Focus Areas - Section 1

# Soil

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# Soil Nutrient Health Scheme

*Alex Higgins, Colleen Ward, Suzanne Higgins, JR Rao, Phil Jordan (Ulster Uni.), Julia Martin-Ortega (Leeds Uni.), Rachel Cassidy*

## Providing a baseline for farm soil nutrient management for all our farmers.

### Key Message

- The Soil Nutrient Health Scheme (SNHS) is the most comprehensive soil sampling and analysis programme ever undertaken.
- The scheme aims to enable Northern Ireland's farm businesses to optimise crop nutrient applications, reduce impact on the water environment, assess on-farm carbon and build farm resilience.

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### Background

The Scheme, which is funded by DAERA, is being rolled out across Northern Ireland in four geographic zones over the period 2022-2026 and is open to all category 1 farmers. Those participating in the scheme will receive:

1. Detailed information on the nutrient and pH status for each field, and crop-specific recommendations for the year of application
2. LiDAR-derived runoff risk maps highlighting sub-field scale hot-spots with potential for nutrient loss to waterbodies
3. Estimates of C stored in soils and as above ground biomass on each farm
4. Training on the interpretation of soil nutrient reports and generation of farm nutrient plans (provided by CAFRE).

Since starting in 2022 over 291,000 fields have been sampled and reports issued in Zones 1 and 2.

All work on the scheme is supported by a comprehensive programme of research in soils, water, carbon and behavioural change led by AFBI and with partners at both Ulster and Leeds Universities.

### Research Studies

Soils Research - Basaltic soils cover nearly a third of the landscape of NI and are characterised by high levels of minerals, including iron and aluminium. Research indicates that the Olsen Phosphorus (P) soil test, when applied to these soils, may be underestimating plant-available P. As a result, SNHS research will assess nutrient interactions and grass nutrient uptake specific and uniquely to these basalt soils through plot experiments on farms across the northeast. The soil test developed from this work will be used to provide recommendations to farmers when this area is soil tested in Year 4 of the scheme.

Water Quality and Catchment Research - Nutrient enrichment of freshwaters by P is a primary cause of water quality impairment in NI, with agriculture a key source. In catchments with high rainfall, impermeable soils and steep slopes overland flow, or runoff, is the primary pathway by which nutrients and sediment are transferred to surface waters. High-resolution LiDAR digital elevation data provides the basis for modelling hydrological connectivity in the landscape, and identifying, in conjunction with soil permeability, those areas most prone to runoff and erosion. A programme of water quality monitoring in agricultural sub-catchments across each Zone will be used to develop and relate soil nutrient status and runoff risk potential to water quality and contribute to the development of strategies for achieving water quality improvements.

Carbon Research - A high-resolution LiDAR scan of NI will provide a basis of modelling activities to estimate above ground biomass held in trees, woodlands and the 120,000 km of hedgerows in the region. SNHS is also gathering information on rates of soil C sequestration in grassland fields on selected commercial farms and along undisturbed field boundaries on different soil types in NI (involving radio-carbon dating and soil microbiological assessments).

*Fields sampled for SNHS*

*SNHS soil sampler (Photo:: Brian Moore)*

Ongoing research will investigate how fungal and bacterial communities are affected by management and elucidate mechanisms and processes governing changes in soil C storage in grassland and hedgerow soils. Information arising from this research will be used to update the UK soil C inventory, and to identify management strategies which enhance C capture by soil and above ground biomass.

Behavioural Research - An assessment of the extent to which participation in the various components of the SNHS scheme has influenced farmer awareness, attitudes and behaviour is an important component in monitoring and evaluation of overall impact. Research will apply a mixed-method approach using a questionnaire-based survey and qualitative semi-structured, in-depth interviews to explore farmers' awareness of the link between soil testing, improved productivity and water quality, and the role of experiential learning in adoption of best management practices for farm management.

## Research findings and impacts

### Key impacts:

Initial results from Zone 1 have highlighted issues with nutrient management on farms, with 57% of fields receiving a lime recommendation and 45% of fields having a surplus of P (Olsen P Index 3 and above). Low soil pH impedes nutrient uptake by the plant, and thus yields, even where nutrient levels are sufficient. Soil P excess is prone to loss to water and a major contributory factor to less than good ecological status across NI lakes and rivers. Improved farm nutrient management through SNHS soil sampling and training is key to improving nutrient use efficiency, minimising chemical fertiliser and concentrate feed imports and reducing the surpluses available for loss to the environment.

The soil test for basaltic soils will have an important role through providing farmers in those areas with corrected P recommendations for grassland fields. The research to establish a more accurate P test is ongoing at pilot sites on basalt farms and by Year 4 of the project farmers within the basalt soil areas of Zone 4 for soil sampling will receive a revised, more accurate P recommendation.

Water quality programmes developed through SNHS will contribute to the development of strategies for achieving water quality improvements across catchments and provide a focus for mitigation through the runoff risk maps. Farmers in Zone 1 of the project have received their maps which are being made accessible through the government gateway portal.

