Chapter 20

METABOLIC PROFILING HORIZONTAL RESISTANCE IN POTATO LEAVES (CVS. CAESAR AND AC NOVACHIP) AGAINST PHYTOPHTHORA INFESTANS

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Abstract: Metabolic profiles were developed for potato leaves, cvs. Caesar and AC Novachip, inoculated with water (CW and AW) or Phytophthora infestans (CP and AP), using gas chromatography/mass spectrometry (GC/MS). The level of horizontal resistance was higher for cv. Caesar than for AC Novachip with an area under the lesion expansion curve (AULEC) of 334 and 857, lesion area of 86 and 224 mm², and sporulation of $4.4 \times 10^3$ and $13.7 \times 10^3$ sporangia lesion⁻¹, respectively. A total of 51 metabolites were detected consistently in all the four replicates of at least one treatment. Of the 51 relatively consistent metabolites, 33 were unique to a treatment and 18 were common to two or more treatments. A total of 7 and 29 PR-metabolites were identified, respectively, in Caesar and AC Novachip cultivars. Most of the phenolic compounds were associated with the AP. The metabolite heptadecanoic acid, 16-methyl was detected only in the CP. In response to the P. infestans attack, the two cultivars appear to follow two different pathways. The susceptible cv. AC Novachip appears to follow the Shikimic acid-phenylpropanoid pathway as we have detected many phenolic metabolites and benzoic acids, the latter is a precursor of the signal molecule salicylic acid (SA), known to trigger phenolic compounds. On the other hand, the resistant cv. Caesar appears to follow mevalonic acid-methylerythritol pathway as we have detected heptadecanoic acid, a probable derivative of linolenic acid that is a precursor of a signal molecule jasmonic acid (JA), known to trigger terpenes. The factor analysis using principal components discriminated all the four treatments and the factor loading indicated which compound loaded significantly to a treatment. The possible function of these compounds in plant defense against biotic stress is discussed.

Key Words: AC Novachip; Caesar; GC/MS; late blight; plant metabolomics; Phytophthora infestans; Solanum tuberosum; horizontal resistance.

1 INTRODUCTION

Potato late blight, *Phytophthora infestans* (Mont.) de Bary, is the most important pathogen that attacks potato (*Solanum tuberosum*) (Flier et al., 2003). *P. infestans* is a heterothallic fungal-like organism requiring the A1 and the A2 mating types for sexual reproduction (Stromberg et al., 2001; Peters et al., 1999; Daayf and Platt, 1999). The A2 mating type was found to be more aggressive than the A1 (Fry and Smart, 1999). In Canada, the clonal lineage US-8 is the most aggressive and dominant on cultivated potato cultivars (Medina et al., 1999; Peters et al., 2001; Daayf and Platt, 2003).

In the past, breeding programs have mainly considered vertical resistance, generally controlled by single or major R-genes, because transferring genes from wild types to cultivated is easy. However, vertical resistance increases the selection pressure (Keller et al., 2000) and recently, many new races of *P. infestans* have been detected in North America. This has made the breeders to consider the horizontal resistance in the breeding programs, as it is considered to be more durable than the vertical resistance due to the polygenic nature of inheritance (Simmonds and Wastie, 1987; Peters et al., 1999). However, the progress made in transferring horizontal resistance to cultivated potatoes has been very limited because of the difficulty in breeding for polygenic traits (Evers et al., 2003).

In Plant-pathogen interactions, the complete pathway involves the binding of an elicitor, a suppressor or an inducer to a specific receptor, a messenger that carries the signal and an effector that activate the phenotypic expression. Pathogens produce different enzymes that can hydrolyze plant cell walls and their products act as signal molecules that evoke plant defense responses by the accumulation of phytoalexins (Esquerre-Tugaye et al., 2000), pathogenicity related (PR) proteins (Palva et al., 1993), the enforcement of cell wall by lignification (Robertsen, 1987) and the accumulation of hydroxyproline-rich glycoproteins (HRGP) in the cell wall (Boudart et al., 1995; Huang, 2001). Biochemical defense compounds produced by plants have been grouped into preformed phytoanticipins and induced phytoalexins that are synthesized following infection (Osbourn, 1996). Some of the phytoanticipins commonly detected in plants include phenols, phenolic glycosides, sulfur compounds, saponins, cyanogenic glycosides and glucosinolates. Phytoanticipins are commonly found in the outer cell layers of the plant tissues and they are usually stored in the vacuoles or other organelles in the healthy plants. Following insect feeding damage or a necrotroph invasion, some of these compounds defend the plant against the attacking pathogen. Saponins are glycosylated compounds that belong to triterpenoid, steroid and steroidal glycoalkaloid groups. The steroidal glycoalkaloids are abundantly found in the Solanaceae family that...