

Biological Diversity and Ecosystem Function in Soil

Soil Biodiversity

NERC Thematic Programme



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Chitin degradation at Sourhope

Chitin is the most abundant nitrogen-containing biopolymer in nature and an important C and N sink. It is found in fungal cell walls, the exoskeletons of arthropods and is ubiquitous in marine ecosystems. Chitin breakdown is essential for the maintenance of nutrient cycles in soil. Currently, we lack information about the different groups of organisms degrading chitin, although actinomycetes, common soil bacteria, have been implicated in soil. The aim of our project is to investigate the molecular and functional diversity of chitinase genes, which are responsible for the degradation of chitin in soil actinomycetes. The study is examining the effects of liming on chitinolytic activity of soil. Liming is the most common agricultural treatment for grasslands and is known, as well as having extensive effects on the whole soil microbial population, to enhance actinomycete populations. We are also investigating the effects of sludge treatment (in collaboration with Ian Head, University of Newcastle) on chitin breakdown. We have taken 766 soil samples and buried 420 chitin bags of which 240 have been recovered (see Fig 1). Nylon bags the size of a teabag, containing 1 g of chitin were buried at Sourhope in August 1999. Half of the bags were recovered after five weeks, the second half after six months. Loss of chitin was determined and DNA was extracted from the chitin and from attached and free soil. After 5 weeks of incubation, 40 % of chitin was degraded and after 6 winter months 70% was gone. Bags were covered by a dense mesh of plant roots which apparently took advantage of the high microbial activity in and around the bags (Fig. 1).

Fig 1

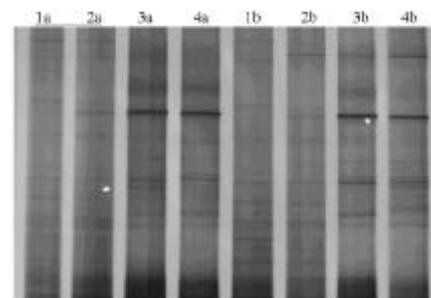


Chitin Bags

Root mesh after removing bags

Chitinolytic activity is determined by using remazol brilliant violet to label chitin. DNA was extracted for Density Gradient Gel Electrophoresis (DGGE) studies. As expected, both liming and chitin amendment increased bacterial and actinomycete counts, but the biggest effect was observed in the combined treatment. DGGE profiles using universal bacterial and actinomycete-specific primer pairs demonstrated changes in bacterial and actinomycete populations. DGGE analysis revealed profound effects of chitin on the composition of bacterial population. As can be seen from the gels in Fig 2, the population of bacteria on the chitin and in the adjacent soil share many common bands.

Fig 2



DGGE profiles of chitin bag experiment communities using a universal bacterial primer pair. Lines: 1 a&b free soil; 2 a&b attached soil; 3 a&b coarse chitin; 4 a&b fine chitin.

To determine minor differences in chitinolytic activity *in situ*, fluorimetric assays with Methyumberliferyl fluorogenic substrate labelled polymers of N-acetylglucosamine were optimised using microcosm experiments (Angela Metcalfe) with sterile soil inoculated by *Streptomyces lividans*. The colorimetric assay was not sensitive enough, but preliminary results are encouraging as we were able to distinguish exo and endo chitinolytic activity *in situ*. Polymerase Chain Reaction (PCR) primers were designed to enable us to detect and distinguish chitinase genes from different groups of bacteria (Neil Williamson), and fungi. These are currently being tested for use with environmental samples.

Dr Martin Krsek, University of Warwick

Website: <http://www.nmw.ac.uk/soilbio>

PROGRAMME WEB FORUM

A Web discussion forum has now been set up for the Soil Biodiversity Programme, as a result of the 1999 Annual Meeting held in Grange. This allows all registered users to read and post messages that may be of general interest to the Programme participants, and to form on-line discussion groups.

The forum will be for use by Soil Biodiversity Programme participants, but it is not intended as a place for posting specific arrangements or decisions. Each user will be able to access all the conferences within the forum, and can choose to be notified by email of any new messages posted to the conferences of their choice. A facility to set up private conferences for sub-groups of the Programme is also available.

Anyone who would like to register, please contact Rebecca Pinder in the Soil Biodiversity office rpinder@ceh.ac.uk

Deirdre Caffrey, Assistant Data Manager

ADDITIONAL RESEARCH AWARDS

Some additions to grants have been made by the Steering Committee and confirmed by NERC this year. The additions arose from discussions at the November 1999 PI's and subsequent Steering Committee meetings.

