Constitutive and induced resistance to pathogens in conifers: An integrated view of molecular, anatomical and chemical responses

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Conifers defenses against herbivores have been challenged by climate change, allowing the expansion in range and frequency of bark beetles and their associated pathogens, into previously unexplored areas. Two of the most aggressive bark beetles (the mountain – MPB- and southern pine beetle -SPB-) are attacking naive hosts in forested areas of Canada and the U.S, where prior colonization by these pests were unforeseen. As these beetles use pathogenic fungi to modify host tissues to favor brood development and overcome tree defenses, fungal associations are crucial for beetle success. To evaluate constitutive (pre-attack) and induced (post-attack) responses of conifer trees, two independent studies were conducted using the MPB and SPB associated pathogenic fungi Grosmania clavigera and Ophiosoma minus at 1-, 7- and 28- and 62-days post inoculation respectively. To understand the complex interactions that modulate tree defense responses, we performed (i) microarray and targeted gene expression analyses (chitinases and terpene synthases), under well-watered and water deficit conditions (ii) UHPLC and GC-MS chemical profiling of phenols and terpenoids, (iii) phyohormones and iv) histochemical analyses, in coevolved and naive pine trees. Results show that upon pathogen attack, jasmonic and salicylic acid were implicated in local and systemic response to fungal inoculation; in addition, an increased transcript expression of chitinases, pathogenesis-related genes, as well as genes associated with jasmonate and ethylene signaling were observed. Differences in expression patterns due to fungal inoculation were observed between naïve and coevolved species (Fig. 1). Chemical analyses showed induction of epi/catechin, three unknown phenolic compounds and several phloem terpenoids (α-pinene, β-myrcene, limonene, terpinolene and α-pinene) indicating an elevated tree response against pathogen attack. Lastly, histochemical analyses demonstrated the capacity of naïve pine trees to induce traumatic resin ducts production and lesion development to confine fungal development. Taken together these responses, naïve and coevolved conifers respond differently to fungal attack.

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