata

A.N. Dodd, J. Love and A.A.R. Webb, University of Cambridge

Stomatal movements are regulated by a diverse array of environmental, physiological and endogenous signals. These signals are integrated to provide a final stomatal aperture that tends to maximize water use efficiency (ratio of carbon assimilation to water evaporation). We are investigating the contribution that the circadian regulation of stomatal movements makes to plant water use efficiency. Each guard cell contains an endogenous circadian oscillator that is entrained by light and dark cycles. The outputs of this oscillator include rhythmic opening and closure of the stomata and rhythmic sensitivity to extracellular signals. Characteristically, these circadian responses persist in constant conditions and have a period of about 24 h. We have designed and developed a new infra-red gas analysis system that has allowed us to investigate circadian regulation of gas exchange in wild type and circadian mutants of *Arabidopsis.* We have coupled these investigations with analysis of circadian- regulated signalling processes to determine the contribution of the circadian regulation of physiology to the survival, growth and development of plants.

P6.10–Genetic manipulation of guard cell metabolism: implications for stomatal function

T. Lawson, C.A. Raines, J.C. Lloyd, J.I.L. Morison, N.R. Baker, University of Essex; S. von Caemmerer, Australian National University

Our previous work, using a high resolution chlorophyll fluorescence imaging system with intact green leaves, has shown that PSII photosynthetic efficiency (monitored through the fluorescence parameter, Fq'/Fm') of guard cell chloroplasts responds in a similar way to that of mesophyll chloroplasts to changes in PPFD, $[CO_2]$ and $[O_2]$. We have inferred from this that Rubisco activity is a major sink for the products of photosynthetic electron transport in guard cell chloroplasts. The importance of sucrose in guard cell osmoregulation has been highlighted recently and sedoheptulose-1,7-bisphosphatase (SBPase) is a key enzyme regulating carbon partitioning between sucrose and starch. We measured photosynthetic efficiency in both guard and mesophyll cells of transgenic tobacco plants (*Nicotiana tabacum* L. cv Samsun) with reduced levels of SBPase Reduced levels of SBPase resulted in similar reductions in guard cell photosynthetic efficiency as those found in mesophyll cells. Differences in CO_2 exchange and stomatal conductance between WT and transgenics are also discussed. These results confirm our suggestion that

photosynthetic metabolism is essentially similar in both guard and mesophyll cells. To extend this work we have developed transgenic plants in which Calvin cycle activity is reduced only in guard cells. Such plants will allow us to separate the effects of mesophyll and guard cell photosynthesis on stomatal function.

P6.11–Expression of aquaporin gene transcript in barley leaves during cell development and in response to abiotic stress

W. Wei, J. Eastgate and W. Fricke, University of Paisley

Aquaporins are thought to be important for water transport in plant tissues, and their expression can be affected by abiotic factors (Plant Cell Physiology 42, 686–693). In growing tissue, regulation of water transport is particularly important, since expanding cells require a constant supply of water (and solutes). Little is known about the role of aquaporins in regulating leaf growth, and there exists controversy as to which degree cellular water transport limits growth. Using RT-PCR, an mRNA transcript, which is highly homologous to a gene encoding barley plasma membrane intrinsic protein (PIP), was isolated from barley leaves. The transcript was differentially expressed in the different developmental zones of the leaf, and expression was particularly high in the elongation zone. However, even within the elongation zone, expression was not uniform, and was closely related to the local rate of cell elongation – the higher the elongation rate, the higher transcript expression. Both source reduction and salt stress altered the expression of the putative aquaporin gene transcript in the elongation zone. This paralleled changes in cell elongation rate. There were no obvious effects on transcript expression in other zones of the leaf. The results indicate that aquaporins play an important role in leaf cell expansion and in stress responses in barley.

P6.12–Rate of change in photoperiod and the intensity and timing of flowering in white yam (*Dioscorea rotundata Poir*)

E.I. Ile, P.Q. Craufurd and N.H. Battey, University of Reading and R. Asiedu, International Institute of Tropical Agriculture, Ibadan Oyo State, Nigeria

Flowering behaviour is erratic and unpredictable in white or Guinea yam (*Dioscorea rotundata*). Among flowering clones, the proportion of flowering plants, the intensity of flowering and the duration from emergence to flowering (f) varies with sowing date, latitude (location) and year. Most tropical crop species are quantitative short-day plants, wherein flowering occurs sooner at short photoperiods and warm temperatures. The control of flowering behaviour in yams has, however, not been elucidated. The objective of this study was to quantify the effects of photoperiod and temperature on the flowering behaviour of white yam. Two flowering clones, Tdr 131and Tdr 99-9, were sown in 10 different environments (sowing dates $\times$ locations) in the field Nigeria, and hence clones experienced different mean photoperiods and rates of change of photoperiod. The proportion of flowering stands and the intensity of flowering varied with sowing date and was greatest with early sowing in March and April; no plants flowered at the last sowing date, which was in August. Longer daylengths therefore increase the number of flowering plants in white yam, and this is probably related to vigour. In both clones the duration from vine (shoot) emergence to f decreased with later sowing. There was no relationship between f (in °Cd) and mean photoperiod, particularly at sowings in March and April, i.e. before the longest day. However, there was a strong relation ($R^2 = 0.87$ and $R^2 = 0.77$) between f and the rate of change of photoperiod (min d^{-1}) for Tdr 131 and Tdr 99-9 respectively.