Award number 2113, to Dr Phil Murray of IGER, North Wyke - Biodiversity of invertebrate root feeders and their impact on soil microbial communities. The brief is to conduct a 1 year study to assess the abundance and impact of slug species on the vegetation of the Rigg Foot plots: £1650

Award number 2127, to Prof. Donald Davidson of Stirling University - Interactions of Soil Biodiversity, micromorphology, structure and organic matter. A project is to be conducted by Dr Mick Whelan, to produce a detailed topographic map of the Rigg Foot site and relate spatial and temporal variation in moisture to topographic criteria. The results will help other teams to interpret variation in observations resulting from the ridge and furrow pattern on the Rigg Foot site: £7143

Award number 2109, to Dr Pete Millard, MLURI - Management of Field Experiments at Sourhope. Extra equipment needs and site works were identified for the field site, and provision of casual labour assistance for the Site Manager, Dr Sarah Buckland, to meet requests for site vegetation data: £11,000.

Richard Scott, Programme Manager

SOURHOPE UPDATE

The second year at Sourhope is now well underway; the kids are back at gate No. 2, the grass is growing and sampling activity on the experiment is building up. The first soil sampling in 2000 was on the 8th February by Alison Rollett and Jacky Garnett but the coldest weather was yet to come. On the 8th April two molecular biologists, Andy Whitely and Rob Griffiths, experienced snow blizzards during their soil sampling expedition. Early spring also saw the introduction of earthworms at 'Sweethope', a stock-proofed area of grassland on the adjacent hillside. Re-application of nitrogen and lime on the experiment began on the 5th April. Fine, calm weather permitted application of lime to be completed in six days. The first dose of nitrogen fertiliser was applied on the 17th and 18th April just before Easter and the second dose on the 16th May, just after the first mowing of the season. Heavy rain fell in late April, washing-in well, the lime and N, and visual effects of the experimental treatments were clearly detectable by early May, as promoted growth of the swards.



By mid-May, wood anemones (*Anemone nemorosa*), occurring mainly at the bottom of the slope, have finished flowering but the wood rushes (*Luzula* spp) are almost at their peak, as are the odd patches of celandines (*Ranunculus ficaria*). The bitter vetch (*Lathyrus montanus*), sweet vernal grass (*Anthoxanthum odoratum*) and lady's-smock (*Cardamine pratensis*) are all beginning to flower with the Fescues about to follow. The leather jackets (*Tipulid* spp) are getting fat and the slugs are grazing greedily and a few ladybirds are searching out the aphids. A pair of whinchats sit on the fence posts watching me closely, along with skylarks and wheatears and on fine days curlews and higher up, buzzards, sweep across the sky, sometimes mobbed by crows. Sometimes the lapwings come and show off their acrobatics!

As spring moves into summer, Sourhope will see two extra experimental assistants; Claire Cornish, a botanist and Nick Ray, a zoologist. In July, soil samples, will be taken from which data on soil profile and vegetation cover will be obtained, before issuing a sub-section, to any group interested in making a contribution towards its description. And now, having taken 1000's of points, work by Mick Whelan and Stuart Bradley allows us to locate our soil samples on a topographical map of the site. Now time to check my emails!

Sarah Buckland, Sourhope Research Station

ECOTRON EXPERIMENT

Three days spent digging up an upland grassland, submerged in Scottish rain, convinced the Ecotron scientist that back home, in the warm dry Centre for Population Biology, there was merit in knowing exactly when it was going to rain. The trip north had been to collect our raw materials for an experiment that would use model analogues of the Sourhope grassland to understand how different soil faunal functional diversities would affect ecosystem function. The Sourhope grassland was mercilessly cut, lifted as intact blocks, wrapped in plastic and smuggled across the border in an articulated lorry. On arrival at Silwood it was divided into five horizons, homogenised, partially-sterilized and reconstructed by horizon. 16 1m² pots of soil were placed in individual chambers, the climate of each carefully controlled, as plants, microbes and soil animals, taken from the Sourhope site, were gradually added.

Under the lights that are the Ecotron sun, diverse communities now flourish. Five chambers contain only micro-fauna, five micro-and meso-fauna, and six micro-meso-and macro-fauna. Along with collaborators from within and without the Thematic Programme, the Ecotron team are assessing how a large array of parameters, from



Phil Small and Dennis Wildman, get digging

microbial to plant abundance, from the CO₂ flux to soil structure, from decomposition to collembolan diversity, respond to the differing diversities.