Information arising from carbon research will be used to update the UK soil C inventory, and to identify management strategies which enhance C capture by soil and above ground biomass.

The Scheme will deliver important baseline data on understanding farmer awareness, attitudes, and behaviour around nutrient management. The behavioural study research is already identifying patterns and changes required to make improvements to best management practice on farms.

## Impact for Farming for the Future

The Soil Nutrient Health Scheme will enable Northern Ireland's farmers to optimise crop nutrient applications, assess on-farm carbon stocks and build farm resilience while providing a basis to develop strategies for improving the sustainability of the region-wide soil resource, agriculture, and the environment.

# Measuring soil health

*Lisa Black, Paul Cottney and Suzanne Higgins.*

## AFBI is working towards developing key soil health indicators for Northern Ireland

### Key Messages

- Soil health is defined as a soil's ability to function and sustain plants, animals, and humans as part of the earths' ecosystem.
- A healthy soil is also one that accumulates, or at least maintains, organic carbon (C) in an intensively used agricultural system such as Northern Ireland.
- Measuring soil health requires assessment of soil chemical, physical and biological characteristics.
- Parameters defining soil health should be easy to deploy, economical, sensitive to change, and reactive to land-use change.
- AFBI data indicate that quantifying soil enzymes and soil respiration can indicate changes in soil C, acting as a proxy for monitoring soil health and the impact of land-use.
- AFBI is working towards developing soil health indicators for Northern Ireland.

### Background

In Northern Ireland, soil health is defined as a soil's ability to function and sustain plants, animals, and humans as part of the earths' ecosystem (DAERA, 2018). To function sustainably, soils need to be in good chemical, biological and physical condition so to measure soil health, chemical, physical, and biological parameters must be included. Soil chemical parameters are measured routinely on farm to determine fertiliser requirements and to inform correction of soil pH. Soil physical health can be measured by assessing soil structure, texture, and bulk density. Soil biology is complex and diverse, and this is reflected in the methodology used to assess soil biological health. Methods range from quantifying earthworm numbers and biomass to assessment of the relative numbers of soil fungi and bacteria. Measuring soil health in Northern Ireland requires selection of parameters that are easy to deploy and economical, sensitive to change but not to temporary, transient oscillations and that are reactive to land-use change. Biological parameters are underrepresented in international evaluations of soil health (Bispo, et al., 2023) and this is highlighted by the new EC Soil Health Law (EC, 2023) which demonstrates the importance of identifying ways to monitor soil health, including biological parameters, and to harmonise methodology. Work at AFBI is identifying key parameters for measuring soil health in Northern Ireland.

### Research studies

In recent years AFBI has evaluated a range of soil parameters as potential indicators for soil health in grassland and arable fields across Northern Ireland and in AFBI long-term experimental trials. Parameters measured include chemical and physical, with a focus on biological traits and soil carbon (C).

### Research findings

Relationships between soil organic C and microbiological traits, using data from a range of soils and land use types, suggest that soil biological traits have potential as indicators of soil health. Soil enzymes, soil microbial biomass and Solvita soil $CO_2$ respiration, showed highly significant correlations with the percentage of C in soil. Earthworms are a key biological soil health indicator, and their numbers and biomass are sensitive to land management practices (Figure 1).

*Table 1. A range of chemical, physical and biological parameters have been measured across a range of land management and land uses. (where N= nitrogen; C= carbon; P = phosphorous, K = potassium, Mg = magnesium and S= sulphur)*

| SOIL MEASUREMENTS TAKEN | | | | | | |
|---|---|---|---|---|---|---|
| **Soil Biology** | β-Glucosidase | Solvita soil burst test | Ergesterol | Phospholipid fatty acid analysis | | Earthworms |
| **Soil Structure** | Penetrologger | | Bulk density | | | |
| **Soil Chemistry** | Total N | Total C | Olsen P | K | Mg | S |

