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Earthworms and ecosystem services– linking their activity to water transport and storage in soils

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We investigated the combined effect of earthworms and plant roots on soil physical and hydraulic properties. Two different ecotypes of earthworms, Lumbricus terrestris which produce vertical burrows and Allolobophora chlorotica which produce lateral burrows, were studied. Three soils with different textures, loam, silt loam and sandy loam, were repacked in columns. Replicate (n=4) treatments were with or without winter wheat plants and with or without either L. terrestris or A. chlorotica. All columns had a buffer soil layer, separated from the bulk soil by a fine nylon mesh to prevent access by the earthworms, of 3 cm height at the base. In this system, the burrows have a finite length and do not connect to a drainage system. Thus, only water flow through the mineral soil matrix was considered. After 16 weeks of bioturbation, the field saturated and unsaturated hydraulic conductivity, soil water release curves, soil water retention capacity, aggregates stability and plant biomass were measured.

Overall, in the L. terrestris experiment water flow under field saturated and unsaturated conditions was mainly controlled by plant roots ($p \leq 0.001$) in all the soil types. The addition of L. terrestris earthworm to the planted and bare columns led to an increase of the hydraulic conductivities in all soils. However, the increase was only significant in the sandy loam soil ($0.001 \leq p \leq 0.05$). The soil water release curves showed the same behaviour between treatments at high matric potential (up to 10 kPa). At lower matric potential (10 – 1500 kPa) the wheat + L. terrestris treatment held water less tightly than the other treatments. The presence of L. terrestris also resulted in a slight, but not significant, increase in water holding capacity. The percentage of water stable aggregates increased and were significantly influenced by plant roots rather than earthworms. Earthworm-present caused a significant increase of shoot dry matter biomass in silt loam soils.

A. chlorotica had a significantly greater influence on soil hydraulic and physical properties compared to L. terrestris, particularly for the plant + earthworm treatments. Compared to the other treatments, the field saturated hydraulic conductivity increased more rapidly across time in wheat + A. chlorotica treatment. After 16 weeks the field saturated hydraulic conductivity was 12, 34 and 39-fold more than the control in loam, silt loam and sandy loam soils respectively. In all the soil types, wheat + A. chlorotica treatment resulted in a significant increase of water holding capacity, % stable aggregates and dry shoot biomass compared to other treatments.

These results suggest that the combined effect of earthworms and plant roots can significantly increase both soil water flow and retention. However, there are species effects due to the different ecological niches occupied by earthworms. In conditions where earthworm burrows are disconnected from drainage system, lateral burrowing earthworms have more of an impact on soil water flow than vertical burrowing species