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Current status of phytoplasma diseases of medicinal and nutraceutical plants in Southern Italy

Carmine MARCONE
Department of Pharmaceutical and Biomedical Sciences, University of Salerno, Fisciano (Salerno), Italy

Abstract

In Southern Italy, several medicinal and nutraceutical plant species are affected by yellows, witches' broom and decline diseases, which severely impair productivity and phytochemical content of affected plants. This brief review, which is a mix of newly and previously published information summarizes the current knowledge about the mentioned diseases of a number of selected plant species. Emphasis is given on description of symptoms, taxonomic position of the associated phytoplasmas and changes induced by phytoplasmal infections in the composition of secondary metabolites of affected plants.

Key words: secondary metabolites, 16Sr group, aster yellows, elm yellows, stolbur, spartium witches' brooms, white leaf.

Introduction

In modern societies, there is an increasing interest in the use of medicinal and nutraceutical plants due to their role in promoting human health. In southern Italy, several plant species which have medicinal and nutraceutical properties are known to be affected by yellows, witches' broom and decline diseases. These diseases severely impair productivity and phytochemical content of affected plants. The present brief review, which is a mix of newly and previously published information summarizes the current knowledge about the mentioned diseases of a number of selected plant species.

Phytoplasma diseases of medicinal and nutraceutical plants

Spartium junceum (Spanish broom) is severely affected by spartium witches' broom (SpaWB) disease. The most characteristic symptoms of the disease are pronounced witches' brooms, shortened internodes, off-season growth and death of the plants. SpaWB is associated with two genetically different phytoplasmas which induce the same symptoms. These agents are (i) '*Candidatus* Phytoplasma spartii', a member of the 16SrX group and (ii) a phytoplasma that belongs to the elm yellows (EY) group or 16SrV group, subgroup 16SrV-C (Marcone *et al*., 1996, 2004a; Lee *et al*., 2004a). Most of the diseased plants are dually infected with the two phytoplasmas of which, one is predominant and readily detectable by direct polymerase chain reaction (PCR) assays, whereas the other occurs at a very low titre and can be detected only by the highly sensitive nested PCR (Marcone *et al*., 1996). A '*Ca*. P. spartii'-related strain is also known to occur in *Sarothamnus scoparius* (syn. *Cytisus scoparius*) affected by the *S. scoparius* witches' broom disease (Marcone *et al*., 2004a). Recent work has shown that the yield of volatile fraction, *i.e*., essential oils, extracted from flowers of SpaWB-affected Spanish broom plants is lower than that of healthy plants (Mancini *et al*., 2010a). Also, substantial amounts of sesquiterpenes and a marked decrease in the amount of *n*-alkanes and aliphatic compounds are known to occur in the volatile fraction from flowers of diseased plants. Sesquiterpenes could not be detected in the volatile fraction of healthy plants (Mancini *et al*., 2010a). Great differences between diseased and healthy Spanish broom plants were also identified in the alkaloid compounds (Mancini *et al*., 2010b). The alkaloid content was considerably higher in samples of diseased plants than in those of healthy plants. Seven different alkaloids were identified only in diseased plants. These compounds included *N*-methylcytisine, its isomer, *N*-formylcytisine and a hydroxy-substituted derivative of sparteine. Four alkaloids including hydroxy-derivatives of cytisine and anagyrine were shared by both healthy and diseased plants. All identified alkaloids were quinolizidine alkaloids (Mancini *et al*., 2010b). Collective data indicated that changes in the composition of secondary metabolites of SpaWB-affected Spanish broom plants can be related to the role of phytoplasma infections in triggering plant defense responses (Mancini *et al*., 2010a, 2010b).

Eucalyptus spp. (eucalypt) are affected by eucalyptus little leaf. The symptoms include abnormally minute leaves, yellowing, shortened internodes and proliferation of axillary shoots. Phytoplasmas of 16SrV and aster yellows (AY) (=16SrI group) groups, subgroups 16SrI-B and 16SrI-C, have been identified in the affected plants (Seemüller *et al*., 1998; Camele *et al*., 1999).