P6.13–Responses of the C_4 plant Zea mays to elevated atmospheric CO_2 : An analysis of gene expression

J.S. Gascoigne-Owens, University of Sheffield; D. Edwards, Plant Biotechnology Centre, Agriculture Victoria, Australia; K.J. Edwards, University of Bristol, UK; M.C. Press and W.P. Quick, University of Sheffield

It is now widely accepted that, despite having internal CO_2 concentrating mechanisms, C_4 plants do respond to elevated atmospheric CO_2 concentrations. We have observed physiological, biochemical and anatomical responses of well-watered maize to elevated CO_2. The underlying genetic mechanisms of these responses remain unclear. To investigate this, we have carried out an analysis of gene expression using maize cDNA microarrays. The results of experiments carried out over a time-course of exposure to elevated CO_2 reveal substantial changes in gene expression. Changes in steady state transcript abundance and/or pattern of expression were observed following a perturbation in atmospheric CO_2 concentration. The results are discussed in the light of the known physiological and morphological responses of maize to elevated CO_2.

P6.14–Studies on the Acclimation of Photosynthesis to Light in *Arabidopsis thaliana*

C.A. Howard, P. Horton, J.E. Gray, University of Sheffield; R.G. Walters, University of Oxford

Light is an ever-changing limiting resource for plants in the natural environment. As a result, plants have developed a range of mechanisms to optimise their photosynthetic responses. Acclimation involves the optimisation of leaf structure and organelle content, specifically involving alterations in the function and composition of the photosynthetic apparatus. The aim of this project is to understand the way in which acclimation is tailored to different ecological niches, and to uncover the genes and proteins that regulate this process. It has previously been difficult to exploit the vast resource of untapped genetic variation in the large number of geographically distinct *Arabidopsis thaliana* accessions which are available, but modern molecular techniques have greatly facilitated this endeavour. To gain insights into the relationship between geographical origin and acclimation, we have characterised in detail the acclimation responses of a number of *A. thaliana* accessions to growth under a range of light intensities from 1000 μmol quanta.$m^{-2}.s^{-1}$ to 35 μmol quanta.$m^{-2}.s^{-1}$. There are marked variations in the extent and nature of the acclimation response which will be discussed. These studies will inform future QTL approaches to the investigation of acclimation. We have also adopted a transcriptomics approach in association with the GARNet Affymetrix microarray project at NASC. Analysis of changes in gene expression in the Ws-2 accession following a transfer from low light (100 μmol quanta.$m^{-2}.s^{-1}$) to high light (400 μmol quanta.$m^{-2}.s^{-1}$) or vice versa will be presented.

P6.15–A novel chloroplast-targeted protein is involved in photosystem II function following exposure to elevated light

R.G. Walters, Plant Sciences, University of Oxford; S. Bailey, University of Warwick; P. Horton, University of Sheffield

Variation in the light environment poses significant challenges to a plant. After growth under low light conditions, a prolonged increase in incident light is not only potentially damaging, necessitating a range of photoprotective responses, but also presents an opportunity for increased photosynthesis and growth. Thus, the ability to respond to changes in growth conditions by modulating the composition of the photosynthetic apparatus ('acclimation') appears to confer a selective advantage for growth in a variable habitat. A mutant of *Arabidopsis* designated *ape1* has been isolated which, although it grows normally under unvarying conditions, has an altered response to an increase in growth irradiance – compared to the wild type, it only slowly adjusts the levels of photosystem II and its associated light-harvesting complexes. Chlorophyll fluorescence analysis shows that this mutant responds normally to an increase in light in the short term, so that its photoprotective mechanisms appear unaffected, but that within one day of the light increase PSII function is severely compromised. This impacts on both the quantum yield of photosynthesis and on subsequent growth rate. Characterisation of the mutant shows it contains a T-DNA insertion in a gene encoding a protein of unknown function, At5g38660, which is only found in oxygenic photosynthetic organisms. The predicted primary sequence of this protein suggests that it is targeted to the chloroplast, probably to the thylakoid membrane. Chloroplast import studies with the products of in vitro transcription/translation are currently being carried out in order to determine the location of this newly-identified protein.

P6.16–Field performance of four broad-leaved tree species following transplantation with different soil injection treatments: evaluation of growth and plant health using in situ chlorophyll fluorescence

P.J. Lumsden, University of Central Lancashire; P. Houslay, Myerscough College

Significant losses of newly planted broad-leaved trees can occur, often due to insufficient development of new roots. Treatments which would improve rooting could therefore contribute to an improvement in tree establishment. We have investigated the efficacy of a range of treatments, including sucrose, a mycorrhizal treatment, a biostimulant, a synthetic auxin and paclobutrazol. These compounds have been applied singly or in combination as a soil injection to four different broad-leaved species, *Acer, Betula, Fagus* and *Tilia*. Trees were planted as 2 m standards in January 2002, and treatments were applied in April 2002. Measurements have been made of changes in height and girth, chlorophyll fluorescence, chlorophyll content and new root growth.
Analysis of data collected during this first season following planting and treatment will be presented and the results discussed.

