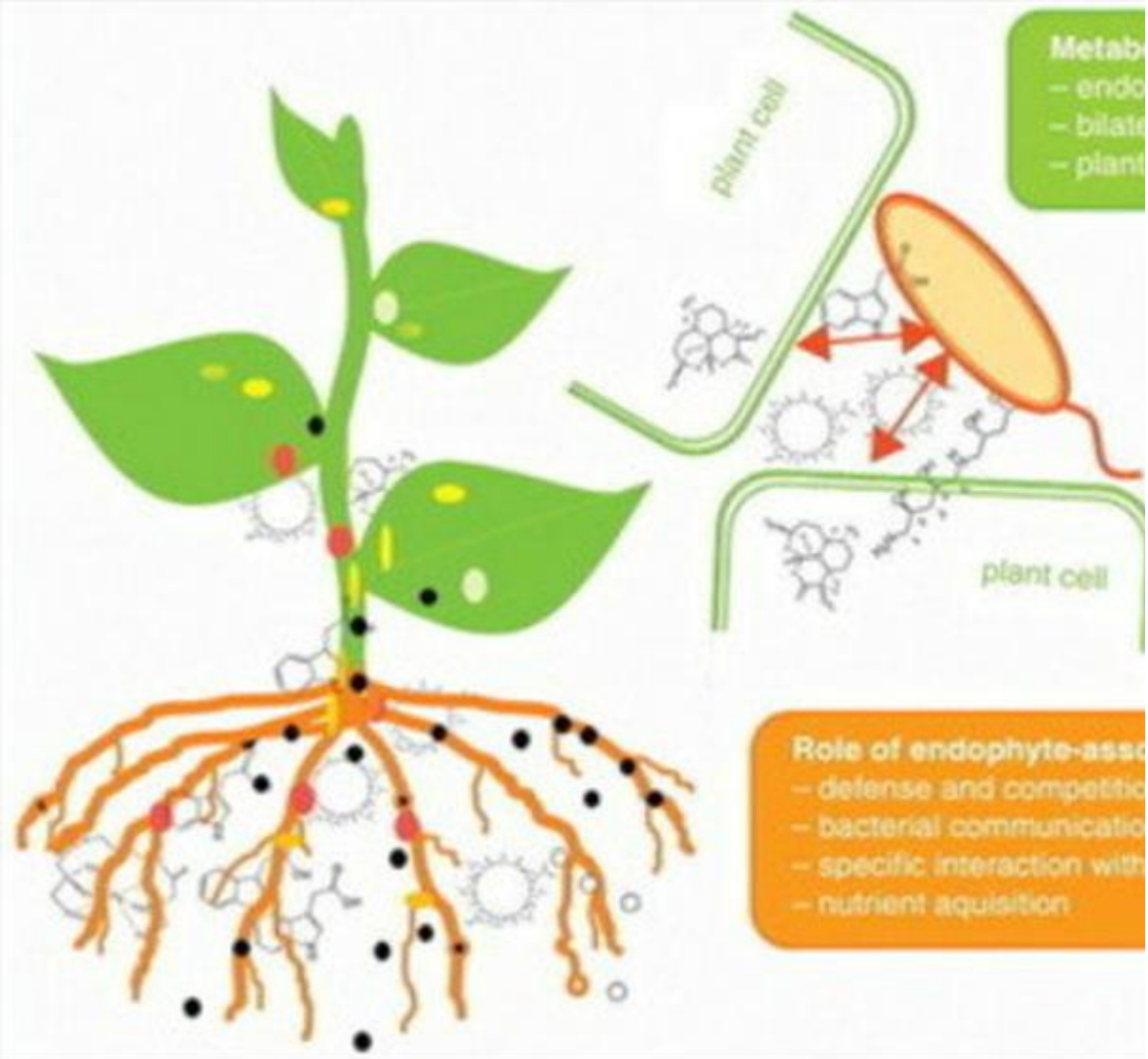
GEORGOFILI WORLD
Newsletter of the Georgofili Accademy

ROLE OF ENDOPHYTIC BACTERIA IN MODERN AGRICULTURE

by Andrea Squartini July 15 2016

***



Plants host distinct microorganism communities on and inside various of their compartments; the diversity of microbes associated with healthy plants is enormous, fungal and other eukaryotic species can be found but a critical importance is attributed to the remarkable richness of beneficial bacteria. In particular, endophytes colonize the internal

parts of plants and can be isolated from various surface-sterilized plant portions.

