ECOWORM

Erosion control in arable land through the management of earthworm communities

Key messages for ecological erosion control

Key messages

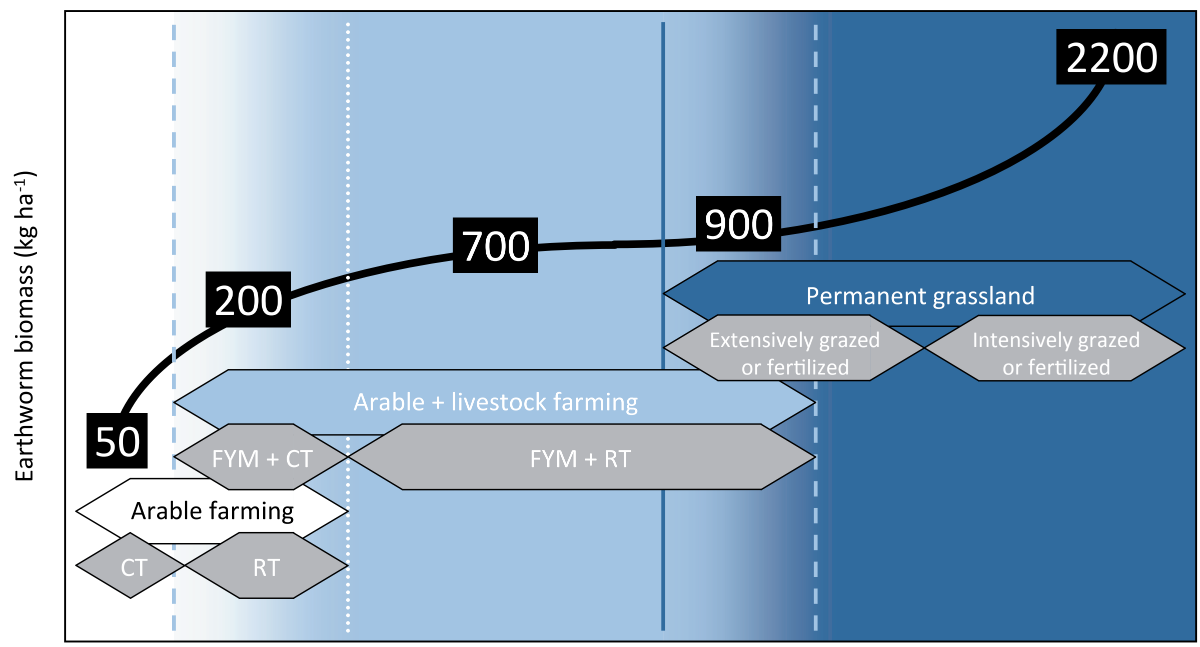
Key message 1

Within the boundary conditions set by climate and soil type, farmers' management is the key factor controlling earthworm abundance and species composition in arable land.

Key message 2

Suitable habitat conditions are the key determinant for the restoration and maintenance of diverse earthworm communities and abundant earthworm populations.

Farmers can increase earthworm habitat suitability of arable land by minimally disturbing the soil (reduced tillage) and supplying food of sufficient quality and quantity (cover crops, crop residues, and organic fertillizers).

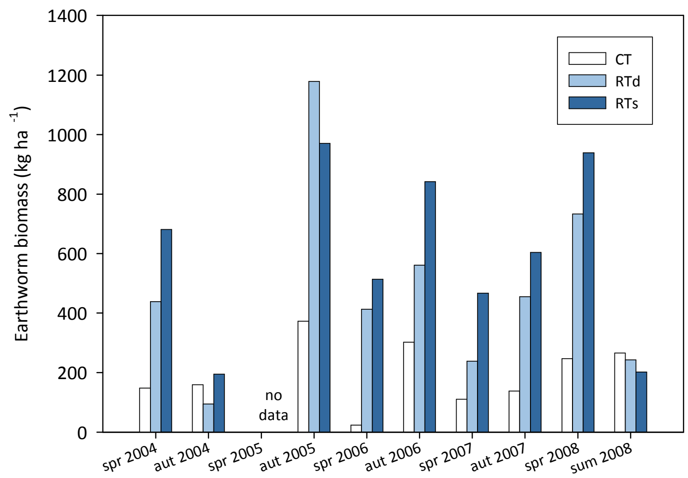


Expected earthworm biomass (black boxes) as a function of farming type/land use. Conventionally ploughed fields (CT) without farmyard manure (FYM) application only support marginal earthworm populations. Reduced tilled (RT) fields with(out) combination of FYM application support substantially larger earthworm populations. Note that the numbers are just indicative from which individual fields can deviate.