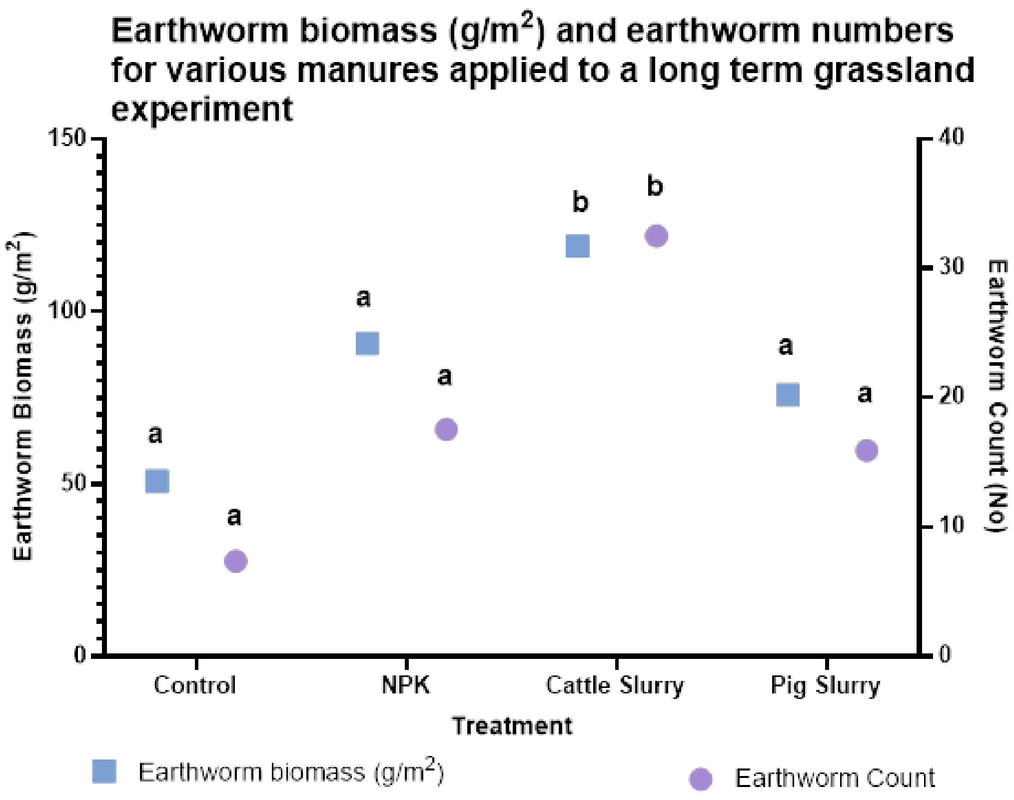


*Figure 1. Earthworm biomass and numbers in long-term grassland under a range of different management regimes.*

## Impact on Farming for the Future

Healthy soil is resilient, productive, and able to support agricultural production whilst having minimal detrimental environmental effects. AFBI is working towards providing clear guidelines for measuring soil health in Northern Ireland. While the chemical properties of soil are currently being measured under the Soil Nutrient Health Scheme, a wider assessment of soil health will be possible and highly valuable in future farming practices.

This project was funded by DAERA

# Soil carbon stock and sequestration in grasslands

*Selvakumar Dhandapani*

## Key Messages

- Grasslands store a large amount of carbon belowground.
- Soil carbon influences several physical, chemical and biological properties of soil that form the basis for soil and plant health. Hence it is integral for agricultural sustainability.
- Mitigation of greenhouse gases from grasslands globally is critical for tackling climate change.
- Sustainable management of grasslands is crucial for low carbon farming in Northern Ireland.

## Background

Globally grasslands are important ecosystems for carbon storage and climate change mitigation. It is estimated that grasslands store 236 giga tons of carbon in soil belowground globally, and 7 giga tons of carbon in aboveground biomass. The soil carbon is also an important indicator for soil health and fertility, which influences beneficial biodiversity in soil, microbial activity, nutrient availability for plants and water holding capacity. Thus, carbon sequestration in grassland soils can provide both agronomic and environmental benefits.

## Important carbon terminologies

**Carbon Stock:** Carbon stock refers to the amount of carbon stored in an ecosystem both in above ground biomass and below ground (in soil). In grassland ecosystems, the amount of carbon stored in the soil is multifold (80-94%) higher than the carbon stored in aboveground biomass. Most of the soil carbon is stored in the top 30 cm of the soil. In Northern Irish context, it was reported that 83.6% of soil carbon are stored in the top 30 cm of mineral soil grasslands. In organic soils like peat, this proportion is smaller. The top 30 cm is also the most active part of the soil carbon, where changes in carbon stock occur due to change in land-use or management practices. There is general reduction in organic carbon with depth, which also reduces other soil organic matter related functions such as water holding capacity, nutrient availability and biological activity and diversity. It should be noted that although most of the soil carbon stock is in the top layer, it is highly variable dependent on environmental conditions, and a significant amount of carbon is stored in deeper layers (going to a depth of 1 m). The carbon stored in deeper layers are relatively more stable and forms an important part of soil carbon stock.

**Carbon Sequestration:** Carbon sequestration happens when the amount of carbon accumulation in soil exceeds the amount of carbon lost. The various carbon input and output pathways are listed below.

Generally, the level of carbon stock and sequestration depends on variety of environmental conditions such as climate, type of soil, land use and management. Carbon sequestration in grasslands also take a long time from removing $CO_2$ via primary production, to final incorporation of biomass to soil carbon stock. Carbon sequestration is generally calculated by measuring the difference in soil carbon stock at two different time periods- the gap between two measurements is usually in the range of few years, as soil carbon sequestration is a slow process. The carbon sequestration measurement can further be enhanced by measuring photosynthetic rates, and ecosystem level gaseous carbon exchange. Hence, it is a complex and time-consuming task to measure carbon sequestration.