Plant-microbe interactions can positively influence plant growth through a variety of mechanisms, including fixation of atmospheric nitrogen by different classes of proteobacteria, increased biotic and abiotic stress tolerance imparted by the presence of endophytic microbes, direct and indirect advantages conferred by plant growth–promoting rhizobacteria, by the production of phyto-hormones or by enhancing availability of minerals or translocating those directly from soil to plant, as the case of mycorrhizal fungi. Bacteria can also positively interact with plants by producing protective biofilms or antimicrobials operating as biocontrols against potential pathogens, or by degrading plant- and microbe-produced compounds in the soil that would otherwise be allelopathic or even autotoxic.

The evidence that the healthy plant interior can normally contain bacteria or fungi not necessarily related to a pathogenic context was first advocated in the twenties and is now well documented by many studies. Stems and roots of the majority of plant species tested harbor a range of 103 to 106 live internal bacteria per gram of fresh weight, whose roles are related to different interactive phenotypes. Endophytes from red clover and potato feature 56% of the taxa as neutral, 21% as plant growth-promoting and 24% as plant growth-inhibiting. The most common genera of bacterial endophytes reported in the literature include *Pantoea, Pseudomonas* and *Bacillus*. Perennial woody plants can also cumulate a vast array of internal biota. As many as 82 prokaryotic taxa were cultured from the phloem of a single elm tree, indicating that a vast endophytic microbial diversity can be hosted by a single plant. Legumes are in this respect no exception, bacteria are found in the xylem of alfalfa roots; red clover harbors rhizobia of different species (not limited to the endosymbiont, *R. leguminosarum* bv. *trifolii*) not only in nodules but systemic throughout the plant. *Pantoea agglomerans* and *Pseudomonas fluorescens* are the most common endophytes in different pea cultivars. The colonization by endophytes can also be fostered by human inoculation as shown in experimentally created situations where enterobacteria achieved internal invasion of *Medicago sativa* and *M. truncatula*. Some plants could also be the unexpected reservoir of clinically relevant human and animal pathogens whose life cycle includes the alternation of niches from animals to plants and back.

Endophytes normally occur at lower cell densities than external rhizospheric and pathogenic microbes, but it is important to consider that they could be better protected from biotic and abiotic stresses, in comparson to their corresponding rhizospheric populations. Some criteria to recognize microorganisms as true endophytes have been defined, and require not only the isolation from surface-sterilized tissues, but also their visualization by microscopy inside plant tissues, and finally their capacity to reinfect plants grown in vitro under microbiologically controlled conditions and obtained from surface-disinfected seedlings or axenic germ lines.

While endophytes do not induce external signs of infection nor negative effects on their host; bacteria inside the plant take advantage of a major availability of nutrients, and plants receive other benefits from bacterial endophytes; these may not only increase plant growth and yield, potentiate plant responses to abiotic stresses, reduce pathogen infection by

nutrient competition with pathogens and/or boosting the defensive capacity by induced systemic resistance (ISR) or producing a range of different secondary metabolic products including antibiotics, volatile organic compounds, antifungal, antiviral, insecticidal and immunosuppressant agents.

Plant growth stimulation is largely due to increased availability of highly unavailable nutrients such as phosphorus, iron and other mineral nutrients, fixed nitrogen, production of plant growth regulators, phosphate solubilisation, production of siderophore molecules for iron uptake and ammonia release. As mentioned endophytes can improve plant health acting as biocontrol agents: they protect host plants by synthetizing a large spectrum of diverse molecules that could be harnessed for potential use in agriculture, industry or medicine. The search of metabolites produced by some of the endophytic bacterial taxa isolated from plants has been undertaken, and a number of interesting compounds have been identified (including auxins and antibiotics. Unravelling these aspects in the plant-endophyte interactions is also giving new insights on the cross-talk between plants and bacteria inhabiting in their inner tissues.

Beneficial fungi that offer protection against pathogens and can also rapidly colonize the cortex of living plant roots without causing harm, but also some pathogenic or necrotrophic fungi, with a latent phase can enter in the same root zone without causing diseases.

Endophytic fungi in particular are ubiquitous in plants and are the most likely source of establishment of new plant–fungus associations. Fungi that live within plant tissues can as well promote host growth, help mineral nutrition, and enhance resistance to pathogens. Some endophytic fungi have been shown to protect plants from herbivores or to be responsible for the synthesis of novel secondary products. Fungal endophytes benefit from occupying plants by gaining: greater access to exudates, the first access to organic substrates after the death of the host and avoidance of competition, predation and parasitism from other soil organisms.

Overall, the expected results in this field of research are envisaged to have future practical implications on plant growth and yield by managing microbial communities, on the selection of strains acting as biocontrol agents to improve soil and plant health and to define an agriculturally-friendly environmental way to cope with plant pathogens.. Moreover growing in vitro endophytes for novel and bioactive natural products will enable future innovative applications in agriculture, medicine and industry.