P6.17–

Abstract withdrawn

P6.18–Comparison of early field performance of micropropagated and seed raised trees of *Betula utilis* 'Jaquemontii'

E.D. Elphinstone, M. Bloye and P. Houslay, Myerscough College

Betula 'Jaquemontii' is an ornamental tree grown, primarily, for its white bark produced by mature trees. Few reports compare the field performance of micropropagated plants for ornamental trees, the majority of reports concerning fruit tree performance, where budded or grafted material is used as the comparison. Seeds were collected from the same source as the original stock used for the micropropagtion material. Shoot tips and nodal stem sections were cultured on McGowan's woody plant media with 0.5 microM BAP. Seeds and rooted microproagules were raised in modules under mist with basal heat. Grown in pots under polythene and then transplanted into the field in blocks. First year field performance shows little difference in growth between microporpagated and seed raised material, although there is some indication of greater maturity of the micropropagaed material, indicated by slightly earlier leaf drop. No white bark has yet been produced by either group of trees. This data supports earlier studies with *Betula pendula* (Jones et al. 1996).

Jones, O.P. Welander, M. Waller, B.J. and Ridout, M.S. (1996) Micropropagation of adult birch trees: production and field performance. Tree Physiology 16 (5) 521–525

P6.19–Effects of stomatal closure and limited carbon dioxide supply on chlorophyll a fluorescence in flooded tomato plants

M.A. Else, Horticulture Research International, East Malling; F. Janowiak, Polish Academy of Sciences; M. B. Jackson, University of Bristol

In tomato plants, stomata close within a few hours of soil flooding and remain closed for at least 48 h. We investigated whether the stomatal response was triggered by reduced photosynthetic efficiency in young, fully expanded leaves of flooded tomato plants or has some other cause. Chlorophyll *a* fluorescence measurements, made with a PAM 2000 fluorometer, indicated that F_q'/F_m' (quantum efficiency of PS II photochemistry) decreased only after stomata began to close in flooded plants. These changes in F_q'/F_m' were due initially to flooding-induced decreases in F_v'/F_m' (an estimate of the operating efficiency of PSII photochemistry) and later to reductions in F_q'/F_v' (photochemical fluorescence quenching). Non-photochemical quenching, a measure of the amount of captured energy quenched through non-radiative decay, began to increase after 12 h of flooding but did not dissipate sufficient energy to avert damage to the photosynthetic system since F_v/F_m (a measure of the overall photosynthetic efficiency of dark-adapted plants) also decreased. Reducing ambient [CO_2] to 260 μmol mol^{-1} triggered changes in fluorescence parameters in well-drained plants that mirrored those in flooded plants. However, when the ambient [CO_2] was raised to overcome the low C_i imposed by stomatal closure, flooding-induced changes in fluorescence parameters persisted. Thus, the observed reduction in photosynthetic efficiency was not due simply to low C_i imposed by reduced stomatal apertures in flooded plants. Alternative ways by which soil flooding may reduce the efficiency of PSII photochemistry will be discussed.

P6.20–Characterising physiological and growth responses of *Arabidopsis thaliana* following a decline in temperature

P. Gan, D.J. Sherlock and O.K. Atkin, University of York

We present data from a study on *Arabidopsis thaliana* that describes the changes in photosynthesis, dark respiration and whole plant growth following a shift from a warm to cold growth regime. We monitored the three parameters following initial transfer to the cold, up to the stage when cold-shifted plants contained cold-developed leaves. In addition, photosynthesis was studied in a more detailed way such that carboxylation and photosynthetic electron transport capacities could be calculated.

P6.21–Effects of mutations in polyamine metabolism on salt tolerance

S. Kasinathan and Astrid Wingler, University College London

Polyamines have been suggested to be involved in the protection of plants against salt stress, although their exact role is under dispute. To determine the importance of polyamine synthesis for salt tolerance, four *Arabidopsis* mutants of the polyamine biosynthetic pathway (*mto1-1*, *mto2-1*, *spe1-1* and *spe2-1*) were compared to their background lines under salt stress. Both *mto* mutants over-produce methionine, a substrate involved in spermine and spermidine production, whereas the *spe* mutants have reduced levels of arginine decarboxylase, an enzyme in polyamine synthesis. The fresh weight and chlorophyll content in *spe1-1* was significantly less than in its background line, whereas both fresh weight and chlorophyll content was increased in *mto1-1*. No clear

relationship was observed with the level of salt tolerance and fresh weight or chlorophyll content in *spe2-1* or *mto2-1*. F_v/F_m, which reflects maximum photosynthetic efficiency, was measured both on the 13th day and the final day of growth. Results indicated that the *spe* mutants had a lower F_v/F_m than their background lines, whereas the *mto* mutants showed no significant difference. The polyamine content, measured in the flower, leaf and stem, was similar in the mutants and wildtype under unstressed conditions. Salt stress increased putresine levels in the wildtype, but not in *spe2-1*. Overall results suggest that polyamines may play a role in protecting plants against salt stress. Furthermore, four spermine resistant mutants have been isolated and are being characterized.

