Conventional and novel strategies for the phytoplasma diseases containment

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Phytoplasmas are obligate bacterial plant pathogens that cause economically relevant yield losses in annual and perennial crops worldwide and they are transmitted in nature by phloem feeders, mostly leafhoppers, planthoppers and psyllids. Impossibility of cultivating phytoplasma impairs the development of efficient methods to control these pathogens. Conventional strategies for phytoplasma containment are based on pesticide application against insect vectors and the use of resistant plants (when available). Owing to the great yield losses caused by phytoplasmas, their absence from propagation materials is essential for sustainable plant production. This is particularly important for vegetatively propagated crops in which infected planting materials transmit the pathogen to the new crop. Pathogen-free plants have been obtained using many different techniques, such as shoot tip culture, thermotherapy, leaf tissue-derived somatic embryogenesis, stem culture, treatment of plant tissues with antibiotics and cryotherapy of shoot tips. Moreover, other strategies have been tested, namely: (i) production of transgenic plants expressing antibodies against the major phytoplasma membrane protein (ii) production of transgenic plants expressing antimicrobial peptides; and (iii) protecting the plants using elicitins, small proteins that stimulate P protein plugs and callose release in phloem sieve elements (Laimer *et al.*, 2009). Till today, such treatments against phytoplasmas have been proved partially ineffective.
Current studies evidenced that a promising approach concerns the use of natural or induced resistance. Different compounds tested as resistance inducers were able to suppress symptoms on specific phytoplasma strain but they have limited applications (Romanazzi *et al.*, 2009). Recently, there has been an increasing interest in the use of biocontrol agents that could be employed in different strategies: (i) study of microorganisms which are pathogenic to the insect (Schnepf *et al.*, 1998), (ii) symbiotic microorganisms able to reduce vector competence (Beard *et al.*, 1998); (iii) antagonisms mediated by the production of allelochemicals; (iv) induction of plant defense response. For example, reduced symptom expression in phytoplasma-infected plants treated with arbuscular mycorrhizal fungi (Kaminska *et al.*, 2010) and *Epicoccum nigrum* Link (Musetti *et al.*, 2011) were recently reported. Moreover, studies on bacteria as potential biocontrol agents or plant resistance inducers have given promising results (Gamalero *et al.*, 2010; Bulgari *et al.*, 2011).

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