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Evidence of the role of earthworms in the regeneration of compacted soils under field conditions

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Abstract

At the INRA Estrées-Mons experimental site, the possible role of earthworm in the regeneration of compacted soils was studied in a reduced tillage plot where a compaction event was done using a 8-tons tractor on a wet soil. Earthworm communities and earthworm burrow systems were then studied either 2 weeks after or 8 or 24 months after the compaction in the control or compacted zone. Earthworms were observed to recolonise the compacted zone in less than 8 months whereas the regeneration of earthworm burrows was a slower process under field conditions.

Keywords: Soil compaction, Burrows, Crop, X-ray tomography, 3D earthworm burrow systems

Introduction

Soil compaction due to intensified arable land use and increasing engine weight, and the associated deterioration in soil fertility, has emerged as a major issue. Alternative agricultural practices such as minimum, zero tillage which minimise the use of tillage or tillage intensity, are now available. In all these systems, soil in compacted zones is expected or even encouraged to regenerate naturally due to climatic conditions (drought/wetting or freeze/thaw cycles) or biological agents such as roots and earthworms (DREWRY, 2006). In this study, we investigated the role of earthworms in this regenaration processes.

Material and methods

The site is a long-term experimental site used to study “cropping systems and soil structure” located in northern France (Estrées-Mons, 50°N latitude, 3°E longitude, 85 m elevation). The soil is a silt loam (Ortic Luvisol following FAO classification with 19% clay, 76% silt, 5% sand and 1.7% organic matter) and has a pH of 7.6. The average air temperature is 9.6°C and the annual rainfall is 667 mm. In April of 2005, a compaction event was done using 8-tons tractor on a soil at field capacity in a reduced tillage plot. Soil bulk density was then measured under the wheels (compacted zone) or between the wheels at -10 cm depth (n=8). At several dates (two weeks after the compaction and then 8 and 24 months after the compaction), earthworm abundances were assessed with manual sorting of soil (4 replicates of 0.4 *0.4 *0.3 m) and soil cores were sampled either in the compacted zone (under wheels) or in control zone (between the wheels). Mean earthworm densities were compared using an ANOVA test. Macroporosity inside the soil cores was assesssed using X-ray tomography at the Amiens hospital. Earthworm burrow systems were reconstructed in 3D following the protocol described in details in CAPOWIEZ et al. (2003).

Results and discussion

Soil bulk densities 2 weeks after compaction were significantly higher under wheels tracks (1.57 +/- 0.028) than in

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control soil (1.46 +/- 0.055 g cm^{-3}). This validated our protocol of compaction.

Only 3 earthworm species were found at the Estrées-Mons experimental site: *Lumbricus terrestris*, *Aporrectodea caliginosa* and *Allolobophora rosea*.

Earthworm density was influenced by the date of sampling (i.e. climate) and was significantly higher in the control zone immediately after compaction (Table 1). But for the two other dates, no significant differences were found. This indicates that earthworm recolonisation of the compacted zone occurred in less than 8 months. It is assumed that the superficial tillage (mean depth = 7 cm) in this plot was a positive factor for earthworm recolonisation. No significant difference was found between earthworm species even if A. caliginosa tended to be the first to recolonize the compacted zones.

Tab.1: Earthworm density (mean and standard deviations in m^{-2}) in the control and compacted zones (n=4). Values bearing different letters are different at the 5% significance level.

Months after compaction	0	8	24
Control zone	84.37[a] (42.24)	67.19 (34.75)	153.12 (59.18)
Compacted zone	33.33[b] (23.01)	60.94 (11.83)	132.81 (41.89)

Regarding earthworm burrow systems, we should first notice that the first centimetres were tilled so burrows could not be traced. It was obvious from Figure 1 that the compaction event initially destroyed most of the burrows. After 8 months, typical earthworms burrows were observed in the compacted zone, however these burrows remained less numerous than in the control zone (result not shown). After 24 months, differences in burrow systems between control and compacted zones (Figure 2) but were limited.

Figure 1: 3D reconstructions of the earthworm burrow systems in the 4 soil cores (diameter=16 cm and length=30cm), 2 sampled in the control (left) and 2 in the compacted zone (right) two weeks after the compaction event. Colours are applied for the 3D rendering (yellow in the front and blue in the back)

