Environment Plant Interactions

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Concerns for the environment we live in and interact with were formally recognised at the World summit meeting in Rio in 1992 resulting in the Convention on Biological Diversity. 150 world leaders agreed a comprehensive strategy for 'sustainable development', two of the three key goals being the 'conservation of biological diversity' and 'the sustainable use of its components'. More than a decade later we are now seeing these goals being addressed on many fronts. The management of agricultural and especially arable land is undergoing major changes in the light of reforms to the Common Agricultural Policy (CAP) for Europe. These reforms are driven both by economic needs of the EU and its members as well as concerns for the environment. Scotland has seen the launch of the 25 year programme, 'Scotland's Biodiversity in Your Hands', which places a responsibility of care for the environment at the forefront of national and local government planning, public bodies and commercial activities that may impact the environment. The CAP Reform has already introduced 'Decoupling' and 'Modulation'. Through decoupling farm businesses no longer receive subsidies for the production of specific food stuffs. Instead the farmer receives a single farm payment. Initially the amount of single farm payment paid to a business reflects the previous levels of subsidies received. However, it is independent of any future crops grown. More significantly, the concept of modulation will determine increasingly the transfer of money towards payments directed at activities that build a more environmentally sustainable future for the industry e.g. by paying farmers to farm in a way which promotes biodiversity.

Two thirds of all land in Scotland, some 2.9 million hectares, is classified as agricultural of which one fifth is arable. Much of the human population in Scotland lives in or is close by this arable land. The opportunities for enhancing this environment for both the benefit of the public and the longer term sustainability of the managed systems are considerable. Arable land is often the most intensively managed. On average in Great Britain, an arable crop receives ten spray applications of pesticides (note two pesticides in a single mixture counts as two applications) during its lifetime. These are predominantly fungicides and herbicides and, to a lesser extent, insecticides, desiccants and seed treatments[1]. While the number of applications has gone up the rates have gone down, so that total amounts of pesticides applied are also declining – reduced inputs used

more efficiently. The conservation and enhancement of biodiversity and the saving of particular species from extinction are seen as key objectives by the public, including many farmers. Biodiversity has become almost a mantra. In drafting advice for policy makers and producers, it is essential that we can take an objective and informed view of how changes in biodiversity, both the quantity and composition, affect the sustainability and resilience of managed systems. Through understanding how biodiversity relates to system function one is in a better position to define how best to measure changes in the environment and manage it better. It is also inescapable that such systems must be socially and economically sustainable.

The central theme of the **Environment Plant Interactions** Programme is 'The efficient use of resources in sustainable and resilient managed systems' with the emphasis on the arable sector and the landscape it resides within. Key resources are water, carbon, nitrogen and phosphorus which are brought together in a common currency of energy. Energy is ubiquitous in the agro-ecosystem e.g. solar radiation is the energy driver of primary production through photosynthesis, as stored energy held in the various chemical compounds produced within the plant; energy is transferred from one organism to another through root exudation, herbivory, predation etc. Energy is also consumed in the production of chemicals, their transport to the farm and in agricultural operations on the farm. Similarly energy is consumed when products are either recycled on the farm e.g. manure, or transported off the farm as products. In order to assess the relative sustainability of alternative managed systems one has to take a holistic view. Sustainability is the ability to hand on to successive generations managed systems that remain environmentally 'healthy' and economically viable. The environment includes above and below ground biodiversity and its functioning. The resilience of a system is the ability to tolerate perturbations such as extremes of weather, pollution events or introduction of a new management practice and still be able to return to its original dynamic state.

The Programme's research activities divide into three main areas: Plant and plant-soil interactions, Functional ecology and Ecosystem upscaling. Each research area stands on its own merit and gives added value by being committed and contributing to a core theme. Within the SEERAD strategy, the Programme makes significant contributions to Sustainable Crop Systems, Soil Quality and Soil Function, providing underpinning science for Protecting Biodiversity and Environmental-Sustainability.