P6.22–Use of bioluminescent bacterial biosensors to quantify exudation of organic compounds from plant roots

E. Paterson and A. Sim, Macaulay Institute

The release of organic compounds from living roots is the primary driver of the elevated activity and distinct species composition of microbial communities in the rhizosphere. In turn, rates of nutrient cycling around roots are increased, which may contribute significantly to acquisition of nutrients. Direct quantification of rhizodeposition in soil is problematic due to the presence of soil organic matter and the rapid microbial utilisation of plant-derived C. In this study, we utilised a *lux*-marked bacterial biosensor to report on C-flow from roots. *Hordeum vulgare* and *Lolium perenne* were grown in systems where roots developed within a thin layer of C-free sand, supplied with contrasting concentrations of nitrate (other nutrients in excess). The biosensor was harvested from batch-culture, washed and then starved in a salts medium for 2 h. The starved biosensor was then applied uniformly to the sand layer. Bioluminescence was quantified via a CCD camera, and images were captured digitally. The results indicated that biosensor bioluminescence (proportional to utilisation of C-substrates) was confined to zones around roots and was greatest at root tips and sites of lateral emergence. For *H. vulgare*, specific root length was increased with decreasing nitrate supply, without a co-incident change in branching frequency. Therefore, there were a greater number of active exudation sites per unit root mass under low nitrate, resulting in increased specific exudation. For *L. perenne*, root branching was increased with increasing nitrate concentration and the greater number of tips and branch points contributed to increased specific exudation relative to low nitrate supply.

P6.23–Solute sorting in grass leaves: the role of the transpiration stream

W. Fricke, University of Paisley

Leaf tissues can differ in the concentration of key osmotic solutes. For example, in mature barley leaves, calcium is almost absent from the mesophyll, but high in the epidermis, whereas phosphorus and sugars distribute the opposite. Chloride accumulates preferentially in the epidermis, particularly during salt stress (Planta 192, 317–323; J Exp Bot 47, 1413–1426). It is not known how such a differential distribution of solutes is achieved, but one possibility is that solutes accumulate differentially due to differences in the pathway of water and solutes. For example, calcium and chloride might reach the epidermis in transpiration stream by-passing mesophyll cells along bundle sheath extensions. The developing grass leaf provides an ideal experimental system to test this possibility. At the base of the leaf, within the elongation zone, cells develop in a non-transpiring environment. Energy-dispersive X-ray analysis was used to determine solute concentrations in individual leaf cells and bulk extracts. Barley plants were exposed to treatments that increased the content of particular solutes. The results show that the distribution of solutes between leaf tissues in the elongation zone is very similar to that in the mature zone. It is concluded that leaf tissues differ in the concentration of solutes not so much because of differences in the supply of solutes to cells, but largely because of differences in solute uptake and storage properties of cells.

P6.24–Water and nutrient flows in the parasitic association *Rhinanthus minor*/*Hordeum vulgare*

F. Jiang and W. Hartung, Julius von Sachs Institut der Universität, Würzburg

Rhinanthus minor is a root hemiparasite that extracts water, nutrients and plant hormones from the host resulting in an improved growth and development of the parasite. *R. minor* has been cultivated on barley and a technique of modelling water and nutrient flows (Jiang et al 2001) has been adapted to quantitatively describe the water, nutrient and abscisic acid flows between both partners, the rhizosphere and their organs.
Attachment of *R. minor* to barley causes water and nutrient deficiency mainly in the stem, to some extent in the leaves but not in the roots. This results in an increased ABA content in the shoot but not in the root of the host. High amounts of ABA are synthesised in the shoot of attached *R. minor*, the largest portion of which is recirculated within the parasite. A small amount of the nutrients, extracted by the parasite is used for the

development of the *Rhinanthus* shoot, again a large portion is recirculated within the parasite.
Jiang Fan, Li CJ, Jeschke WD, Zhang FS (2001) Journal of Experimental Botany 52, 2143–2150.

P6.25–Immunolocalisation of abscisic acid and t-zeatinriboside in maize roots and other plant tissues. The effect of radial water transport

D. Schraut and W. Hartung, Julius von Sachs Institut der Universität, Würzburg

Abscisic acid (ABA) immunolocalisation has been performed with maize roots under transpiring conditions. Strong signals could be detected in the radial cell walls of the inner cortex layers of hydroponically cultivated plants, including the endodermis with the Casparian bands. Immunolocalisation of cytokinins reveals similar results. The Casparian bands of the endodermis, however, did not emit signals. These findings are consistent with an apoplastic radial transport of ABA across the cortex directly into the xylem. For zeatine riboside, however, the Casparian band seems to be an effective transport barrier.
With roots of aeroponically cultivated plants, that exhibit Casparian bands in the exodermis signals from the cortical tissue were substantially weaker pointing to the barrier properties of the exodermis. An intercellular localisation of ABA could be shown with cells of A*grobacterium* tumours growing on *Arabidopsis* with the strongest signals originating from the cytoplasm.

P6.26–Nitrogen uptake from mixed sources

B. Thornton, The Macaulay Institute and D. Robinson, University of Aberdeen

It is established that soil solutions contain mixtures of different nitrogen forms including amino acids and that plants can directly acquire amino acids by root uptake. However, the importance of organic nitrogen in the overall nitrogen budget of plants growing naturally in soil still remains unanswered. In part this is due to lack of knowledge in the acquisition of nitrogen from mixtures of different nitrogen forms, and how this is affected by changes in environmental conditions.
We grew *Lolium perenne* under sterile conditions supplied with a complete nutrient solution containing nitrogen as 1 mol m^{-3} NH_4NO_3, at two temperatures (11 °C and 21 °C). After 26-days growth ^{15}N tracers were used to quantify the nitrogen uptake over 24 hours at the temperatures of growth. Uptake (g^{-1} dw root) was determined from solutions containing a single source of nitrogen: 0.66 mol m^{-3} nitrate, 0.66 mol m^{-3} ammonium or 0.66 mol m^{-3} glycine. Additionally, uptake of each individual form of nitrogen was determined from a mixture containing all three forms of nitrogen, each at 0.66 mol m^{-3}.
Reducing the temperature reduced the uptake of nitrate and glycine whilst ammonium uptake was unaffected. All three forms of nitrogen had reduced uptake from the mixture compared with the single source solutions. The proportion of the total uptake of all three nitrogen forms as ammonium was unaffected by the presence of other forms of nitrogen whilst the proportion as nitrate was reduced and glycine increased when supplied in mixtures compared with as a single source.

