RESEARCH PAPER

NMR metabolomics of esca disease-affected Vitis vinifera cv. Alvarinho leaves

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Abstract

Esca is a destructive disease that affects vineyards leading to important losses in wine production. Information about the response of Vitis vinifera plants to this disease is scarce, particularly concerning changes in plant metabolism. In order to study the metabolic changes in Vitis plants affected by esca, leaves from both infected and non-affected cords of V. vinifera cv. Alvarinho (collected in the Vinho Verde region, Portugal) were analysed. The metabolite composition of leaves from infected cords with visible symptoms [diseased leaves (dl)] and from asymptomatic cords [healthy leaves (hl)] was evaluated by 1D and 2D ¹H-nuclear magnetic resonance (NMR) spectroscopy. Principal component analysis (PCA) of the NMR spectra showed a clear separation between dl and hl leaves, indicating differential compound production due to the esca disease. NMR/PCA analysis allowed the identification of specific compounds characterizing each group, and the corresponding metabolic pathways are discussed. Altogether, the study revealed a significant increase of phenolic compounds in dl, compared with hl, accompanied by a decrease in carbohydrates, suggesting that dl are rerouting carbon and energy from primary to secondary metabolism. Other metabolic alterations detected comprised increased levels of methanol, alanine, and γ-aminobutyric acid in dl, which might be the result of the activation of other defence mechanisms.

Key words: Esca, metabolomics, NMR, PCA, Vitis vinifera.

Introduction

Esca is a destructive disease that affects grapevines worldwide. The etiology of the disease is complex and is not fully understood; however, several fungi are known to be associated with this disease: Phaeomoniella chlamydospora, Phaeoacremonium aleophilum, and Fomitiporia mediterranea or Fomitiporia punctata, are the most frequently isolated from diseased plants. However, because not all the attempts to prove the pathogenicity of these fungi were successful and considering that esca-associated deutromycetes have been isolated from asymptomatic plants, it is thought that other factors are required for the development of esca. These factors are still unclear but may include vine age, variety susceptibility, site and time of infection, the host’s defence response, and environmental factors (Graniti et al., 1999). Symptoms of the disease occur both internally, in the trunk and branches, and externally, in the leaves and berries. Frequently the disease is detected only when external symptoms appear, particularly in leaves, but the plants may be infected for long periods of time before external symptoms become visible (Surico et al., 2000). Typical leaf symptoms appear as small chlorotic spots expanding between the veins or along leaf margins, merging to fill the entire leaf, except a small line of healthy tissue along the main veins (Mugnai et al., 1999). Today, esca affects grapevines worldwide and the incidence of the disease has been increasing on a global scale. In Portugal