LINKING ENVIRONMENT AND FARMING
Integrated Farm Management

The James Hutton Institute

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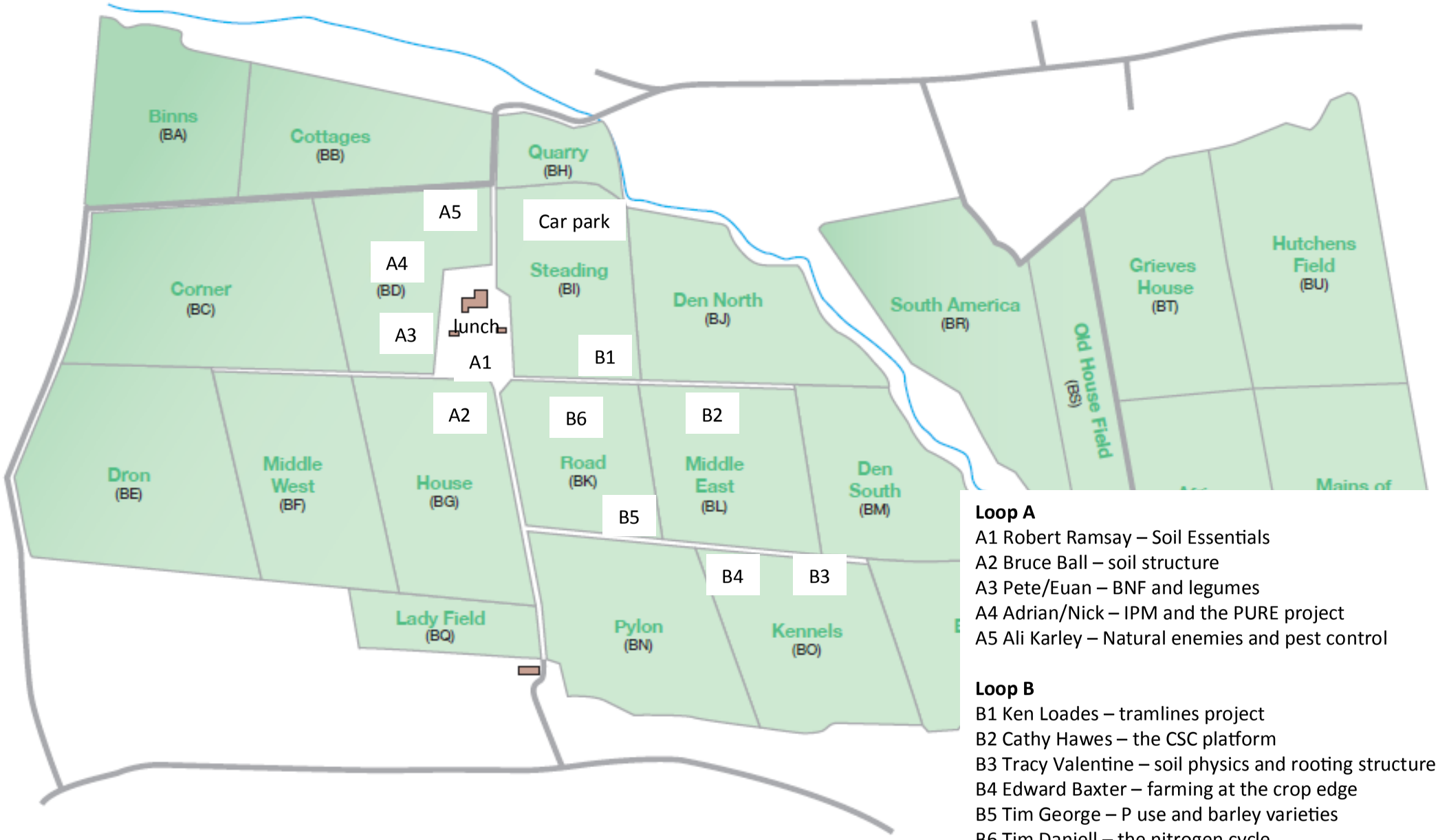
LEAF
Technical Day For Farmers

3 June 2014

The Scottish Government

Balruddery



Loop A

A1 Robert Ramsay – Soil Essentials
A2 Bruce Ball – soil structure
A3 Pete/Euan – BNF and legumes
A4 Adrian/Nick – IPM and the PURE project
A5 Ali Karley – Natural enemies and pest control