P6.27–Assessment of the contribution of current assimilation in supplying carbon to root exudates of Lolium perenne using steady state ^{13}C labelling

B. Thornton; E. Paterson; A.J. Midwood; A. Sim and S.M. Pratt, The Macaulay Institute

Plant growth in temperate ecosystems often depends on microbial driven nutrient cycling processes in soil. In turn, microbial growth and activity may be limited by C availability. Root exudation of C is therefore vital in the functioning of such ecosystems.
Growth of *Lolium perenne* in sterile solution culture was coupled with the use of steady state $^{13}CO_2$ labelling. This allowed quantification of C, assimilated either before or after a specific time point, in plant compartments and root exudates. Plants were grown in atmospheres containing CO_2 at ambient concentration (372 ± 4 μmol mol^{-1}) but with contrasting $\delta^{13}C$ signatures (−13.5 ‰ or −36.1 ‰). After 27 days growth, the air supplies to the plants were reciprocally switched to the opposing $d^{13}C$ signature (day 0). Plants were destructively harvested and root exudates collected over the following 8 days. The $\delta^{13}C$ signatures of C in plant compartments (shoot, root tips and root non-tip material) and root exudates were determined.
In roots, C assimilated after day 0 was initially only detected in the tips. Assimilation pre- and post-day 0 contributed equally to exudate C at 4.5 days. Beyond day 8, assimilation pre-day 0 still contributed 41.7% of exudate C. A positive linear relationship existed between the $\delta^{13}C$ of root tips and exudate, suggesting all newly assimilated C in the exudate was from root tips.
Current results using steady state labelling imply that pulse-labelling approaches to study root exudates are discriminative in the forms of exudates labelled and in the sites from which exudation occurs.

P6.28–Photosynthetic nitrogen and water-use efficiency of Marama bean, *Tylosema esculentum*, an African legume

R.A.C. Mitchell, A.J. Keys, Rothamsted Research; Y.-H. Gong, University of Agriculture and Forestry, Yangling, China; D.W. Lawlor, Rothamsted Research

Marama bean is a tuber-producing, non-nodulating legume which grows around the southern rim of the Kalahari. It is not cultivated but has long been considered a good candidate because of its highly nutritious bean (30% protein) and edible tuber. Marama grows naturally in an extreme environment with nitrogen-deficient sandy soils, high temperatures (typical daily maximum 37 °C in growing season) and long periods of severe drought. The hypothesis tested here was that adaptation to this environment would be reflected in higher photosynthetic nitrogen-use efficiency, water-use efficiency or tolerance to high temperature. The relationship between light-saturated photosynthetic rate at Ci = 20 Pa with leaf N and rubisco content in marama was very similar to that for rice and wheat. Greater specificity of rubisco for CO_2 over O_2 could increase water-use efficiency. However, the specificity factor of purified marama rubisco was within the normal range for C3 plants and no evidence of increased photosynthesis per unit transpiration was detected under well-watered and drought conditions. There is also little evidence of improved photosynthesis at high temperature. Therefore substantial adaptation of photosynthesis to the natural marama environment does not seem to have occurred. Rather, adaptive traits were observed in closure and solar-tracking of leaves and maintenance of green leaf area under severe drought by early stomatal closure and use of tuber water reserves.

P6.29–Quantitative trait loci analysis of leaf rolling, transpiration and leaf morphology to clarify the physiology of above ground mechanisms of drought avoidance in rice

F.S. Khowaja and A.H. Price, University of Aberdeen

Identification of markers linked to genes contributing to drought resistance promises opportunities to breed high yielding rice varieties for drought prone areas. Several studies using different mapping populations have identified quantitative trait loci (QTLs) for traits theoretically related to drought resistance, especially root traits. Less emphasis has been placed on above-ground physiological processes. A mapping population of 176 F_6 lines derived from two drought resistant upland rice varieties (Azucena and Bala) with a linkage map of 154 markers was used to map QTLs for leaf morphology, leaf rolling and transpiration. Plants were grown for 6 weeks in controlled environment conditions with 3 replications. Leaves were excised and placed on a balance. Initial transpiration, time to stomatal closure, non-stomatal transpiration, leaf area, specific leaf area and the relationship between water content and leaf rolling were measured. A total of four QTLs were revealed with LOD > 3.2 for leaf area, three for specific leaf area, five for initial transpiration, one for time to stomatal closure, two for time taken for leaves to reach a roll score of 4, three for proportional water loss at leaf roll score 4, one for time taken to reach a leaf roll score 4.5 and two for proportional water loss at leaf roll score 4.5. A total of 11 regions contained QTLs of which seven influenced more than one trait. Bala was the donor for most of the drought avoidance-related QTLs. These results are discussed in relation to data on field performance and drought avoidance QTLs.