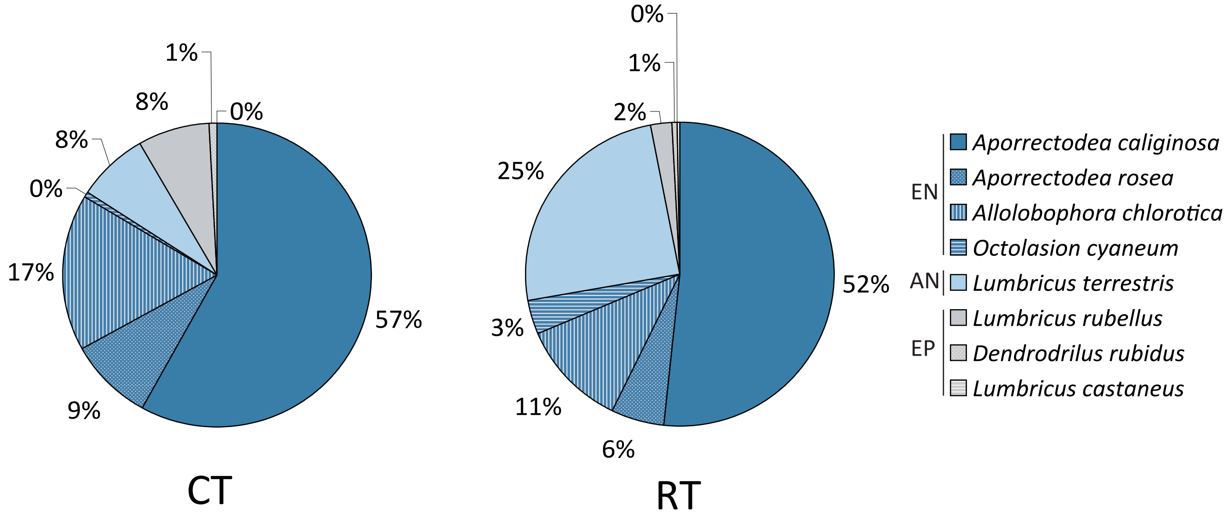
Key message 3

Reduced soil disturbance - non-inversion tillage in particular - promotes the abundance of deep-burrowing earthworm species, of high importance for erosion control.

Mechanical soil disturbance detrimentally affects the soil habitat. It particularly destroys the permanent vertical burrow systems of deep-burrowing ('anecic') earthworm species from which these depend for their survival and reproduction (e.g. during drought and cold spells, to escape from predators). After heavy soil operations, deep-burrowing earthworms need to invest time and energy in newly building or restoring their destroyed 'homes'. Inversion tillage (e.g. ploughing) also burries the organic surface layer. This drastically reduces food availability and reproduction success for deep-burrowing species which by nature forage and mate at the soil surface at night. Endogeic or shallow-dwelling earthworm species can temporarily benefit from the mixing of organic material with mineral soil by ploughing, but in general inversion-tillage based soil disturbance significantly reduces earthworm populations. Soil cultivation tools also directly kill and wound considerable numbers of earthworms and the turning over of soil by ploughing exposes many worms to predation by natural enemies (e.g. birds). Compared to ploughing/conventional tillage, non-inversion tillage or reduced tillage leave the majority of crop residues at the soil surface and destroy burrow systems to a lesser extent. Crop rotation also plays an important role: potatoes on ridges and mechanical beet harvesting considerably disturb the soil.



Earthworm biomass (kg ha^{-1}) under conventional tillage (ploughing, CT), deep reduced tillage (RTd) and shallow reduced tillage (RTs) in sandy loam soil in Huldenberg, Belgium, during the period 2004-2008. Notice the remarkably higher biomass under reduced tillage systems (RTd and RTs) as compared to conventional tillage and temporal and seasonal variability due to weather conditions and crop rotation (spr and aut refer to sampling periods in spring and autumn respectively) (Source: SOWAP; Valckx et al., 2009).



Species' percentual contribution to total earthworm biomass in conventionally ploughed (CT) and reduced tillage (RT) fields on (sandy) loam soils in the Flemish region, Belgium. Shallow-dwelling (endogeic) species are indicated in dark blue tones (EN); the single deep-burrowing (anecic) species in light blue (AN); epigeic species in grey (EP). Notice the dominance by endogeic species in arable land but the signficant increase in L. terrestris abundance under RT. Average biomass was 85 kg ha^{-1} under CT and 180 kg ha^{-1} under RT (Source: Valckx et al., 2009).

Key messages

Key message 4

Earthworm populations need time to recover after years of intensive soil management.

Adoption of reduced tillage and good soil management results in the recovery of earthworm populations after a relatively short time - one to five years. Not only earthworm numbers and biomass will increase, but also species diversity. In particular the share of deep-burrowing species spectacularly increases. The success and rate of recovery depend on the initial population conditions (e.g conversion from ploughed field vs. grassland), the time since adoption of reduced tillage, and food availability. Naturally, populations will not grow indefinitely and will stabilze at a level that is in equilibrium with food and habitat availability and interactions between earthworms. A single drastic intervention such as ploughing once in a full rotation cycle does not necessarily lead to an irreversible reduction of earthworm populations, but deep-burrowing species will suffer most from this intervention. Suitable habitat conditions remain a prerequisite for the populations of deep-burrowing species to recover from intensive soil operations.