Loop B

B1 Ken Loades – tramlines project
B2 Cathy Hawes – the CSC platform
B3 Tracy Valentine – soil physics and rooting structure
B4 Edward Baxter – farming at the crop edge
B5 Tim George – P use and barley varieties
B6 Tim Daniell – the nitrogen cycle

About LEAF

LEAF (Linking Environment And Farming) promotes environmentally responsible farming. We help farmers produce good food, with care and to high environmental standards, identified in-store by the LEAF Marque logo. We build public understanding and trust of food and farming in a number of ways, including Open Farm Sunday and visits to our national network of Demonstration Farms.

Membership

LEAF is a charity and membership organisation. LEAF members receive a range of benefits including the LEAF Audit, field events, visits to Demonstration Farms, as well as regular newsletters. Becoming a LEAF member is also the first step to becoming LEAF Marque certified.

Speak Out – the LEAF communications initiative

LEAF's 'Speak Out' initiative encourages farmers to improve their communication skills and provides them with the know-how to explain 'what they do and why they do it.' Speak Out is a self-help CD-Rom that has already helped thousands of farmers tell their story. LEAF also arranges communications training events for farmers.

Making your Marque – The LEAF Marque

LEAF Marque is an assurance scheme based on LEAF farming principles. You can buy food grown on some of our members' farms in retail outlets across the country. Food carrying the LEAF Marque logo has been grown by farmers who are committed to improving the environment for the benefit of the countryside. LEAF Marque operates both in the UK and globally and is increasingly getting wide spread support throughout the food chain. See www.leafuk.org for more information.

Integrated Farm Management

LEAF's Integrated Farm Management (IFM) is a farming system which is environmentally and socially responsible and ensures the continuity of supply of safe, affordable food, while conserving and enhancing the wildlife of the countryside for future generations.

LEAF's Demonstration Farms and Innovation Centres

Our Demonstration Farms are working farms committed to sustainable farming practices and our LEAF Innovation Centres pioneer new approaches to push forward the boundaries of IFM through research and development. All these sites proudly demonstrate best practice Integrated Farm Management to a variety of different groups.

LEAF's Technical Tools

LEAF produces a range of practical management tools for farmers such as, the LEAF Audit, LEAF's Green Box, LEAF's Water Management Tool and 'Simply Sustainable Soils' guide book, all helping them adopt the sustainable farming practices of Integrated Farm Management.

Outreach

For the last 7 years LEAF has encouraged nearly one million members of the public out on to farms across the UK through Open Farm Sunday, the farming industry's annual open day. See www.openfarmsunday.org for more information.

LEAF and the Sensory Trust are working together on the Let Nature Feed Your Senses project to provide opportunities for those deprived of opportunities to connect with nature and the countryside, through food and farming. The project involves sensory rich visits to farms and nature reserves across England. See www.letnaturefeedyoursenses.org.

Blog: leafmarque.wordpress.com

www.facebook.com/linkingenvironmentandfarming

www.twitter.com/LEAF_Farming

Integrated Farm Management

THE JAMES HUTTON INSTITUTE

The James Hutton Institute is at the forefront of meeting the global challenges of providing food, energy and water from finite land and natural resources. The institute is a world-leading scientific research organisation focused on land, crops, water and the environment.

Our strengths in land, crop, waters, environmental and socio-economic sciences enable a broad range of science disciplines to interconnect, delivering knowledge, products and services that improve the quality of life.

In partnership with people, organisations and governments, our work enhances sustainable environmental, social and economic development, delivering practical solutions for our shared future and influencing the agenda for land use and development for the 21st Century.

THE JAMES HUTTON INSTITUTE AND LEAF

Scientific research at the James Hutton Institute covers a wide range of scales and disciplines from landscape processes to gene functioning.

The James Hutton Institute is also a LEAF Innovation Centre with a remit to take research to practice for the betterment of farming and food production.

In that context our priorities are:

- to understand how arable farming can provide multiple 'services' - a stable and resilient ecological infrastructure, supporting high yield and quality of products, within an attractive landscape that people feel a part of and are proud of,
- to achieve this through improving and stabilising soil structure and function, the efficient use and conservation of nitrogen and phosphorus fertiliser, the beneficial cohabitation between crops and other arable vegetation, and regulating pests without reliance on chemical pesticides,
- to demonstrate through on-farm trials and the Centre for Sustainable Cropping (CSC) that sustainable crop production is achievable and that we are getting there.