***Carbon input pathways:***

- Above ground biomass (Primary production through photosynthesis)
- Root biomass
- Hyphal/fungal biomass
- Root exudation

The main carbon input pathway is primary production through photosynthesis. Plant utilise carbon dioxide ($CO_2$) from the atmosphere, and produce biomass aboveground, which if left in the field can build up carbon on the soil surface. Similarly, roots are produced belowground as part of primary production, which builds up carbon in deeper layers. Roots further release labile carbon as root exudates to trade nutrients with soil microbes such as bacteria and fungi, which forms an active soil organic carbon pool. Plant primary production is highly dependent on soil nutrient health.

***Carbon output pathways:***

- Soil carbon emissions through microbial decomposition
- Autotrophic plant respiration
- Carbon run off (erosion and leaching)
- Use of biomass as feed for cattle/animals.

The main carbon output pathway is gaseous emissions from soil through microbial decomposition in the form of carbon dioxide ($CO_2$) from aerobic decomposition (occurring in drier conditions with oxygen availability) and methane ($CH_4$) from anaerobic decomposition (occurring in wet water-logged conditions when oxygen is not available). Autotrophic plant respiration also contributes to net $CO_2$ emissions from grasslands, however they do not contribute to carbon loss as they are part of the immediate photosynthetic cycle. Physical degradation of soils and carbon runoff and erosion has a great potential to be a big carbon loss pathway, however heavy loss through physical disturbances usually occurs only in the incidences of land-use change or natural disasters. Harvesting or grazing also results in removal of aboveground biomass which would otherwise be left in the field and incorporated to soil carbon pool.

As these carbon input and output pathways are highly dependent on environmental conditions dictated by management practices, land managers can use informed management strategies to sequester carbon in soil for both ecosystem sustainability and reduced environmental impact.

**Soil management impact on carbon dynamics:**
In a Northern Ireland context, slurry application plays an important role in soil carbon management. Slurry provides important macronutrients such nitrogen, phosphorus and potassium that are essential for plant health and primary production that locks up carbon in biomass by capturing $CO_2$ from the atmosphere. Slurry also adds carbon directly to soil and helps in direct enrichment of organic matter in soil. In these ways slurry application helps in carbon sequestration. It should be noted that carbon enrichment in soil just by application of organic amendments would not be as effective in slowing down climate change, as this carbon would be readily available to be released back into the atmosphere by microbial decomposition. However, carbon sequestration through primary production which represents the absorption of carbon dioxide from the atmosphere into the soil system, effectively slows down climate change.

Another indirect way slurry application could impact soil carbon dynamics is by influencing microbial communities in soil that take part in decomposition and mineralization of organic carbon. This aspect of slurry management on soil microbial communities and functions needs to be explored in Northern Ireland. However, this undoubtedly poses a great carbon loss mitigation potential, as grasslands store large amount of carbon belowground and microbes control carbon emissions from soil.

Furthermore, it is known that grassland soils can become saturated with carbon at some stage, and this will vary depending on soil type and environmental conditions. However controlled Long-Term Slurry (LTS) experiment on grasslands at AFBI Hillsborough site is showing that the soil under grassland under different slurry applications over the past 50 years is not yet saturated. However, this needs to be taken with caution considering the different management strategies followed by farmers across Northern Ireland that differ from controlled LTS experiment. Currently, work is under way through Soil Nutrient Health Scheme (SNHS) to further explore our understanding on soil carbon stocks and sequestration in wider areas of Northern Irish grasslands. A part of the SNHS project also focuses on microbial community properties in grassland soils, that can further shed light on microbial aspects of soil carbon dynamics, and inform beneficial management practices for soil carbon sequestration in Northern Irish grasslands.

This work is funded by DAERA.

# Evaluating the Impact of a Range of Organic Manures Applied to Arable Land

*P.Cottney; S. Higgins; N. Corchionivoschi; L. Black*

## Effect on spring barley yield and soil health after three years of consecutive spring applications of organic manures.

### Key Messages:

- Organic manures are essential in arable rotations to offset the need for inorganic fertiliser, maintain long term soil fertility and improve crop yield.
- The value of manures often only considers the nutrients available.
- Organic manures can increase crop yield, offset inorganic fertiliser, and provide a legacy benefit in the soil.
- These benefits can be incorporated into calculating the viable transport distances for manures.
- Novel organic manures and treatment techniques show promise for future land management practices.

### Background

Organic manures are essential to arable production, not only to offset inorganic fertiliser requirements, but also to improve overall soil health. Arable land is an essential nutrient sink for livestock manures and helps reduce the amount of imported inorganic fertiliser which is a key contributor to nutrient overloading on land, especially phosphorus. The RB209 gives accurate estimates of nutrient availability from organic manures and indicates legacy values. However, it is essential to understand the longer-term benefits of organic manures and evaluate their impact on crop yield over and above inorganic fertilisers.

### Research studies

Using a site with a low history of organic manure applications, a range of organic manures (Table 1) were ploughed in prior to planting in the spring, at typical industry application rates. Additional Nitrogen (N), Phosphorous (P) and Potassium (K) was applied to ensure all treatments received the same available nutrients.  The applications were made for three consecutive years.