Key message 5

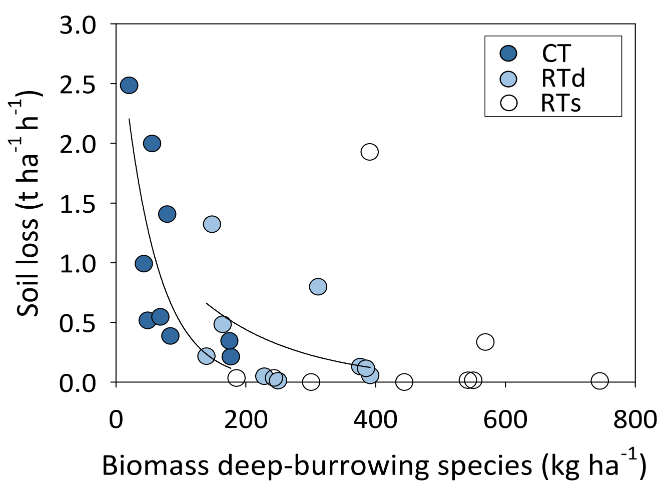
Soil biofumigation by the widely grown cover crop Yellow mustard (Sinapis alba L.) does not harm earthworm populations.

Members of the Brassicaceae family have previously been demonstrated to act as biofumigants on certain weed and crop species, pathogenic microorganisms, nematodes and insects through the release of isothiocyanates. The effects of these plant species on beneficial soil organisms such as earthworms were not studied until now, but the use of mustard as an expellent in earthworm sampling might suggest adverse effects on earthworms. Now, experimental results indicate that neither surface applied residues nor the living root system of the commonly used cover crop Yellow mustard (*Sinapis alba* L.) have lasting negative impacts on earthworms. However, it is strongly advised that mustard residues are only superficially worked and not plouhged into the soil as to stimulate volatilization of detrimental isothiocyanates. The use of mustard (and other Brassicaceae such as rapeseed and colza) as a cover crop in combination with other techniques to reduce soil erosion can be applied without the risk of harming earthworm populations.

Key message 6

Earthworms - in particular deep-burrowing species such as the night crawler (Lumbricus terrestris L.) - significantly reduce runoff and soil loss in arable land.

Earthworms significantly contribute to a reduction of soil erosion. Deep-burrowing species in particular play a crucial role. Field experiments show that the net effect of (sub)surface activities of deep-burrowing earthworm species result in an exponential decrease of soil erosion as a function of earthworm biomass. Thus, the potentially erosive effects of earthworms by removal of surface crop residues and deposition of easily disrupted fresh surface casts are outweighed by an increased infiltration capacity and macroporosity due to maintenance of a burrow network, increased soil surface roughness due to midden formation, and increased soil aggregate stability by ageing of casts by deep-burrowing species. Ecological erosion control through the action of deep-burrowing earthworm species is most effective in earthworm-poor ploughed fields: there each additional burrow has a relatively larger erosion-controlling effect as in the already earthworm-rich reduced tillage fields. These conclusions underline the importance of good soil ecosystem management by the farmer and the need for the promotion of agricultural practices supporting populations of deep-burrowing earthworm species (non-inversion tillage, direct drilling). Farmers who stimulate the occurrence of deep-burrowing earthworm species also reduce the erosion risk.



Exponential decrease of soil loss as a function of biomass of deep-burrowing earthworm species in a field experiment in a wheat parcel on sandy loam soil. The exponential decrease is most pronounced in the conventionally ploughed (CT) plots, and less in the reduced tillage plots with deep cultivation (RTd). Some exceptions apart, no erosion was observed in the shallowly reduced tilled plots (RTs). The latter plots also supported the largest populations of deep-burrowing earthworm species (Source: Valckx et al., 2009).

Key message 7

Weather conditions and soil status cause variability in the erosion-controlling effects of reduced tillage and deep-burrowing earthworm species.

Weather and soil (surface) condition have a large effect on soil erosion. No-tillage or direct drilling fields in particular are susceptible to compaction, usually after relatively long wet periods. These particular conditions may override the positive effects of earthworms in erosion control.

These key messages are based on the results of the ECOWORM project (2005-2009) - Erosion control in arable land through the management of earthworm communities - financed by the Flemish Institute for the Encouragement of Innovation through Science and Technology (www.iwt.org) and was co-funded by Syngenta Ltd. The research was conducted at the Department of Earth and Environmental Sciences, K.U.Leuven, Belgium.

Valckx J., Govers G., Hermy M., Muys B., 2009. ECOWORM - Erosion control in arable land through the management of earthworm communities. Final report IWT project 040681 (in Dutch). Department of Earth and Environmental Sciences, K.U.Leuven. 44 p. Available at www.ecoworm.be.

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