As part of its role as a LEAF Innovation Centre, the Institute is creating habitat on a large scale at Balruddery Farm, making connections and refuges for wildlife not just within its own land but to surrounding structures in the landscape.

The CSC is an experimental research platform at the Institute's Balruddery Farm near Dundee and is very germane to its role as a LEAF Innovation Centre.

Six fields, amounting to more than 40 hectares of the farm, have been reserved for a long term experiment to examine the biophysical and economic sustainability of arable farming.

While the farm as a whole is managed as an integrative unit within the surrounding landscape, the six fields of the platform operate as a rotational, split field experiment that compares best conventional practice on one half and innovative (sustainable) practice on the other half. After two years of baseline measurements, the split field experiment began in autumn 2010 with the sowing of the first winter crops.

The CSC is the first of its scale in the UK and will provide a test-bed for new sustainable management practices and crop varieties that are designed to:

- maintain yield quality and yield stability at lower levels of agrochemical inputs
- reduce greenhouse gas (GHG) emissions and nutrient leaching from the system
- enhance soil quality and arable biodiversity.

The CSC provides a broad framework for research on a wide range of system components from crop physiological stress responses to arable biodiversity and soil microbial function. It also acts as a facility for demonstration, knowledge transfer, exchange and education activities.

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The tools required to help protect soil health

Robert Ramsay
Director, SoilEssentials Ltd

Key Principles

- Soil carbon is a good indicator of overall soil health.
- Maintaining good soil biology is dependent on good soil physics and chemistry.
- What happens on the soil effects the health of the soil.
- Trafficking and cultivation vs Yield and crop residues.

Key Recommendations

- In Scotland manage Soil pH intensively to maximise nutrient availability and yield.
- Use RTK steering to reduce and control trafficking.
- Control traffic to reduce requirements for cultivation.
- Create virtual tramlines to prevent runoff.
- Use autoboom control to decrease double application.

Economic Benefits

- Reduced Lime and fertiliser bills.
- Up to 5% across the board reduction in costs from RTK.
- Up to 40% reduction in cultivation fuel use from controlled traffic.
- Increased yield from both controlled traffic and variable rate lime.

Environmental Benefits

- Reduced waste.
- Lower runoff problems.
- Increased water managing capacity from controlled traffic.
- Soil Carbon storage as an Environmental service.

Contact details for further information

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soilessentials
precision farming solutions

Soil structure

Bruce Ball
Scotland's Rural College, Edinburgh

Key Principles

- Why is soil structure important?
- What is the optimum structure for my soil?
- Why is Visual Evaluation of Soil Structure (VESS) important?
- How can VESS be used to improve soil management?

Key Recommendations

- Test representative areas and/or problem areas
- Loosen the soil gently to reveal any compact zones
- Take photographs to compare locations and times
- Plan to loosen any compact or waterlogged soil

Economic Benefits

- Optimum structure allows good yields by improving plant growth conditions
- Optimum structure keeps down tillage and fertiliser costs
- Improving soil structure improves profitability
- Good timing and location of field traffic saves soil structure
- Save fuel by subsoiling only where necessary

Environmental Benefits

- Optimum structure increases porosity and soil life and helps store nutrients
- High porosity reduces runoff and erosion
- Good structure helps climate change by allowing carbon storage and reducing greenhouse gas emissions

Contact details for further information

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Download a VESS diagnostics chart and access training videos at www.sruc.ac.uk/vess

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SRUC

Biological Nitrogen Fixation by field bean (*Vicia faba* L.)

Euan James, Laura Lopez del Egido, Cathy Hawes, Pietro Iannetta
The James Hutton Institute, Dundee

Faba beans can help improve have multiple beneficial pre-crops effects including fertiliser- and pesticide-offset, increasing post-crop yields and improving soil qualities. In addition, faba beans provide high levels of food for pollinators, and their grains can help sustainable protein production live-stock feeding (including fish-farming - see www.benas4feeds.net), and if eaten directly by humans can also help avoid the onset of diabetes and heart-disease.