*Slurry applications made to the 19 m x 6 m plots in March prior to ploughing and planting with spring barley.*

### Research Findings

Using certain organic manures resulted in not only considerable yield benefits, but also substantial fertiliser savings. Table 1 below demonstrates the value of the organic manures taking account of effect on crop yield, fertiliser offsetting and legacy value of nutrients. For example, if using cattle slurry the fertiliser offset value and extra yield benefit is worth £5.80 per tonne whilst the legacy fertiliser offset value to future cropping is worth £4.10 per tonne. This means that the total value of cattle slurry is £9.90 per tonne. Applying at 30 tonnes per hectare is worth an estimated £297 per hectare.

*Table 1. The Financial Value of Various Organic Manures in this Experiment compared to the 'control unfertilised' treatment*

| ORGANIC MANURE | YIELD AND FERTILISER REPLACEMENT VALUE (£/TONNE) | LEGACY NUTRIENT VALUE (£/TONNE) | TOTAL ORGANIC MANURE VALUE (£/TONNE) |
|---|---|---|---|
| Biochar | -10.9 | 4.4 | -6.5 |
| Broiler Litter pellets | 39.7 | 17.3 | 57.0 |
| Food Waste Compost | 5.3 | 6.2 | 11.5 |
| Cattle Farmyard Manure | 4.8 | 6.8 | 11.6 |
| Cattle Slurry | 5.8 | 4.1 | 9.9 |
| Control Unfertilised | 0.0 | 0.0 | 0.0 |
| Digestate Fibre | 3.9 | 6.4 | 10.3 |
| Digestate Plasma Treated | 9.8 | 2.1 | 11.9 |
| Digestate Plasma Treated - unincorporated | 6.2 | 4.8 | 11.0 |
| Digestate | 2.9 | 2.0 | 4.9 |
| Digestate -unincorporated | 1.9 | 6.3 | 8.2 |
| Fertiliser Control | 0.0 | 0.0 | 0.0 |
| Garden Waste Compost | 2.9 | 5.8 | 8.7 |
| Layer Manure | 12.7 | 5.9 | 18.6 |
| Pig Slurry | 5.4 | 2.0 | 7.4 |
| Struvite | 469.5 | 329.8 | 799.3 |

Assumptions:
Prices)- Grain Price £200/tonne of Barley, Calcium ammonium nitrate £330/tonne (£1.22/kg N), Triple Super Phosphate £510/ tonne (£1.11/kg $P_2O_5$), Muriate of Potash £500/tonne (£0.83/kg $K_2O$.
Legacy nutrient value - 8 kg of $K_20$ required to increase soil K by 1/l mg, 20 kg of $P_2O_5$ required to increase soil P by 1/l mg (PDA)
Values as of Jan 2024

These are values which have been determined from this trial using assumed prices in Table 1. Therefore, they are a reference estimation as value depends on underlying soil fertility, also the organic manure nutrient concentrations can vary significantly, and the prices for fertiliser and crop will change. The struvite is a concentrated recovered fertiliser which contains both N, P, and magnesium (Mg) and is comparable to an inorganic bagged fertiliser. It raised soil P levels significantly and improved spring barley yield which is why the value is considerably higher than all other products in Table 1.

Many of the organic manures improved long term fertility and also soil pH. No differences were observed in soil biology or soil structure. However, soil carbon and nitrogen (%) were increased after only three consecutive years of applying food waste compost.

## Potential Impact for Farming for the Future

This project quantifies the fertiliser replacement value, legacy nutrient value and effect on grain yield to value the manures. This allows a financial value per tonne to be estimated which allows viable manure transport distances to be calculated. Efficient use of organic manures can contribute to reducing the overall nutrient loading to land at a regional scale, by encouraging transport of organic manures from sources (livestock) to crop land (sink). Organic manures are variable, and response will depend on underlying soil fertility, however, this project demonstrates organic manures cannot be valued just upon immediately available nutrients. It is highly recommended to submit organic manure samples for analysis to help reduce crop fertiliser needs and improve overall gross margins.

# Contribution of earthworms to NI agriculture

*Archie Murchie*

## Valuing and safeguarding our subterranean helpers

*Earthworms, our subterranean friends*

### Key messages

- Earthworms are the dominant soil fauna in Irish agriculture.
- Earthworm populations consist of several common species existing in different niches but which interact in the soil.
- Earthworm feeding and burrowing activities recycle nutrients, aerate and drain the soil and drive microbial decomposition.
- Application of organic manures, including slurry, and even inorganic fertilisers is beneficial to earthworm populations.
- Soil tillage and the invasive New Zealand flatworm are harmful to earthworm populations.

### Background

The term 'soil health' implies a living function and it is widely appreciated that soil organisms contribute to the fertility and sustainability of soils. However, the roles of soil animals in the recycling and release of nutrients for plant uptake are not fully understood and hence valued. In Irish agriculture the dominant soil macrofauna are lumbricid earthworms.