P6.30–Responses of antioxidant enzyme to cadmium stress in higher plants

R.A. Azevedo, G.J.G. Pereira, P.L. Gratão, R.A. Gomes-Junior, F.R. Capaldi, V.A. Vitorello, Universidade de São Paulo; R.F. Fornazier, R.R. Ferreira, P.F. Cardoso, Universidade Estadual de Campinas; A.P. Vitória, Universidade do Norte Fluminense; S.B. Filippi, P. Mazzafera, Universidade Estadual de Campinas and P.J. Lea, Lancaster University

Cadmium is a toxic heavy metal which normally occurs in low concentrations in soils; however, its concentration can be high in areas that have been subjected to mining. Cd can rapidly enter the plant system where it accumulates mainly in the roots. Hyperaccumulator plants that grow on metalliferous soils can translocate Cd from the roots and accumulate it in high concentrations in the shoots. Cd can also induce the production of reactive oxygen species (ROS). We studied the antioxidant responses of higher plants to Cd treatment. Seedlings were grown in increasing concentrations of $CdCl_2$, (0.01–2 mM), for up to 96 h in a hydroponic system. Most of the Cd accumulated in the roots, but some was also accumulated in the leaves. Roots and leaves were analysed for catalase (CAT), glutathione reductase (GR) and superoxide dismutase (SOD) activities. GR activity increased in the roots of all species, indicating a direct correlation with Cd accumulation. CAT activity increased in roots but to a much lesser extent when compared to GR, and varied depending upon the plant species. The analysis by native PAGE enzyme activity staining revealed several SOD isoenzymes in leaves of all plant species; however, only in radish there was a clear increase in enzyme activity. The results suggest that the main response may be via the activation of the ascorbate-glutathione cycle for the removal of hydrogen

peroxide, or to ensure the availability of reduced glutathione for the synthesis of Cd-binding proteins. (Financial support from FAPESP, Brazil, and the British Council).

P6.31–Structural changes in radish seedlings (*Raphanus sativus*) exposed to cadmium

A.P. Vitória, M. Cunha, Universidade do Norte Fluminense; A.P.M. Rodriguez, R.A. Azevedo, Universidade de São Paulo and P.J. Lea, Lancaster Univesity

Radish (*Raphanus sativus* L. var. Redondo Vermelho) seedlings were analyzed by light and scanning electron microscopy to characterize the anatomical and morphological changes caused by the exposure to 0.5 or 1.0 mM $CdCl_2$ for 24, 48 and 72 h. The analyses showed changes in the anatomical and morphological characteristics of roots, stems and leaves of two-week-old seedlings. In all tissues, loss of cell turgidity was observed. Premature death with disintegration of the epidermis and an increase in number of root hairs were observed in roots exposed to the heavy metal. The stems of seedlings exposed to cadmium exhibited an increased number of cells in the cambial layer. The main effects observed in leaves were stomatal closure, increase in chloroplast size and number, followed by a decrease in number of chloroplasts in response to the metal toxicity. This study suggests that the anatomical and morphological changes observed in seedlings treated with $CdCl_2$ were mainly caused by a decrease in water absorption due to the presence of this heavy metal. (Financial support by FAPESP, Brazil, and the British Council).

P6.32–The effect of an amino acid transporter (At5g49630) on the performance of insect herbivores: a functional genomic approach

E. Hunt, H.J. Newbury, J.S. Bale and J. Pritchard, University of Birmingham

The nutrition an aphid acquires from the sieve element sap of its host plant is a crucial factor controlling both the initiation and the development of an aphid infestation on crop plants. It is hypothesised that alterations in sieve element composition, in particular nitrogen and carbon, will significantly affect the initial acceptance or rejection of a plant, as well as aphid performance, in terms of both the growth rate of individuals and their longer-term reproductive success at the population level (fitness). This in turn suggests potential for the manipulation of selective components of the host plant phloem for the control of aphids.

In this study, knockout mutants of amino acid transporter genes, for example, an amino acid permease (AAP 6, At5g49630) in the model plant *Arabidopsis thaliana* have been used to manipulate sieve element nitrogen. Sieve element sap was extracted from mutant and control plants and analysis of solute, amino acid, sucrose and inorganic ion composition carried out. The consequent effects on aphid feeding and performance of the peach-potato aphid, *Myzus persicae,* on mutant and control plants were then studied. Aphid performance was assessed as intrinsic rate of increase, r_m. A significant difference in aphid performance on mutant and control plants has been found in preliminary experiments.

P6.33–Leaf development in lettuce: Identifying the processability traits in parents of a mapping population

F.Z. Zhang, K. Cherry, G.J.J. Clarkson, M.S. Dixon, G. Taylor, University of Southampton and S. D. Rothwell, Vitacress Salads Ltd.

Our previous research has identified leaf characteristics in baby leaves of lettuce that are linked to 'processability' – the ability of leaves to withstand the washing and packing process in the production of pre-packed salads. In order to improve salad leaves through breeding, it is necessary to determine the genetic basis of such traits. Here we report on our preliminary findings on a mapping population of lettuce that we have used to determine phenotypic differences in leaf characteristics for traits linked to processability.