Key Principles

Grain legumes such as faba bean can:

- Fix nitrogen from the air into a biologically useful form by 'biological nitrogen fixation' (BNF)
- Provide a yield without any added nitrogenous fertiliser
- Have their performance enhanced in soils with lower soil-nitrogen and higher soil-carbon contents (the "sustainable" treatment)
- By understanding BNF in grain legumes a service can be provided to help farmers maximise the nitrogen fixing capability of their faba bean (and pea) crops
- Faba bean is a crop that provides a yield and gives back to the farmed-system

Key Recommendations

- Do not fertilise your legume crop with nitrogen fertiliser
- Ensure low nitrogen levels in soils to be sown with legumes
- Use faba bean more extensively in your rotation
- Have your legume crops and soil tested for their capacity to support high levels of BNF
- If fixation is not optimal employ recommended remedial measures

Economic Benefits

- Faba beans pre-crop effects are greater than any other grain legume (in the UK)
- Faba-bean has higher rates of nitrogen fixation (under "sustainable" treatments)
- Higher gross margins through pre-crop/off-set effects (see below)

Environmental Benefits

- Pre-crop effects: fertiliser- and disease offset, soil carbon sequestration, increase available phosphorous, improved soil quality, disease off-set

Contact details for legume-BNF & soil testing or further information

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Integrated Pest Management (IPM)

Nick Birch, Adrian Newton, Graham Begg
The James Hutton Institute, Dundee

Key Principles

- Exploit multiple pest management options in the IPM toolbox
- Choose compatible/synergistic combinations of IPM tools
- Minimise "unsustainable" inputs
- Make the agro-ecosystems and plants and do the work to replace inputs (eg biocontrol to reduce reliance on pesticides)
- Based on Uses ecological and evolutionary principles to regulate agro-ecosystems, rather than short term synthetic interventions that can lead to more problematic weeds, pests and diseases (e.g. insecticide resistant pests, herbicide resistance weeds, fungicide resistant pathogens)
- Use modelling and forecasting tools to optimise IPM strategies: field-farm-landscape

Key Recommendations

- Choose more pest and disease resistant varieties
- Use complex mixtures (if markets allow)
- Reduced mixture fungicides targeted to variety weaknesses
- Optimise nutrients to promote crop vigour and tolerance
- Use pest and disease forecasting and/or treatment thresholds
- Rotation: use different crops, including fertility-building legumes
- Use weed-competitive varieties and manage non-crop habitats to sustain essential biodiversity functions (e.g. pollination, biological control, soil fertility etc)

Economic Benefits

- Reduced inputs cost less
- More yield stability → more consistent profit
- Highest yield may not be most profit
- Reduced likelihood of unpredicted epidemics
- Crop market diversity
- More resilience to biotic and abiotic stressors (e.g. climate change, invasive pests)

Environmental Benefits

- Reduced fungicides and other pesticides
- Reduced herbicides (weed competitive varieties and reduced nutrients)
- Less ground-water/diffuse nutrient pollution
- Lower carbon footprint
- Reduced losses to pests and pathogens
- Increased on-farm biodiversity, increasing long-term sustainability

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Natural Enemies and Insect Pests

Can insect ecology research improve pest biocontrol?

Alison Karley, Carolyn Mitchell and Graham Begg
The James Hutton Institute, Dundee

Key Principles

- Increasing biodiversity in arable systems can promote biological control of pests
- Conserving biodiversity at a range of scales – patch, field and landscape, can be effective
- Understanding biodiversity effects across scales is critical for optimising biocontrol

Key Recommendations

- This is a new area of research that has produced promising preliminary results
- Within-species variation in pest susceptibility to natural enemies could impair biocontrol
- Increasing the diversity of vegetation in and around fields can help conserve natural enemy populations
- Landscape context is important – the effectiveness of measures to increase biodiversity depends on the diversity of habitats in the surrounding landscape
- Understanding the local and landscape drivers of pest and natural enemy populations will help in the design of sustainable approaches to pest control

Economic Benefits

- Reduce chemical crop protection costs
- Devise alternative pest control strategies

Environmental Benefits

- Decrease reliance on chemical crop protection
- Multiple benefits of improved biodiversity

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www.hutton.ac.uk/research/groups/ecological-sciences/agroecology/research-and-applications/beneficial-insects
www.hutton.ac.uk/research/groups/ecological-sciences/agroecology/field-campaign-2014
www.pure-ipm.eu/sites/default/files/content/files/PureBooklet2014_WP10.pdf