### Research studies

AFBI research seeks to determine the contribution to soil ecosystem services and crop yield from earthworms, the threats facing them and how we safeguard earthworm functions.

Data on earthworm prevalence has been collected from several soil health experiments, most notably from the long-term slurry experiment at Hillsborough. Another area of research in which AFBI is internationally-recognised is the impact of invasive predatory flatworms on earthworm populations.

## Research findings

The numbers and densities of earthworms varies considerably but typically there are 200-600 earthworms/$m^2$ of pasture, equivalent to 2 to 6 million worms/ha[1]. In Northern Ireland, 14 species of earthworm were found in pasture fields during a survey for the New Zealand flatworm. A meta-analysis of 58 studies found that earthworm presence increased above-ground biomass of grass by an average of 24% (van Groenigen et al., 2014). Using these figures, we can calculate that the value of earthworms to NI agriculture is in the region of £80-90 million per annum.

Slurry application often results in an initial earthworm kill close to the soil surface due to the high concentrations of ammonia and inorganic salts. However, in a long-term study that examined the effects of continual seasonal applications of slurry and fertilisers to a ryegrass sward over 33 years, earthworms largely benefitted from slurry application.

The invasive 'New Zealand' flatworm (*Arthurdendyus triangulatus*) is an obligate predator of earthworms and potentially harmful to their populations. In a replicated field experiment, flatworm populations of 0.8 per $m^2$ resulted in a 20% reduction in overall earthworm biomass but they had a disproportionate impact on large, long-lived species such as *Lumbricus terrestris* which saw a reduction of 74% in their biomass.

*The invasive flatworm, Arthurdendyus triangulatus, poses a risk to our earthworm populations*

## Potential impact for farming for the future

Earthworms are often under-appreciated but perform vital ecosystem services within pasture-based systems. Soil is a living substance and to maintain soil health means that we must understand the role and contribution of soil organisms. Furthermore, we must seek to safeguard and enhance their activities to develop truly sustainable agro-ecosystems.

## Reference

**van Groenigen JW, Lubbers IM, Vos HMJ, Brown GG, De Deyn GB, and van Groenigen KJ. (2014)**. Earthworms increase plant production: a meta-analysis. Scientific Reports 4: 6365. doi 10.1038/srep06365.

This work was funded by DAERA

# SilageCheck: AFBI study investigating silage crop variability in Northern Ireland

*Suzanne Higgins and David Patterson*

## Key Messages

- Grass silage yields can vary by 5-6 t DM/ha within individual fields and between adjacent fields on the same farm, despite similar management.
- The main drivers behind yield variation include soil pH and nutrient differences across fields, topography, compaction and drainage issues.
- There is potential to improve the yields of under-performing areas using technology such as variable-rate fertiliser and slurry applications and addressing site-specific compaction and drainage issues.
- This can only be achieved through regular assessments of soil nutrient status and grass yield mapping at sub-field scale.

## Background

Optimising milk from forage is very important for the NI grassland farmer. However, a number of challenges exist, particularly in terms of climate and environmental pressures. With recent trends towards wetter winters, periods of summer drought and more frequent storm events, farmers are facing difficulties in terms of how and when they can apply slurry and fertiliser to their land. There is a need to improve nutrient use efficiency on farms, reduce the reliance on imported feedstuffs and inorganic fertiliser, and minimise emissions to the environment.

Previous AFBI research, including the GrassCheck project, found considerable variation in grass yield performance both between farms and between fields within a farm. However, a more robust study representative of the wider geoclimatic regions of NI was necessary to support these findings.

## Research Studies

AFBI has recently completed a three year on-farm project assessing the within- and between-field spatial variability in grass silage yields, grass quality and soil nutrients within ten fields across five commercial dairy farms in NI. The overall aim of the project was to identify and interpret the drivers behind areas of poor performance, and to understand how silage production may be improved across NI.

## Research Findings

Using a handheld Real Time Kinematic (RTK) differential correction GPS receiver with sub-metre accuracy, samples of grass silage were collected at geo-referenced sampling locations prior to Cut 1 and Cut 2 on five commercial dairy farms (ten fields total) (Figure 1). Results indicated a number of key findings. Grass dry matter yields varied widely within the fields, but the extent of the variability differed between fields on the same farm and between different farms.  For example:

- some fields were quite uniform (1-2 t DM/ha yield difference across a field)
- some fields were extremely variable (up to 5-6 t DM/ha yield difference across the field) (see figure 1)
- first cut silage yield generally exhibited greater variation than second cut.

Further analysis identified a number of drivers behind the yield variability, including soil pH, soil and plant nutrients and topography.

## Potential Impact for Farming for the Future:

By assessing soil nutrients and grass yields at a sub-field scale, there is potential to reduce nutrient surpluses and deficiencies, improve nutrient use efficiency and minimise nutrient loss to the environment. Technology to precision manage land, such as variable rate fertiliser and slurry spreaders, is advancing at pace. By mapping yield and nutrients, it is also possible to identify areas of fields with potential compaction or drainage issues that, if improved, could lead to lasting benefits for silage performance and overall soil health.

