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Nanorhizosphere: a new approach to study the interactions between plant and soil microorganisms - The effect of pollutants

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Global and local environmental changes are exerting significant pressures on organisms living in ecosystems. In the terrestrial ecosystem, plant, soil and microorganisms mutually interact in the rhizosphere, i.e. the volume of soil surrounding roots that is affected by the release of rhizodeposition (root exudates, root debris, volatiles and gases) by plants. Such interactions can be beneficial, neutral or harmful for organisms, depending on the stimulatory or inhibitory (or null) effect resulting from these relationships.
Soil organisms are sensitive indicators of environmental alterations. Effects induced by climate changes (e.g. global warming and elevated CO_2), land-use (e.g. forest vs. agrosystems, and conventional vs. conservation agriculture) and pollution (e.g. agrochemicals, and industrial and urban wastes) can affect the attitudes, composition, physiology, metabolism and morphology of organisms in the rhizosphere and their interactions.
Plenty of studies published to date has been devoted to analysing the effects of a multitude of factors on the rhizosphere ecosystems (e.g. root exudate amount and composition, microbial community dynamics, populations of soil animals) and their biogeochemical properties (enzyme activities). Accordingly, a lot of markers, protocols and techniques have been created on purpose and used for such analyses until now.
In this study, a new approach based on the creation of a nanostructured support mimicking the rhizosphere environment and its main features is proposed. Sketching them out: i) solid materials (grain-shaped minerals and fibrous and crumble-like organic matter) distributed in a 3D space; ii) release of nutritive substrates. This nanorhizosphere is composed of both micro-beads and nano-to-micro fibres of organic polymer approximately mimicking the soil structure. A biodegradable organic polymer has been selected on purpose.
The nanostructure was created employing a nanotechnology named electrospinning, which typically generates nanofibres, but also beads, by deposition under an electric field and onto a collector.
Root exudates, previously collected from crop plants, were supplied to microbial cultures either by a proper solution or by an agar medium containing these compounds or finally by the organic nanoframework itself, where the exudates had been loaded by mixing with polymer solution before the electrospinning process. Microbial species (Actynomycetes, Pseudomonads or Lactobacilli), previously isolated from the rhizosphere of various plants, were used as model microorganisms to recreate a proper rhizosphere ecosystem. Pure and mixed cultures were tested.
Heavy metals were used as model soil pollutants to generate an environmental pressure on either the generation of a new rhizosphere ecosystem or on an already settled one.
Metabolic, physiological and morphological traits were analysed after a fixed period.
Results of this artificial nanorhizosphere are discussed.