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Reducing risks associated with autumn wheeling of combinable crops

Kenneth Loades and Blair McKenzie
The James Hutton Institute, Dundee

Key Principles

- Tramline wheelings from within agricultural crops account for ~80% of runoff and diffuse pollution losses from winter cereals
- Given pressures to improve water quality, spatially targeted measures which are practical and cost-effective are needed to limit losses from high-risk fields
- Tramlines are an important management tool but can increase risk of compaction, erosion, nutrient & sediment loss in runoff
- Project aimed at providing practical guidance to farmers in reducing tramline compaction and reducing erosion risk
- Sites monitored from October – March for 3 years
- Data collected included runoff volume, nutrient load and sediment load
- Tramline treatments assessed included sowing tramlines, sprayer installed spiked harrow and an optimal (low compaction) tyre developed by Michelin

Environmental Benefits

- Reduced surface runoff and soil erosion through use of low pressure tyres
- Significant reductions in N, key in nitrate vulnerable zones (NVZs)
- Help maintain GAEC and satisfy SPR requirements

Key Outcomes

- Correctly-inflated low ground pressure tyres reduce compaction, surface runoff and sediment loss from autumn spraying..... at NO extra cost
- Sowing tramlines has no consistent effect, as autumn spray operation still causes compaction
- **Minimise risk** - identify high risk fields (Soil Protection Review); increase tramline spacing (≥ 24 m); correctly inflate tyres; LGP tyres in autumn; careful timing
- **Adapt practice** - on high risk fields consider targeted change in land use / rotation
- **Mitigate losses** - remove near-surface soil compaction (e.g. rotary harrow unit)

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The Centre for Sustainable Cropping – can we optimise crop production and biodiversity for long term sustainability?

Cathy Hawes
The James Hutton Institute, Dundee

Key Principles

- Can we design a cropping system that maintains yield with less non-renewable inputs?
- How can we improve efficiency by reducing losses from the system, including greenhouse gas emissions, nutrient leaching and soil erosion?
- What are the benefits that can be gained from enhanced soil quality and biodiversity?

Key Recommendations

- The CSC is a long term platform: the sustainable cropping system will be designed in the first 6 year rotation (2010-2016), and then tested and demonstrated over the following 3+ rotations.
- Data is being collected to provide recommendations on:
  - Sustainable sources of plant nutrients (e.g. BNF, margin vegetation recycling, cover cropping, straw and compost incorporation).
  - Maximising plant resource use efficiency (variety choice and improved soil biophysics through organic amendments and tillage).
  - Minimising losses through erosion, greenhouse gas emissions and leaching.
  - Encouraging biodiversity for natural enemy control of pests and pollination.

Economic Benefits

- A healthy system for long-term production requiring fewer inputs.
- Potential for greater prices for better quality and sustainably managed products.
- Reduced fuel costs and tractor time.

Environmental Benefits

- Enhanced biodiversity value across the farm, not just in designated areas.
- Improved soil physical structure resulting in less soil, biodiversity and nutrient losses.
- Reduced environmental pollution.

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Effects of tillage on soil physical properties, root growth and crop yield

Tracy Valentine
The James Hutton Institute, Dundee

Key Principles

- Soil physical properties affect root growth
- Soil physical properties are influenced by soil type, tillage and weathering
- Soil compaction increases soil strength, reduces pore volume and reduces root growth
- Changes in soil pore structure also change the water holding capacity of soil
- Reduced root growth can reduce crop yield

Key Recommendations

- Large variation in the physical properties of soil across East Scotland
- New project - "Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments" includes the Tillage experiment at Pilmore (Hutton), Centre for sustainable cropping (Hutton) and STAR and NFS trials (at NIAB –TAG, Cambridgeshire)
- 4 years project aims to understand the changes in soil physical conditions over the growing season and how these impact on root growth - Paul Hallett (Aberdeen), Blair McKenzie, Tim George, Adrian Newton, Tracy Valentine (Hutton), Ron Stobart, Nathan Morris (NIAB Tag)

Economic Benefits

- Economic cost balance for tillage vs yield is being assessed (NIAB).
- Reduced fuel costs due to lower fuel usage under some tillage systems
- Better understanding of root:soil physical relationship may assist in developing varieties particularly suited and higher yielding under the newer tillage approaches

Environmental Benefits

- Potential for reduce fuel usage under some tillage systems decreasing greenhouse gas emissions
- GAEC – environmental stewardship through CAP advocating reduced tillage

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NIAB TAG

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Sustainable environment – can we easily stop loss in biodiversity on farmland?

