



A modeling approach to simulate the role of anecic and endogeic earthworms in soil structure dynamics of two agricultural systems

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In agriculture, one of the main purposes of innovative systems is to preserve and improve soil quality and noticeably their physical quality. This physical quality of a soil is intimately linked with its structure, i.e. the spatial arrangement of voids and solids. It is well-known that agricultural systems may deeply impact on soil structure through their effect on various structuring processes, in particular (i) the mechanical action of soil tillage and (ii) the burrowing activity and casts production of earthworms. As the assessment of agricultural systems needs long term experiments, it is not feasible to assess them all. However, the modeling approach has been used seldom despite it seems promising. As a first step towards the modeling of agricultural systems, we propose a model that simulates the impact of earthworm bioturbation and several tillage practices on soil structure dynamics.

The proposed model accounts for two earthworm ecological categories: anecics and endogeics. Anecics are split into epi-anecics and true anecics and endogeics are kept at the specific level. The model takes into account their physiological and morphological features such as their diapause period, their gut transit time or their body size. In order to simulate the bioturbation activity of earthworms, they can make six different actions: (i) burrow new paths by ingesting soil particles, (ii) move inside existing paths, (iii) move to soil surface, (iv) wait, (v) produce a subsurface cast or (vi) produce a surface cast. For the various species and groups of earthworms, the probability of these actions was adjusted from experiments and published results. This part of the model dedicated to earthworms allows to build and study their network of burrows but also the position and volume of their subsurface and surface casts. This network may be couple with models of water conductivity to assess the role of earthworm on this soil functional property. To better simulate soil structure dynamics in agricultural systems, the model also simulates the impact of tillage practices. By now, it accounts for ploughing and direct seedling by simulating the destruction of burrow paths and the mixing of void and solid particles into the soil. The model could be used to simulate the dynamics of soil structure for a year or more but a deeper understanding of earthworm behavior would greatly improve its reliability.

The mix of a biological and a tillage model is an important first step to modeling soil structure dynamics in agricultural systems. In addition to acquire more precise knowledge on earthworm behavior, it is now needed to extend the model with new processes such as soil compaction due to climate and due to heavy machinery.