Myrtus communis (myrtle) plants showing symptoms of yellowing, small leaves and witches' brooms have been observed in Apulia, Molise and Basilicata regions. These plants proved to be infected by a subgroup 16SrI-B phytoplasma (Camele *et al*., 1999). Myrtle plants exhibiting the mentioned symptoms are also common in several areas of the Campania region (C. Marcone, unpublished observations).

Rubus fruticosus (wild blackberry) is affected by rubus stunt (RuS), a disease causing stunting, small leaves and proliferation of axillary shoots. The RuS agent is a member of the 16SrV group, subgroup 16SrV-E, recently described as '*Ca*. P. rubi' (Seemüller *et al*., 1998; Malembic-Maher *et al*., 2010).

Taraxacum officinale (dandelion), *Cichorium intybus* (common chicory) and *Picris echioides* (bristly oxtongue) showing symptoms of yellowing, proliferation of slender secondary shoots, small leaves and phyllody are infected by phytoplasmas of the 16SrII group, subgroup 16SrII-E. However, *P. echioides* is also known to harbour a 16SrIX group phytoplasma (Marcone *et al*., 2001).

Medicago sativa (alfalfa) has been reported to be affected by a witches' broom disease, the Italian alfalfa witches' broom, in the Basilicata region. Main symptoms of the disease are witches' brooms, yellowing and small leaves. The causal agent was identified as a member of the 16SrII phytoplasma group (Seemüller *et al*., 1998).

Brassica spp. (*Brassica oleracea* var. *capitata*, *italica*, *palmifolia*, *rapifera* and *botrytis*), *Raphanus raphanistrum*) (wild radish), *Allium cepa* (onion), *Catharanthus roseus* (periwinkle), *Calendula officinalis* (pot marigold), *Papaver rhoeas* (corn poppy), *Primula* sp. (primrose), showing symptoms of virescence, phyllody, yellowing, upright growth habit, little leaves, and general stunting, *Daucus carota* (carrot) with cluster of dwarfed, chlorotic, upright adventitious shoots, *Portulaca oleracea* (purslane) with spindling upright growth, small leaves, and chlorosis, and *Plantago lanceolata* (English plantain) which grows poorly with narrow and chlorotic leaves, are widespread in southern Italy. Diseased plants of the mentioned species are known to harbor the aster yellows phytoplasma '*Ca*. P. asteris', 16SrI group, subgroup 16SrI-B (Marcone *et al*., 2000, 2001; Lee *et al*., 2004b).

Capsicum annuum (red pepper), *Lycopersicon esculentum* (tomato) and *Nicotiana tabacum* (tobacco) showing typical stolbur symptoms, *Apium graveolens* (celery) with yellowing and stunting, *Convolvulus arvensis* (field bindweed) showing yellowing, stunting and/or proliferating and erect growth habit, and *Vitis vinifera* (grapevine) with typical grapevine yellows symptoms, are all infected by subgroup 16SrXII-A phytoplasmas (Marcone *et al*., 2001).

Cynodon dactylon (Bermuda grass) and *Digitaria sanguinalis* (crab grass) with white leaf symptoms are infected by '*Ca.* P. cynodontis' (16SrXIV group) (Marcone *et al*., 2004b).

Concluding remarks

This brief review reflects the advances made during the last two decades in detection, molecular characterization and identification of phytoplasmas associated with yellows, witches' broom and decline diseases of medicinal and nutraceutical plants in southern Italy. However, there is still very little known about several other aspects of the mentioned diseases including disease management, phytoplasma insect vector relationships and role of phytoplasmas in eliciting secondary metabolites which can be pharmaceutically important.

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Corresponding author: Carmine MARCONE (e-mail: cmarcone@unisa.it), Department of Pharmaceutical and Biomedical Sciences, University of Salerno, Via Ponte Don Melillo, I-84084 Fisciano (Salerno), Italy.