Plant biostimulants and their integration into agro-bioeconomy value chains

Habilitation thesis

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ABSTRACT

Plant (agricultural) biostimulants are an emerging class of agricultural inputs. Their effects on plants are different from those exerted by the traditional inputs, fertilizers, pesticides (including plant growth regulators) and amendments. Under this umbrella term, relative recent introduced into scientific community, are included products which improve plant growth, stimulate early stage of plant development, delay senescence, prime plant resistance to biotic and abiotic stress, enhance phytonutrients content on edible yields, promote plant beneficial microbiome harnessing, bio-remediate soils.

In this thesis I present my achievements related to this continuous evolving field of agricultural inputs and to their integration into bio-economy value chains. Plants biostimulants unify three apparently separate directions of my research activities: (*i*) studies of the mechanisms involved in plant systemic defense activation; (*ii*) selection and formulation of beneficial plant microorganisms, initially for biocontrol / plant protection and bio-fertilization / plant nutrition purposes, and then for the application in high residues agricultural systems; (*iii*) bioconversion of by-products from bio-fuels fabrication into agricultural inputs.

During my Ph.D. thesis I demonstrated an increase on oxidative stress and reactive oxygen species (ROS) in treated plants with a mixture of bacterial lipopolysaccharides (LPS) and their specific receptors from common bean seeds. Considering ROS importance in plant physiology I decide to focus on a category of endo- and exo-signals which participate to its regulation, polyamines (PAs), small ubiquitous poly-cationic nitrogenous molecules. I initiated in the research teams wherein I was involved researches for selection of beneficial plant microorganisms which are releasing polyamines into plant rhizosphere. This approach was related to the use of microbial inputs into high residues agricultural systems (HRAS) and aims to compensate some negative

aspects of such agricultural technologies with environmental benefits, related to delay of the initial development stages, increased risk for soil borne plant disease and nutrients immobilization. We called this treatment of plant residues (including mulch from winter cover crop), with formulated plant beneficial microbial strains, "biocomposite mulch", in case of system used for vegetable cultivation, and "bioactive mulch", in case of system used for field crop. Selection of PAs releasing strains, intended to compensate HRAS negative impacts, led us to the selection of plants biostimulants strains since 2006, thus the concept of such category of plant beneficial microorganisms was defined more recently. In controlled conditions released PAs, in combination with others actives signals produced by our selected strains, stimulated plant growth and development and enhanced nutrient uptake. These two characteristics should reduce the impact of a lower soil temperature due to residues shadowing and, respectively, balance initial nutrient immobilization into high residues and boosted soil micro-biota. The competition for niche and nutrients should reduce the population of soil-born plant pathogens, usually promoted by high residues. PAs releasing strains applied to high residues should also increase water use efficiency, prime systemic defense and enhance phytonutrients contents on edible yield.

Field experiments which we done with biocomposite / bioactive mulch (our microbial biostimulants strains applied for plant residues treatments) demonstrated phyto-nutrients enhancement, improved water use efficiency, reduction by more than 50% of weed population, decreased diseases incidence, a higher fruit setting and yield increase by 23-30% on tomatoes, increased yield by 10-20% on sunflower, corn, soybean and common bean, enhanced nodulation on legume crops and AMF activity on sunflower, decrease of *Fusarium* diseases on wheat-corn rotation. We patented 10 plant biostimulants strains (including, in some situation, their formulation composition) and the biocomposite / bioactive mulch key technological sequences. We largely disseminate our bioactive mulch approach, intended also to stimulate the adoption of winter cover crop, agri-environment measure promoted by support of 2nd pillar of Common Agricultural Policy. One of our microbial plant biostimulants strain proved to improve the uptake of a plant beneficial nutrient, selenium, which is essential for humans and animals, and we used this for development a protective bio-fortification technology.

I initiated and I leaded research activities related to conversion of by-products from bio-fuels fabrication into bioproducts, initially intended for plant nutrition and plant protection. We used raw glycerol, by-product from biodiesel, and fermentation yeast, by-product from bio-ethanol,

as ingredients of growing media of microbial plant biostimulants strains. We used rapeseed meal and stems to produce a soil biofumigant. We converted sweet sorghum bagasse and distiller grains by a biotechnological approach, using *Pleurotus* and *Bacillus* and *Trichoderma* strains, into edible biomass mushroom and a plant biostimulants based on spent *Pleurotus* substrate, useful also for bioremediation purposes. We produced a plant biostimulants from de-fatted / spent micro-algae biomass. We developed a process for recovery humic acids and glycine betaine osmoprotectant from vinasse.

My capacity to: lead research teams, organize and co-ordinate didactic activities, explain and promote learning and research is supported by my experience: on leading RDI projects, scientific management and coordination of licence or dissertation thesis. I will develop this capacity by continuation of the RDI activities intended to further integrate plant biostimulants production with bio-economy chains related to bio-refinery.

I intent to further develop my professional, scientific and academic career by continuation of the RDI activities intended to further integrate plant biostimulants production with bio-economy chains related to bio-refinery. The main directions which I intent to develop is a systemic approach for production of plant biostimulants in the agro-bioeconomy value chains, related to the use of phyto- silicon solubilizing and cerato-platanins producing microbes as both plant biostimulants and bio-catalysts in (pre)treatment of lignocellulose, and an integrated production from micro-algae of bio-oil, biochar and a plant biostimulants based on protein hydrolysate / microalgae extract.