This project was funded by DAERA

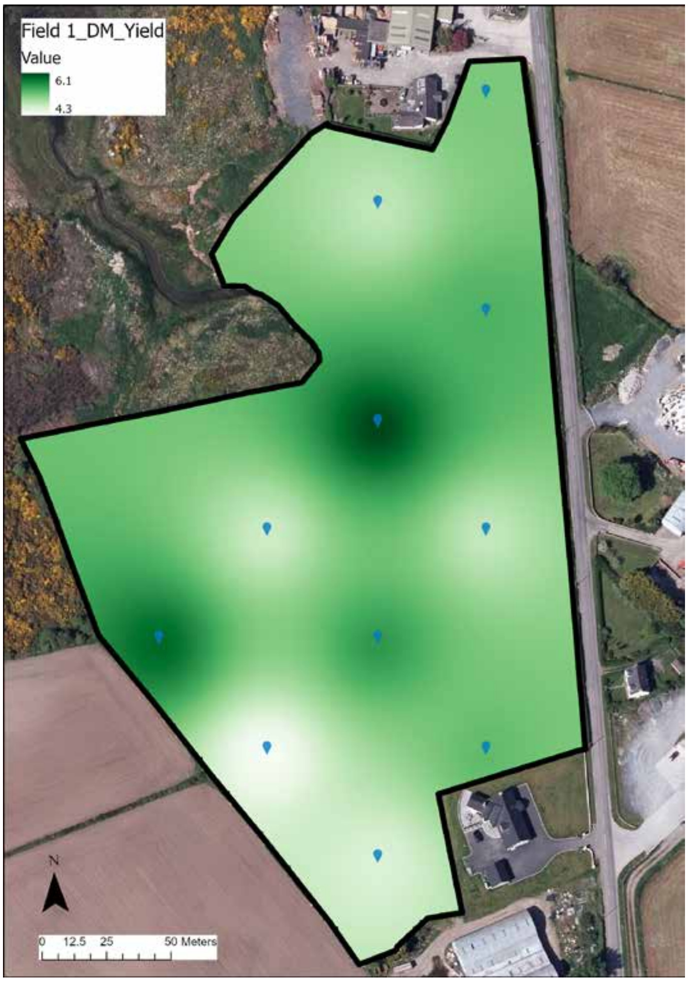


*Figure 1: Grass silage yields were mapped at Cut 1 and Cut 2 at geo-referenced sampling locations within ten silage fields across NI.*

# Soil Compaction

*Suzanne Higgins*

## Key Messages

- Compacted soil contains less oxygen, root penetration becomes difficult, and drainage is poor. Soil compaction can reduce grass yields by 25%.
- Compaction can be caused by heavy machinery and animal poaching, especially on saturated ground conditions.
- To reduce the risk of soil compaction, keep off fields when wet and reduce axle loads.
- Use large tyre diameter and width, in combination with low inflation pressure.
- Mild topsoil compaction will recover, but in severely compacted soils, expensive remediation such as subsoiling may be necessary.

## Background

Compaction, sub-optimum soil nutrient management and climate change are important factors influencing soil health, forage grass yields and grass quality. In the UK and Ireland, soil compaction has been identified as a key threat to soil health in grassland systems, mainly through machinery and livestock pressures on wet soils. Damage to soil structure through compaction not only impacts soil physical health, but also affects carbon residence time and decomposition rate, soil biota abundance and nutrient transformations. In Northern Ireland, climate change predictions and recent trends suggest wetter winters, regular periods of drought during summer, and increased frequency and intensity of storm events. This presents many challenges, including longer periods of reduced trafficability of soils, greater risk of deep and long-term soil compaction that requires expensive remedial action, poor growing conditions and reduced yields, combined with a shorter grazing season which necessitates longer winter housing of livestock.

## Causes of Compaction

Soils become compact through the repeated operation of tractors and heavy farm machinery within fields. Most farms will display some degree of soil compaction. A mildly compacted soil will normally recover naturally if the source of compaction is removed. Severely compacted soils can take years to recover, and would require some targeted intervention, otherwise productivity will be greatly reduced.

A compacted soil is where the soil particles have become consolidated beyond an optimum level (Figure 1), making root penetration difficult and reducing soil aeration, water infiltration and drainage.