Edward Baxter
LEAF Demonstration Farmer

Key Principles

- Increased food production is associated with reduced biodiversity.
- Edges of fields are more important to wildlife than the middle.
- The effect is **in** the crop. We farmed wildlife out – we must now farm it back in.

Key Recommendations

- 1st year of a 4 year project so the science has to be proved.
- Don't use herbicides on the outer boom width of your sprayer in cereal crops.
- Don't apply Nitrogen fertiliser.
- Rotate the wild headland around cereal fields every year.

Economic Benefits

- Effect achieved by **not** doing something.
- Across a whole farm it is 4% of cropped area.
- It is sustainable – rotating headlands avoids a build-up in weeds.
- May qualify as an ecological focus area under greening.

Environmental Benefits

- Weeds are the host plants for vital insects
- Flowering weeds produce nectar for hoverflies
- Refuge for rare arable weeds

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Rhizosheaths and root hairs for future sustainable agriculture

Tim George
The James Hutton Institute, Dundee

Key Principles

- Rhizosheaths are formations of soil around the root hair zones of plants and are the main point of contact between plants and soil.
- Rhizosheaths occur on the roots of all cereal crops and many other species have the potential to have them.
- They were first noted as a trait helping desert grass species avoid drought.
- It has been shown that larger rhizosheaths are related with tolerance to drought, nutrient deficiency and acid soils in cereals and can aid in penetration of compact soil.
- We have identified potential genes and markers for the trait in barley that may allow us to breed cultivars with better rhizosheaths for future agricultural sustainability.

Key Recommendations

- Selecting the cultivars with beneficial rhizosheaths will allow crops to cope with seasonal variation better.
- Larger rhizosheaths will allow farming systems to be run with reduced fertiliser, irrigation and lime inputs and may also be better for reduced tillage systems.
- Use of this easy to screen trait in breeding programmes will produce cultivars with better traits for future agricultural systems following environmental change.
- The benefits to crops other than cereals should be studied.

Economic Benefits

- Reduced inputs and reduced need to till land will reduce costs to farmers.
- Ability to cope with seasonal variation will limit economic risk associated with variable years.
- More efficient use of marginal land (low pH, low fertility).

Environmental Benefits

- Reduced fertiliser use will reduce the environmental costs associated with production and misuse of fertilisers.
- Reduced need for supplementary water will reduce environmental impacts of water extraction for agriculture.
- Less need for tillage will reduce the carbon footprint of agriculture and reduce the soil degradation impacts of traffic.

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Can plant selection be used to reduce environmental impact of barley growth?

Tim Daniell
The James Hutton Institute, Dundee

Human effects on the global nitrogen cycle has led to the suggestion that we are living outside the planets N limits. This is, at least in part, due to an 800% increase in Nitrogen fertilizer application through the Haber-Bosch process but only a 40% increase in use efficiency leading to environmental issues such as eutrophication of water bodies and increased nitrous oxide (N_2O) production. N_2O is an important greenhouse gas with a global warming potential around 300 times greater than that of carbon dioxide (CO_2) over a 100 year period, as well has having the potential to damage the ozone layer.

Key Principles

- Nitrogen transformations in soil are dominated by microbial processes.
- Nitrification in agricultural soil is rapid
- Nitrification converts ammonium which is relatively immobile to the highly mobile nitrate
- Denitrification occurs when Oxygen is limited
- Denitrification can result in the release of the potent greenhouse gas nitrous oxide
- Soil condition dramatically affects N cycling processes

Research Findings

- Plants can alter soil Nitrogen cycling
- There is significant variation in barley for alteration in nitrification and denitrification
- Effect driven by root exudation
- Nitrification inhibition likely driven by secondary product chemistry
- Inhibition linked to shift in rhizosphere community structure
- Denitrification driven by both quality and quantity of exudate

Possible Outcomes

- Breeding targets for reduced environmental impact
- Possible route for more efficient use of Nitrogen fertilisers

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