Environment Plant Interactions

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Research in the EPI programme seeks to describe, understand and predict how the environment impacts on plants, and how plants modify their environment – an environment that changes physically, chemically and biologically in both space and time. We focus on the efficient use of resources, such as water and minerals, and the development of sustainable and resilient arable ecosystems. We are committed to communicating our research to academics, industry, policy makers and the public in general.

Roots provide anchorage for a plant and stabilise soils In an EPSRC-funded collaboration with engineers at the University of Dundee, Glyn Bengough and Paul Hallett have demonstrated recently the beneficial effects of living roots in mechanically reinforcing soils, particularly on unstable slopes. Insights from this work have informed the landscape management strategies of organisations such as Network Rail. Our research has also identified key mechanisms involved in the development of soil structure by roots and microorganisms. Scientists from SCRI visited China and Nepal under the EU AsiaLink programme to lecture on the complex interactions between the biological and physical properties of the soil and their consequences for sustainability.

Roots explore the soil to acquire water and essential minerals In collaboration with the QHN programme, we have been analysing the composition of root exudates and its consequences for the movement of roots through the soil, releasing minerals from recalcitrant substrates, and fostering synergistic interactions with biota in the rhizosphere. Because crop growth can be constrained by physical properties of the soil, Blair McKenzie and Tracy Valentine are identifying traits that enable roots to penetrate compacted soils. In a BBSRC-funded collaboration with computer scientists at the University of Dundee, Glyn Bengough and Tracy Valentine have been developing novel computer-vision techniques to automate the analysis of root growth over

short time intervals using confocal microscopy and particle image velocimetry.

Improved fertiliser use efficiency reduces costs and pollution The EU Water Framework Directive seeks to reduce the nitrogen (N) and phosphorus (P) concentrations in surface and ground waters and, thereby, restore them to good ecological quality. To appraise the current situation, Defra commissioned Philip White and John Hammond of Warwick–HRI to update the estimates of the sources of P in UK waters. Their report indicated that agriculture contributed substantially to P pollution, and that improving P-fertiliser use efficiency would benefit the environment. This advisory work was complemented by SEERAD-funded research to identify genetic and agronomic factors to improve the use of P and N fertilisers. In parallel work, Tim George demonstrated the significance of genetic variation in rhizosphere phosphatase activity for plant P nutrition in soils with low phosphate availability.

Interactions in the rhizosphere improve plant growth and soil resilience Using a combination of traditional and molecular techniques, scientists at SCRI are able to survey complex microbial communities. In a commercial context, Scottish Enterprise is funding Tim Daniell to develop high-throughput diagnostic techniques to identify micro-organisms impacting on environmental and water quality. In an academic context, and with a focus on below ground communities, Tim Daniell has been studying the population dynamics of nitrogen cycling organisms with Ron Wheatley and the relationships between plants and their intimate symbiotic partners, such as arbuscular mycorrhizal fungi, with Maarja Öpik. In collaboration with scientists at Nanjing Agricultural University, Bryan Griffiths has shown that bacterial-feeding nematodes alter root development through changes in the rhizosphere microbial community that affect the production of plant growth regulator substances. Our studies of the resilience of soils in response to changes in agricultural practice have indicated that, whilst the physical properties of soils can improve quickly, the recovery of biological functions can take many years.

Interactions between plants and insects An area of ecological research that is rarely undertaken in managed ecosystems is the linkage between below ground and above ground biota. However, Scott Johnson, Nick Birch and colleagues have shown that even minor root herbivory by vine weevils can compromise the resistance of raspberry plants to the large raspberry aphid. Since this aphid is a vector of several major viral diseases of raspberry, this may have serious consequences for the industry. Research is now underway to determine the processes behind this phenomenon, with a view to improving plant resistance to pests. In other entomological research, Ali Karley is investigating both the effect of plant macronutrient status on plant–insect interactions and the role of aphid microbial symbionts in aphid–plant and aphid–parasitoid interactions.

Studies of the non-specific consequences and spread of transgenes in the environment This year, Bryan Griffiths and colleagues reported results from the EU ECOGEN (soil ecological and environmental evaluation of genetically modified crops) project. This project undertook field and glasshouse trials across Europe that included herbicide tolerant and Bt-maize. The data indicated that soil biology was affected greatly by soil type, tillage treatment and the stage of plant development. Factors such as crop cultivar and application of biocide had lesser effects on soil biology, and smaller still were effects attributable to genetic modification (GM). The EU SIGMEA (sustainable introduction of GM crops into European agriculture) project and several complementary Defra-funded projects led by Geoff Squire were also successfully completed, or produced major outputs, this year. The analysis of over 200,000 plant samples has provided unique insights to GM persistence in near-commercial arable ecosystems, and this knowledge has been used by Graham Begg and colleagues to develop mathematical models of gene flow in the environment. These comprehensive studies have not only informed policy makers, farmers and commercial parties, but are also enabling the development of novel techniques to study the movement and persistence of genes that underpin ecologically important traits. In related SEERAD-funded work, Pete Iannetta and colleagues are developing diagnostic molecular tests for key functional traits in plant populations as a measure of ecosystem diversity, using ecotypes of *Capsella* (shepherd's purse) as a model system.

Gladys Wright and Ron Wheatley beside an automatic weather station monitoring the environment near Mid Pilmore field plots with contrasting cultivations.

The role of plant diversity in sustaining food webs in arable ecosystems The extensive farm scale evaluations of arable biodiversity in GM crops conducted between 2000 and 2003, and subsequent SCRI investigations of seedbank diversity and GM persistence, have provided data for us to identify functional types of weed and invertebrate species and to model the relationships between weed density and crop yield. This year, Cathy Hawes and colleagues began a BBSRC-funded research project to model, and ultimately provide advice on, strategies for maintaining biodiversity within arable systems whilst maintaining crop yield, in collaboration with Dave Bohan of Rothamsted Research. This project is synergistic with other SEERAD-funded studies to elucidate the complex relationships between crop yield, biodiversity, sustainability and ecosystem resilience. In one of these, Bruce Marshall and Ali Karley are developing techniques to quantify and explore the influence of plant architecture, through its impact on competition for light and nutrients, on food webs and species diversity in arable ecosystems.

The Environment Plant Interactions Programme supports 'The Living Field' An educational project informs schoolchildren, in particular, and the public, in general, about the importance of the environment, agriculture and science. Several members of the EPI programme have manned popular exhibits at Gardening Scotland and the Dundee Flower and Food Festival to promote the opening of the Living Field Study Centre at SCRI in Spring 2007.