Cultivated (*Lactuca sativa* L.) and wild lettuce (*L. serriola* L.) differ in leaf development. Parents from a mapping population of these two species were investigated as a first step to identify traits for processability that may be mapped as quantitative trait loci (QTL). The original seed material was supplied by R. W. Michelmore (University of California, Davis). Leaf development traits, considered to be important for baby leaf processability, include leaf area, weight, epidermal cell area, epidermal cell number and cell wall extensibility. These traits were measured 4 weeks following germination. The leaf area and cell area differed greatly between the two parents. Cell biochemical characteristics were also assessed, as were leaf surface properties. Our latest findings on a highly informative set of progeny lines from this population, for mapping QTL, will also be presented.

P6.34–What controls the size and shape of a poplar leaf?

P.J. Tricker, G. Taylor, University of Southampton; S. Jansson, K. Wissel, A. Sjödin, University of Umeå; G. Scarascia-Mugnozza, C. Calfapietra, University of Viterbo and P. Nilsson, KTH Institute, Stockholm

Leaf growth in the fast-growing tree *Populus x euramericana* was stimulated in response to long-term exposure to elevated CO_2 using FACE (free air CO_2 enrichment) technology. Temporal and spatial patterns of epidermal cell expansion and production were characterised in relation to leaf growth. The rate and timing of cell production were important in determining final leaf size and shape. Developmental stage (Leaf Plastochron Index) was the main determinant of cellular growth patterns and cell expansion and production were coupled so that cells re-entered the cycle having reached a critical size defined by developmental age. A genomic analysis of POPFACE leaves from two years and two leaf ages, using cDNA microarrays for >13 000 *Populus* leaf and wood ESTs, related cell expansion and cell cycle gene expression to measured growth. Particular attention was paid to the transcripts of cyclin genes known to regulate cell cycle phasing, to cell wall modifying agents and to hormonal stimuli and sugar signalling. These were considered likely candidates for the promotion of leaf growth through stimulated cell production under elevated CO_2. Using microarray technology we were able, for the first time, to relate altered leaf growth in elevated CO_2 to altered gene expression profiles across the genome.

P6.35–Modification of xyloglucan endotransglycosylase: consequences for leaf physiology in lettuce

G.J.J. Clarkson, M.S. Dixon, G. Taylor, University of Southampton and S.C. Fry, University of Edinburgh

A transgenic approach using *Agrobacterium tumefaciens* has been employed to modify endogenous XET activity in *Lactuca sativa* L. cv. Valeria, a 'lollo rosso' type lettuce. A fragment of xyloglucan endotransglycosylase was cloned using RT-PCR with primers designed to conserved regions from known XETs in *Arabidopsis*. Lettuce cotyledons were transformed with the XET-like fragment in antisense orientation under the control of a constitutively expressed promoter together with a gene conferring Kanamycin resistance. T_1 plants were grown to seed, the T_2 generation germinated and screened for Kanamycin resistance by daily spraying of the seedlings with the antibiotic. Expression of the antisense XET fragment was shown by northern blot.
The T_2 generation has been assayed for XET activity. Positive transformants have a reduced enzyme activity in comparison to the wild type plants. In leaf tissue, the enzyme and its endogenous donor substrate have been co-localised in the cell wall by use of a fluorescent acceptor substrate. These results and the latest findings on the impact of the reduction in XET activity on the leaf physiology of the transformants, including cell wall extensibility, leaf cell size, epidermal cell area and epidermal cell number will be presented at the meeting.

P6.36–Assessment of form and productivity at four breeding seedling orchards of *Fraxinus excelsior*: 10-yr results

E.R. Wilson and J. Clarke, University of Central Lancashire

Abstract not supplied

P6.37–The role of polar auxin transport through cherry pedicels in the regulation of fruit abscission

T. Blanusa, HRI, East Malling & Lancaster University; M.A. Else and C.J. Atkinson, HRI, East Malling; W.J. Davies, Lancaster University

Inconsistency of cropping is a major problem for the UK sweet cherry industry. Often, premature fruit abscission reduces yields severely, but the environmental cues and hormonal signals that trigger abscission are not known. Auxin (IAA) can delay abscission by reducing the sensitivity of cells in the abscission zone to ethylene, a promoter of abscission. We tested whether the capacity for polar auxin transport (PAT) through sweet cherry pedicels influenced fruit abscission. Two groups of cherry 'spurs' (short shoots), with similar leaf areas, but different numbers of fruit, were phloem girdled to limit assimilate availability. Cherries from spurs with many fruit (eight fruit) abscised within 14 days after girdling (DAG); cherries on spurs with two fruit were retained. The pedicels' capacities for PAT on spurs with different fruit numbers were determined 1, 3 and 9 DAG. Fruit were collected for endogenous IAA quantifications 3, 5, 7 and 9 DAG. PAT inhibitors tri-iodo-benzoic acid or naphthylphtalamic acid were applied to pedicels on spurs with two fruit. The effect of these inhibitors on fruit abscission was determined 14 DAG. By 9 DAG, symptoms of abscission were visible and 40% less [^{3}H]-IAA was transported through pedicels on spurs with many fruit. Fruit IAA concentrations were not different between the two groups of spurs. Application of PAT inhibitors increased fruit abscission by 30%. The relationships between PAT, fruit IAA concentration and fruit abscission will be discussed.