Within **Plant and plant-soil interactions** the plant is seen as the central driver through which the agro-ecosystem is manipulated both through genetic manipulation of the crop plant and the way in which the crop is managed both in space and time. Areas of research include

• Soil structure and strength, which are key to a sustain-

able soil and strongly influenced by the plants and associated microbial communities that grow in it.

- Root development and exploration, which determine the spatial and temporal availability of resources both to the plant and from the plant to the soil microbial community.
- Resource acquisition, partitioning and utilization by plants, which are central to the quantity and quality of resource flows through the system and the food-webs that depend upon them.

Within **Functional ecology** the primary focus is the relation between the diversity of functional traits and key system processes: resource capture by plants and cycling of this energy, carbon and nutrients through the system via the soil and arable food webs. The overall goal is to identify sets of plant traits and their management which optimise the productivity, sustainability and resilience of the system. Two, frequently implicit, assumptions to be tested in this research are that functional diversity is more important than biodiversity *per se* and that the greater the diversity of organisms within a functional group the more resilient that process is. While a system with low diversity will have low functional diversity the converse is not necessarily true. A system comprised of many species does not necessarily mean that that system is necessarily functionally diverse. Equally, one should not ignore the diversity within species. The diversity within species is at least as important as the diversity between species. Plant breeders depend upon the diversity within a species to discover new genes that, for example, confer added disease resistance to or improve nutritional quality of new cultivars. Both above (crop, weeds, herbivores and predators) and below (roots, nematodes, N-cyclers and AM fungi of soil function) ground food webs are being studied using a combination of approaches including:

- Trait-based approaches to quantify the links between diversity and system function.
- Molecular techniques to determine the genetic basis for phenotypic variation within and between species or groups.
- Ecological impact of changes in management practices on functional diversity (above and below ground), temporal stability and productivity.
- Root exudates and root biophysical properties affecting soil-dwelling herbivores and associated feed-back mechanisms.
- Soil resilience: critical factors affecting soil biological and physical resilience.

Ecosystem upscaling is essential to be able to predict at farm- and regional-scales, the impact of a new crop variety or a change in field practice on factors such as carbon sequestration, food web activity, biodiversity, and genetic containment. In the reverse direction, predictive capability is needed to assess the effect of 'global' changes (climate, deposition, new pesticides) on the requirement for and efficacy of new crop varieties and practices. Indeed, most questions of policy are asked at these large scales (climate change, biodiversity, invasives). Initial studies will proceed both through analysis of existing extensive databases in Great Britain and the European Union and new measurements of targeted processes (energy/carbon dissipation), communities (arable plant biodiversity) and target organisms (e.g. wild and feral crucifers). The following generic topics extend the trait-based modelling of resource flows at plant and patch scales to the ecosystem:

- Assessing the sensitivity of main biophysical factors at field- and landscape-scale to new biotechnology.
- Predicting best field practice and crop cultivars to stabilise food webs over the rotation.
- Spatial-temporal characterisation of the SCRI's 'regional study areas' in Angus.
- Developing a generic modelling framework for determining how a process upscales, e.g. how a change in crop variety affects the wider environment.

The knowledge and expertise generated by the programme reaches out to many sectors in Society, as well as the scientific and commercial sectors, where it plays a strong role in influencing policy e.g. the Defra Farm Scale Evaluation trials and gene flow, and public. Most recently we have been working on a suite of new, exciting resources to inform schoolchildren and the general public about the importance of the environment, agriculture and science. The result is the Living Field CD, a multi-media project based on the Scottish Executive's 5 - 14 National Guidelines for Environmental Studies: Science. It contains more than 300 pages of high quality images, sound, games and activity sheets to reinforce the curriculum. The CD has been distributed to all Scottish Primary and Secondary schools and it has been received enthusiastically by teachers, pupils, parents and education advisers alike.

References

[1] Central Science Laboratory. (2004) *Pesticide Useage Survey Report 202. Arable Crops in Great Britain, 2004*, Central Science Laboratory, York.