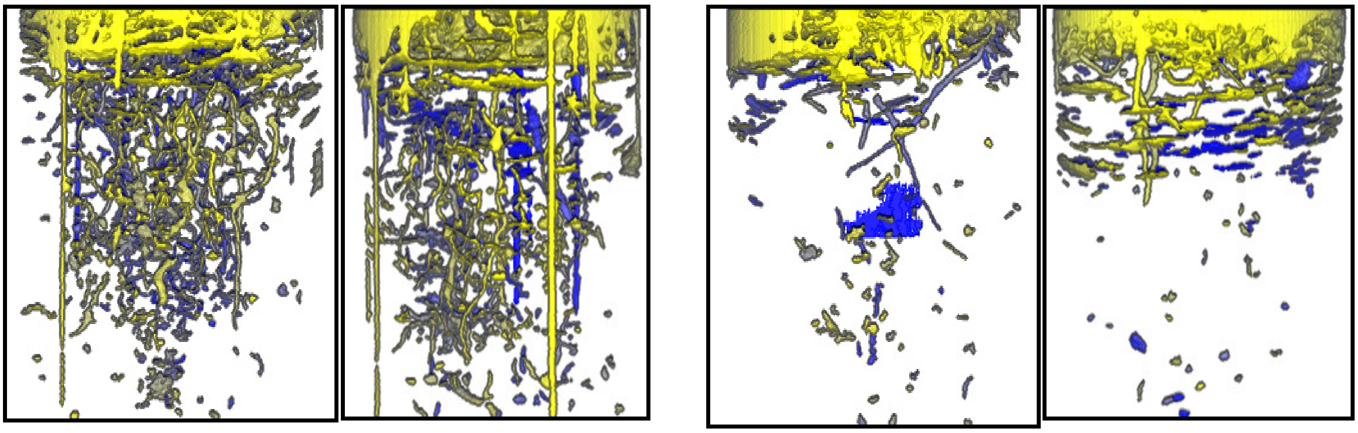
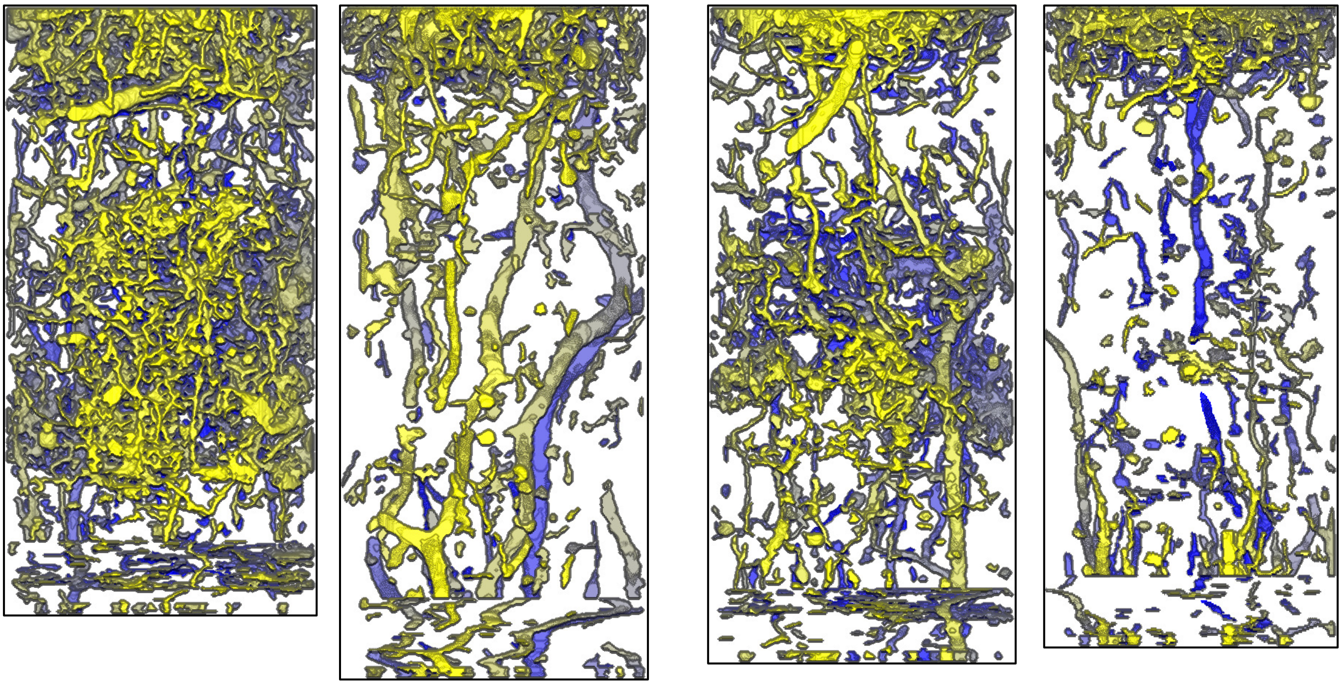


Figure 2: 3D reconstructions of the earthworm burrow systems in the 4 soil cores (diameter=16 cm and length=35 or 40cm), 2 sampled in the control (left) and 2 in the compacted zone (right) 24 months after the compaction event. Colours are applied for the 3D rendering (yellow in the front and blue in the back)



These preliminary observations are qualitative and should be confirmed by the quantitative assessment of the characteristics (length, burrow diameter, sinuosity) of the burrows systems.

To our knowledge, these results are the first to provide evidence of the effective recolonisation of compacted zone by earthworms under field conditions. Recolonisation by earthworms was relatively rapid and was possibly facilitated by the fact that this plot was under reduced tillage (earthworms could then survive and/or move laterally in the 7 first cm of the soil). Recolonisation by earthworm burrows was a much slower process. In both cases, it should be noticed that the compacted zones (wheels tracks) were limited to less than 0.5 m in width.

References

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