Environment Plant Interactions

Philip J. White

The EPI Programme comprises three Teams. The Resource Capture Team seeks to optimise energy, mineral and water use by crops for sustainable economic and environmental benefits. The Plant–Soil Interactions Team investigates the belowground interactions between plants and their abiotic and biotic environment, applying knowledge from a wide range of disciplines to monitor, understand and advise on soil resilience, sustainability and environmental quality. The Agroecology Team scales between individual interactions and landscape processes, to anticipate responses to agricultural innovations and global change. Together, these teams combine to translate basic scientific research into solutions for current and future challenges for agroecosystem management in a changing world.

The Resource Capture Team is addressing the need to maintain crop yields whilst reducing fertilizer inputs and irrigation. Philip White has already identified genetic loci affecting mineral acquisition, yield with reduced fertilizer inputs, and tissue mineral concentrations in brassica crops in collaboration with researchers at Warwick HRI and Nottingham University. This knowledge can be used to develop genetic markers for breeding programs. In collaboration with the Genetics Programme, this Team are screening the extensive barley and potato collections available at SCRI for superior genotypes in both glasshouse and field experiments. This research effort has been strengthened by the appointment of two Research Leaders: Tim George, who is studying how resource acquisition can be improved through manipulation of the rhizosphere, and Lionel Dupuy, who is modelling how plant genotype affects root architecture and resource acquisition. The recent purchase of

an inductively coupled plasma mass spectrometer has enabled a wide range of elements to be assayed, which not only facilitates work on the mineral nutrition of plants but also our investigations of the role of plant chemistry in plant–insect interactions and the effects of agriculture on geochemical processes.

Alternatives to conventional inorganic fertilisers are being trialled at SCRI. These include the phosphorus-rich product 'struvite', which can be reclaimed from sewage, and nitrogen-rich composted municipal waste. This year, Ron Wheatley undertook agricultural trials sponsored by the UK's Waste & Resources Action Programme (WRAP) to investigate the market opportunity for quality green composts in both conventional and organic systems producing barley and potatoes. In these trials, effects on weeds and disease incidence, and soil health, moisture retention and permeability and soil carbon levels, are being assessed in addition to crop yield and quality. Previous field trials with spring barley showed enhanced crop establishment and development during the early growth stages and a significant increase in grain yield.

The Plant–Soil Interactions Team has been investigating how roots grow through the soil and how this knowledge can be used to ameliorate adverse soil conditions for crop production. Glyn Bengough and colleagues from the Norwegian University of Life Sciences have been tracking the local deformations and changes in substrate density around roots as they grow through soil. Using maize mutants, they have demonstrated the importance of the root cap in this process. In parallel, computer-vision techniques for quantifying root growth and development are being developed by Nathalie Wuyts, Tracy Valentine and Lionel Dupuy in collaboration with scientists at the Universities of Cambridge, Dundee and Abertay. In work supported by the Mylnefield Trust, Blair McKenzie is developing field and glasshouse assays to identify barley varieties better able to penetrate compacted soils and exploit limited water availability.

Physical stresses experienced by field crops during the growing season, have also been investigated by this Team. These appear to depend on the location of plant roots in the soil profile. During the dry spring of 2007, they observed that the barley crop experienced mechanical impedance as the dominant physical stress, followed by periods of hypoxia in the very wet summer months before harvest. In addition, using techniques developed by Paul Hallett in collaboration with scientists from the University of Kiel, they observed that compaction stresses from tractors caused irreparable damage to the subsoil under these environmental conditions. A major EPSRC research project on ecoengineering of slopes with vegetation was also completed. This project, led by Glyn Bengough and Paul Hallett in collaboration with the Geotechnical Engineering Group at the University of Dundee, combined knowledge of soil mechanics and plant sciences to understand how plant roots reinforce soil and prevents slopes collapsing.

The EU ECOGEN Project was successfully completed this year and eleven papers from this project were published in a Special Issue of *Pedobiologia* edited by Bryan Griffiths (SCRI) and Paul Henning Krogh (University of Aarhus). This project brought together eight academic partners from five EU countries plus Monsanto to investigate the ecological and economic consequences of introducing GM crops to agriculture. It concluded that transgenic maize expressing either herbicide resistance or an insecticidal protein from *Bacillus thuringiensis* had no deleterious effect on soil biota, demonstrated the effectiveness of *Bt*-maize against the European Corn Borer, generated a predictive model to summarise the effects of soil organisms on soil quality, and suggested that, while the immediate economic benefits from adopting *Bt*-maize were small, the benefits foregone from non-adoption could be several million Euros per year for the EU-15.

The Agroecology team successfully completed the EU SIGMEA Project. This project studied gene flow in the environment, which determines whether coexistence is feasible between different forms of crop production. Geoff Squire coordinated the collation of experimental results from 24 scientific partners throughout Europe to produce the most comprehensive synthesis available of experimental data on cross pollination, seed persistence and movement, and ecological impacts in relation to the introduction of GM crops. This data has enabled the

Soil sampling for biodiversity across arable fields in the East of Scotland.

development of novel conceptual models for scaling from the individual to the landscape and produced unique insights on commonalities and differences in gene flow in the environment between geographical regions. This knowledge has linked the science of gene flow with policy on biodiversity and genotypic coexistence within the EU and its member states.

A survey of arable biodiversity and resilience in the east of Scotland, covering 60 farms from mid-Lothian to Moray, has been initiated by Cathy Hawes. This survey, together with a collaborative BBSRC-Link project with Rothamsted Research, is extending the datasets obtained during the Defra Farm Scale Evaluations to provide data for modelling the influence of trophic interactions on farmland species diversity and the ecological consequences of changes in agricultural management. This work is also providing an opportunity to discuss our research directly with farmers and assess their attitudes towards arable management, biodiversity and sustainability. In tandem with these field studies, Jane Wishart and Pete Iannetta are developing genetic markers for plant functional-traits, to enable intra-specific diversity of weed populations to be monitored and predictions of biodiversity and ecosystem services to be made.

Assays of community structure using genotyping techniques have also been developed for commercial applications. EnPrint™ is an emergent spin-out company being incubated within EPI under the auspices of Mylnefield Research Services. Using state-of-the-art molecular genotyping techniques developed through Proof of Concept Awards, Tim Daniell and colleagues aim to overcome the limitations of traditional taxonomic methods for obtaining biological indices of environmental quality. To demonstrate the efficacy of this approach they have developed a marine-monitoring assay, based on quantifying the abundance of different pelagic algae, in collaboration with the Scottish Environment Protection Agency (SEPA). They are now in the process of beta-testing a commercial system in the marketplace before offering a full commercial service in 2008.