George Tordoff (Ecotron Technician) Homogenises the Soil Horizons.

John Newington & Mark Bradford, CPB Silwood Park

SOIL BIODIVERSITY MODELLING CONFERENCE

CEH EDINBURGH, 15TH SEPT 2000

The Soil Biodiversity Modelling Initiative has collated information on each award holders project and has been reviewing carbon and nitrogen models with a view to recommending a modelling methodology to the Steering Committee. The modelling group will be running a one day conference in September 2000 to discuss a practical way forward for modelling within the Programme. Professor Bill Hunt from NREL, Colorado will also attend. All award holders are encouraged to send a representative from their project. Any enquiries regarding the meeting will be welcomed, particularly if groups would like to present their calibration data sets. Further updates, with details of the conference will be sent to each award holder in the coming weeks. It would be greatly appreciated if each award holder could contact Mark Toal to indicate if they will be attending. mto@ceh.ac.uk

Mark Toal, CEH Monks Wood

DATA MANAGEMENT

Data management for the Programme is being handled by the UK Environmental Change Network (ECN), based at CEH Merlewood. The Soil Biodiversity Database has been designed to store information on all aspects of the Programme's research, including the site and treatments, sampling and experiments, baseline data (soils, vegetation and meteorology), project results and meta-information such as data definitions, coding systems and analytical methods.

Over the past year, information on site visits, sampling, experiments and treatments has been fed into the database on a regular basis, along with various baseline datasets. Datasets, which the originators have been happy to make freely available, are downloadable from the Soil Biodiversity website. Datasets, which are for internal Programme use only can be made accessible through the 'extranet' (restricted access website) which will shortly be available. More restricted datasets will not be connected to the Web, and would be made available only on explicit authorisation from their originators.

We are now at the stage of being able to link in further background data or interim results and would welcome any relevant data which projects would like to submit, particularly datasets which can be shared across the Programme. Everyone should have received a copy of the data template, sent out in December of last year, designed to provide a generic format by which project data and essential meta-data can be submitted. A copy is also available on the Soil Biodiversity website. Please contact us if you would like guidance or further information about its use (decaf@ceh.ac.uk).

Mandy Lane & Deirdre Caffrey, CEH Merlewood

SWEETHOPE

Three studentships tied to Prof David Hopkins' Soil Biodiversity grant are investigating the interactions between earthworms and soil microbial processes (Mark Pawlett, UEL), organic matter transformations (Hannah Bishop, Stirling) and physical structure (Christian Spring, Stirling). As part of these studies required that we manipulate the earthworm community, it was necessary to move these experiments offsite to protect the main Soil Biodiversity plots from any escapee earthworms.



In late November 1999, with many helpers, we removed 100 boxes of soil (approx. 8 t) from the control and limed plots and reburied them in an enclosure 100m away. We have named this experiment 'Sweethope'. Prior to reburial the soil in half the boxes was hand sorted to remove earthworms.



Using information collected in an earlier census of the earthworm community at the main Sourhope plots, we selected *Lumbricus rubellus* (epigeic),

Allolobophora chlorotica (endogeic) and *L. terrestris* (anecic) to be the species experimentally inoculated. The earthworms were added as a single species, or as a mixture of all the species, to both the undisturbed blocks and the hand sorted soil. The boxes to which worms were introduced were fitted with a fine mesh lid to prevent escapees and one box per plot of hand-sorted soil was left uncovered to determine the rate and composition of natural earthworm inoculation.

Hannah Bishop, University of Stirling

RIGG FOOT MICROTOPOGRAPHY

Topographic variations at Rigg Foot (due to ridge and furrow agricultural activity) result in significant systematic variability in soil moisture content which may have a considerable impact on the activity and distribution of soil organisms.

Accurate and detailed maps of the plot boundaries and the topography of the site will be produced using an electronic distance meter. This will allow the provenance of spatially referenced sample sets to be differentiated objectively on the basis of topographic criteria or to be related to other measured (or interpolated) soil properties by superimposition of the sampling plan and topographic or thematic maps. In addition, soil moisture content will be monitored continuously at a limited number of points and the spatial pattern of near-surface soil moisture content will be measured periodically using a portable 'theta probe'. The project will yield valuable information about the spatial organisation of soil moisture at this site.

Dr Mick Whelan, University of Stirling

DATES FOR THE DIARY

**27th June 2000 Steering Committee meeting,
MRC, London**

**3RD AWARD HOLDERS MEETING
8th and 9th November 2000
Warwick University**



**Centre for
Ecology & Hydrology**

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