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Novel approaches and tools to reduce environmental impacts in agrosystems

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The world population is estimated to increase until about 9 billion of people in 2050. The contemporary limitation and increased degradation of land areas for agricultural uses have been posing serious problems to the management of food production. In the last century, an excessive use of agrochemicals (fertilisers and pesticides) in intensive agrosystems to improve crop yields and match human nutritional needs have caused great impact on the soil ecosystems (properties and biodiversity) and people's health.
Consequently, more ecofriendly solutions (e.g. integrated crop and pest management - ICPM - and organic farming) have started to be pursued by scientists, public opinion and governments. In nature, several strategies and mechanisms have been evolved to provide nutrients to plants and defend them from pest and pathogen attacks.
They consist in modifications of the environment surrounding plants (e.g. acidification), or the production of compounds for plant protection (e.g. biopesticides). As a consequence, farmers have often adopted practices to modify soil properties according to the crop needs for nutrients to facilitate their mobilisation and uptake by plants.
Other more sophisticated natural strategies involve interactions between plant, soil and microorganisms, so that plants attract beneficial organisms that assist them: i) to mobilise and collect nutrients upon symbiotic or non-symbiotic relationships; ii) to suppress pests and pathogens by predation or the secretion of biocidal compounds; iii) to stimulate plant growth (regulators).
In recent studies, we have created nanomaterial-based tools to: i) support plant growth; ii) detecting soil metabolic activities and quality; iii) degrading pollutants in environments; iv) detecting and monitoring pollutants in environments. Such nanostructured tools have been generated employing a nanotechnology capable of producing nanofibres under an electric field, called electrospinning.
By electrospinning, it is possible to obtain fibres in the range of tens of nanometres to few micrometres to create 2D and 3D fibrous scaffolds. These nanostructures are characterised by considerable porosity and large surface area. The further possibility to use a variety of materials (inorganic and organic) to produce pure and composite polymers enlarge the possible properties of the resulting nanostructures for a multitude of applications (medicine, environment, healthcare, textile, energy, etc.) considerably.
The nanofibrous scaffolds we created on purpose were specifically aimed at i) preventing micronutrient deficiency in plants (iron mobilisation mediated by siderophore release followed by plant uptake); ii) developing PGPR-biofilms stimulating plant growth by hormones and mobilising nutrients (phosphorus) and micronutrients (iron); iii) developing biocontrol fungal biofilms protecting plants from diseases by suppressing phytopathogen activity; iv) removing organic xenobiotics by adsorption and degradation mechanisms, thus limiting their environmental and health impact; v) developing sensing systems to detect xenobiotics, monitor their degradation and assess holistic soil metabolic activity.