P6.38–Effects of two different canopy manipulations on leaf water use and photosynthesis as determined by gas exchange and stable isotope discrimination

J.M. Dunn, C.J. Atkinson, N.A. Hipps, HRI, East Malling; N.R. Betson, H. Griffiths, University of Cambridge

Trees can contribute significantly to soil moisture deficits, which may result in subsidence damage to low-rise buildings situated on shrinkable clay soils. Over the past thirty years the cost to the insurance industry of such tree-related subsidence has increased. Reduction of the leaf area is seen as a solution and wide-spread canopy manipulation has become common in urban environments. The aims of this investigation are to compare the effect of two different canopy manipulations, at the leaf level, on water use and photosynthesis using gas exchange and stable isotopic compositions of leaf, water ($\delta^{18}O$) and organic matter ($\Delta^{13}C$). During the dormant seasons of 1999–2000 and 2000–01 the leaf canopies of cherry trees were reduced by approximately 30% by crown reduction and crown thinning. Crown reduction induced very compact canopies with high leaf densities, while crown thinning induced an open canopy with low leaf densities. These differences in canopy architecture were shown to significantly alter tree water use through changes in leaf boundary layer conductance. Leaf and canopy boundary layers may alter the relationship between $\Delta^{13}C$ and WUE. The results suggest that $\delta^{18}O$ is a more reliable indicator of leaf water use when there is a significant leaf boundary layer change, providing a more direct record of leaf transpiration.

P6.39–The influence of competition and timing of damage on the response of sapling trees to browsing damage by deer

J. Millett, Macaulay Institute & University of Aberdenn; A. Hester, P. Millard, Macaulay Institute and J. Macdonald, University of Aberdeen

Semi-natural woodland expansion is an important issue in the UK. Expansion is often constrained by the effects of browsing by deer, which in many areas occur in artificially high densities due to management for sport. A field study at Creag Meagaidh NNR found differences in growth and morphology of *B.pubescens* saplings that had experienced different severities of browsing damage. Differences were also found between saplings growing in *Calluna vulgaris* dominated vegetation and *Molinia caerulea* dominated vegetation. In order to investigate possible physiological reasons for the effects seen, a pot study has been set up investigating the effect of competing vegetation type and timing of browsing damage on the growth and N dynamics of *B.pubescens* saplings. This is described.

P6.40–Analysis of *Pinus sylvestris* morphologically abnormal needles by RAPD PCR

L.B. Zelena, Institute of Cell Biology and Genetic Engineering, Kyiv

An increasing of a number of different morphological abnormalities among coniferous trees was observed under the influence of chronic irradiation in low doses at the Chernobyl region. Near 50–60% of all young spruce and pine trees from the Chernobyl zone have the samples of abnormal morphogenesis. The changeability of needle length was detected among major part of pines and spruces growing in the Chernobyl zone. In order to investigate genome diversity comparative analysis of *Pinus sylvestris* normal and morphologically dwarf needles was carried out by RAPD PCR with 15 primers. Three among 15 primers were chosen as producing polymorphic bands. A number of bands for each primer was ranged from 5 to 9 with their sizes between 2000 and 300 bp. Genetic distance between normal and dwarf needles was calculated with RAPD-PCR program and according to Nei's coefficient amounted to 0.195. PCR products allowing distinguishing morphologically abnormal and normal needles were not detected.

P6.41–Mapping QTLs for shelf life of broccoli (*Brassica oleracea* var. *botrytis*)

E. Mathas, V. Buchanan-Wollaston, D.Pink, Horticulture Research International, Wellesbourne; M.J. Kearsey, University of Birmingham

Broccoli (*Brassicao oleracea* var. *botrytis*) is a very popular and widely consumed vegetable. It has a very high nutritional value and it is currently used in a number of value-added products. However, its commercial value is affected by its relatively short life (5 days). Recent research in our laboratory has shown that there is a genetic determinant that affects shelf life of broccoli. The aim of this project is to identify regions in the genome of broccoli that determine the rate of post-harvest senescence. Thirty eight (38) double haploid (DH) broccoli lines have been produced through microspore culture from a cross between two very different storage characteristics. This mapping population was tested in a field trial that took place at HRI, Wellesbourne during the summer of 2002. The broccoli heads were harvested and stored in the dark at 21°C for 6 days. For the assess-

ment of their shelf life, the colour changes during storage were evaluated daily using both Colour Charts (Royal Horticultural Society) and a Chromameter (Minolta). The phenotypic data is presented here along with the comparison of the two methods used for the determination of greenness. Also, the expression patterns of different senescence enhanced genes have been compared in the best and worst storage broccoli line. The mapping population have been screened with a number of SSR and AFLP markers in order to generate a genetic map containing quantitative trait loci (QTL) for shelf life.

P6.43–Production Factors Effecting Marketability of Potted Pinks (*Dianthus*)

K.Y. Hawkins (University of Plymouth and
H.R. Whetman and Son

Potted pinks (*Dianthus*) are a new product being introduced into the market place. Therefore it is important to evaluate production factors affecting the marketability of potted pinks. Plants were evaluated for flowering, foliage, uniformity, and overall form and appearance (1). Five potted pink varieites were trialed and data gathered for the number of days to 1st and 3rd flower, stem height at 1st and 3rd flower and number of days to flower senescence. The results show the most suitable marketable timing, differences between varieties and pot size, differences in crop growth with different planting times, varieties and pot size. Flower initiation corresponded with variations in day length, temperature change and rainfall variations, with changes to light levels. Conditions for evaluation of flowering potted plants are provided. Further trials will be conducted exploring nutritional factors affecting plant height (2,3) Detailed studies as proposed here have not been carried out previously with pinks.

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