

Bio4Ag Toolbox Indicators: earthworms

Background

Soil biodiversity is essential for litter decomposition, pest suppression, nutrient cycling and uptake by plants, but in cultivated soils, these functions are reduced compared to natural, undisturbed ecosystems. Soil disturbance by cultivation particularly impacts larger taxa (earthworms) but all groups are affected by high rates of agrochemical use. Earthworms are especially important in arable fields. They connect above and below ground processes and stimulate microbial activity in the soil. They maintain soil structure, cycle nutrients, increase organic matter and improve water infiltration. Earthworms, together with other arthropod groups including springtails and mites, are essential for soil food-web functioning, breaking down dead plant matter and providing resource for higher trophic groups. Less intensive management options particularly reduced tillage and retention of crop residue are needed to support earthworm related functions within arable fields.



Integrated cropping strategies

Earthworms and other soil invertebrates benefit from a combination of reduced tillage intensity, organic matter inputs, crop residue management and reduced agrochemical input. Direct drilling minimises disturbance, generates more diverse pore structure and increases large macropore volume in the top layer (0–5cm), providing habitat for a greater diversity of soil organisms. Crop residue at the soil surface also provides resources for detritivores and improves soil conditions for microbial and invertebrate foodwebs. An integrated approach, combining these interventions with crop diversification, weedy stubbles and cover cropping, enhances soil biodiversity, while also increasing C storage, nutrient cycling, reducing nutrient losses and soil erosion. At the CSC, the soil is disturbed only one year in six for potato planting and harvest. Winter wheat is sown into the disturbed soil following potato, but the remaining crops in the rotation (winter barley, oilseed, beans and spring barley) are direct drilled. Organic matter amendments include green waste municipal compost from Dundee City Council applied at 5 t ha⁻¹ yr⁻¹. Rye and mixed species cover crops are sown immediately after harvest prior to spring crop sowing to provide green cover over winter, helping to retain soil and nutrients and providing organic matter inputs from DOM and root exudates.



Results from the CSC

Earthworms were sampled from all 6 fields in spring and autumn each year from 2017 to 2024, averaging 145 m⁻² in conventional and 240 m⁻² in integrated soils across all crops, but with a strong effect of crop on treatment response and overall abundance. Number of juveniles sampled in autumn showed the largest effect of treatment, crop and rotation (Figure 1). Fields cultivated for potato and those in the following winter wheat crops (y1 and y2 in Fig.1) had the lowest number of earthworms and showed no difference between cropping system. In y3, the effect of reduced tillage in the integrated system started to impact on earthworm number, though numbers were still low overall. By y4, both treatments had recovered from the potato cultivation in y1, but numbers were significantly greater in the integrated system compared with standard cropping practice (Kruskall-Wallis H = 8.81, Chi-sq p=0.003). Earthworm rate of recovery following potato cultivation is therefore faster in integrated systems with reduced tillage and additional organic matter inputs.

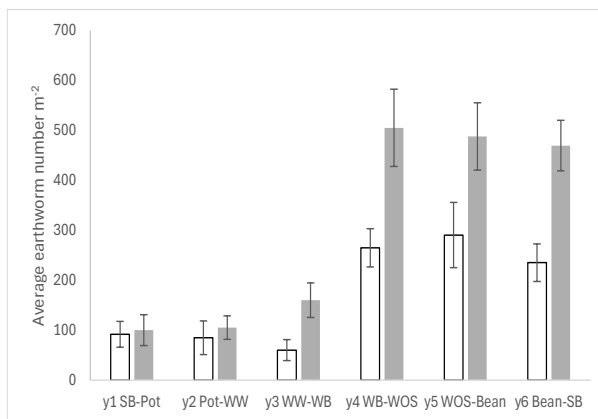


Figure 1. Average number of juvenile earthworms sampled per m² to a depth of 20cm in the conventional (open bars) and integrated (shaded bars) crop systems in the 6 fields of the CSC platform. Previous and current crop for each year in the rotation are labelled: SB (spring barley), Pot (potato), WW (winter wheat), WB (winter barley), WOS (winter oilseed), Bean (spring faba bean).

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How to measure earthworm abundance

Earthworms are an excellent indicator of soil health and sustainable management, particularly in terms of the frequency and intensity of disturbance and the amount of organic matter present. Surface active, litter dwelling species will be more abundant where crop residue is left as a mulch; top layer species are sensitive to disturbance and respond rapidly to organic matter inputs; deep burrowing species thrive in undisturbed conditions and are important ecosystem engineers, creating drainage channels and moving dead organic matter to deeper layers of the soil.

For a comparative assessment of earthworm abundance across fields or between farms, follow the simple instructions below.

Equipment: 20 x 20 cm quadrat, trowel, white tray, pot for worms, record sheet, camera, ruler

Timing:

Sample 1. late March/early April (before sowing if possible)

Sample 2. October/November (after crops are harvested)

Field conditions: Sample when soil is damp (preferably after rain) but not when waterlogged or frozen.

Location: Carry out assessments at 9 locations in each field arranged in a W pattern to achieve full coverage across the field.

Procedure:

1. Record soil conditions (dry, damp, wet), field conditions (stubble, ploughed, cultivated, sown) and the date
2. At each sample point, count and record the number of middens and wormcasts in a 20 x 20 cm quadrat.
3. Dig out a 20 x 20 x 20 cm soil pit and place soil on a white tray.
4. Hand sort through the soil and place all worms into a pot.
5. Empty tray of soil into pit and brush clean.
6. Tip pot of worms out onto the clean tray.
7. Record the number of juveniles and return them to the pit.
8. Place ruler and a label indicating the sample location and date next to the adult worms and take photograph.
9. Record number of adults in each functional group (see over) and return them to the pit.

Useful links

- <https://www.rothamsted.ac.uk/news/earthworm-research-spurs-farmers-act>
- <https://agricology.co.uk/blog/30minworms-survey-get-involved/>
- <https://agricology.co.uk/resource/know-your-soils-2-earthworm-quiz/>
- <https://www.nfuonline.com/updates-and-information/10-top-facts-about-earthworms/>
- Chan, K.Y. (2001) An overview of some tillage impacts on earthworm population abundance and diversity — implications for functioning in soils. Soil and Tillage Research 57, 179-191.
- Hawes, C., Iannetta, P.P.M., Squire, G.R. (2021) Agroecological practices for whole system sustainability. CAB Reviews, 16, no. 005. <https://doi.org/10.1079/PAVSNNR202116005>
- Stroud, J.L. (2019) Soil health pilot study in England: Outcomes from an on-farm earthworm survey. Plos one 14(2): e0203909 <https://doi.org/10.1371/journal.pone.0203909>
- <https://csc.hutton.ac.uk>
- https://csc.hutton.ac.uk/resource/Handbook_of_indicators_v1.pdf

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Earthworm ID Guide

Midden: pile of straw or stones over a permanent burrow



Wormcasts: digested soil produced by *Aporrectodea* and *Lumbricus* spp



Juveniles: no saddle



Adults: with saddle



Adult functional groups: 3 types

Surface worms



Size: small
(matchstick, <8mm),

Colour: red

Habit: fast moving,
found in leaf litter

Topsoil worms



Size: small-medium
Colour: pink, grey,
green, mottled yellow

Habit: most common,
found in topsoil

Deep burrowers



Size: large (>8mm)
Colour: red or black
head

Habit: large, vertical
burrows, middens