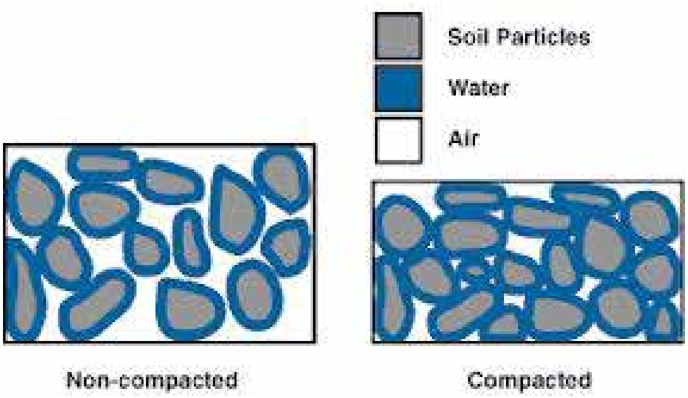


*Figure 1: A compacted soil is when soil particles have become consolidated beyond an optimum level, reducing porosity and impeding drainage.*

## Indicators of Compaction

Wet soils are more vulnerable to compaction. Indicators of compaction include areas of surface water (ponding) following rainfall, suggesting reduced infiltration; patchy crop growth, which often coincides with wheel tracks and areas of heavy trafficking (Figure 2); and soil with a 'cloddy' appearance and often containing blue mottles (through lack of oxygen).

*Figure 2: Heavy machinery such as tractors, on wet soils can cause compaction.*

In severely compacted soils, subsoiling may be the best mechanical way of relieving compaction, but 'blind' subsoiling, without prior soil examination both before and during the activity, may result in a poorly executed job of little or no value. Compaction can also be removed by using a mole-plough, aerating the soil or by cultivation.

Preventing soil compaction by careful management practices is by far a more cost effective strategy. Improving soil drainage and unblocking old drains will reduce soil wetness. Drains can become blocked frequently, particularly along hedgerows where tree roots can impede drainage channels. 'Slitting' the soil surface will improve infiltration and also free-up surface compaction.

New technology such as GPS-enabled Controlled Traffic Farming guides farm machinery along designated paths within the field, preventing machinery using the same tracks repeatedly, which is often a contributing factor to compaction.

## Potential Impact for Farming for the Future:

Minimising compaction is extremely important for the long-term health of soils. Mild surface soil compaction will recover, but deep subsoil compaction will require expensive remediation, and this should be avoided where possible.

# Leatherjackets in grassland

*Dr Archie K. Murchie, Dr Florentine Spaans, Dr Stephen Jess, Ms Jillian Hoy.*

## Integrated pest management (IPM) of a resurgent pest

*Leatherjackets, these grubs eat the roots and underground stems of grass*

### Key messages

- Instead of relying on pesticide application, integrated pest management (IPM) uses a combination of complementary pest management measures, most of which are nature based.
- Most measures are good agronomy and maintaining soil health, e.g. drainage, reseeding, liming and break crops.
- Each measure incrementally reduces leatherjacket populations.
- Tight grazing in late summer /autumn can potentially reduce cranefly egg-laying and egg survival.
- Unlike pesticide application, IPM is not instantaneous and involves pest population management over seasons.

### Background

Leatherjackets are the larval stage ('grubs') of craneflies or daddy-long-legs. The leatherjackets develop in the soil and eat the roots and underground stems of grass. High numbers of leatherjackets can significantly reduce grass yield and even lead to sward destruction.

Unfortunately, for us here in NI, leatherjackets thrive in mild, damp conditions. Prior to 2016, leatherjackets were controlled with the organophosphate insecticide chlorpyrifos but that was withdrawn from use due to human health concerns, leaving farmers with no straightforward options for pest management.

*Adult female cranefly also known as daddy-longlegs*

## Research studies

Recognising the problem with leatherjackets, AFBI and AgriSearch sought to construct an integrated pest management (IPM) framework for leatherjacket management in Fermanagh grassland. IPM is a multi-season and multi-pronged approach, which seeks to use a combination of complementary measures to reduce leatherjacket populations below economically damaging levels; whilst at the same time protecting soil health.

## Research findings

An online questionnaire survey found that 67% of NI farmers (n = 335) reported issues with leatherjackets. This figure was highest in the west, with 93% of farmers in Fermanagh and 74% in Tyrone having problems with this pest. The cost of leatherjacket damage per ha is estimated at £153 for every million leatherjackets. Leatherjacket sampling on farms in Fermanagh gave leatherjacket populations averaging 470,000 per ha (2021), 930,000 (2022) and 1.13 million (2023), corresponding to potential losses between £72 to £173 per ha. The greatest level of infestation was 5.5 million per ha.

The IPM framework consisted of long-term, medium-term and short-term measures. Most of the long-term (10 years) measures are good agronomic practices such as drainage and reseeding. Medium term (2-3 years) measures include liming, the use of a brassica break crop and potential use of multispecies swards. Whereas short-term (within the season) focussed on sward management with tight grazing in late summer /autumn having the potential to remove cranefly oviposition sites, opening the sward to reduce egg survival and stimulating plant defences.

## Potential impact for farming for the future

Chlorpyrifos was withdrawn because of possible genotoxic effects on the unborn child. Over reliance on insecticides can also have negative effects on the environment as well as fostering pest resistance to active ingredients. IPM does not exclude the use of pesticides but determines that they are used in a targeted and judicious manner. IPM approaches require a different mind-set and longer-term planning than insecticidal control.

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