Interactions between induced potato defenses, life-history traits and effectors of *Phytophthora infestans*

Cécile THOMAS

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Institute for Genetics, Environment and Plant Protection

Inra - Agrocampus Ouest -Université de Rennes 1

Team name
Resistance and Adaptation

Direction
Florence VAL
Didier Andrivon

Partners
ACVNPT

Social-economic context

Pathogens are still responsible for an important part of yield loss despite the use of pesticides and they have a negative impact on ecological footprint. Furthermore the current challenge is to find economically viable and environmentally safe methods of disease control [1]. Potato crops play a key role in the world food system but it still faces *Phytophthora infestans* (causal agent of the devastating late blight) despite resistance genetic resources. Thus agrochemicals are extensively used in order to monitor effectively this pathogen (10-15 treatments/cropping season). Quantitative host resistance combined with plant defenses induction could be an alternative method to provide suitable potato protection against late blight. A better understanding of the interaction between *Solanum tuberosum* and *P. infestans* could contribute to improve the development of these methods.

Scientific context

The zig-zag model of co-evolution [2] describes the interactions between plant and pathogen as an arms race: plants are able to recognize pathogens *via* pathogen-associated molecular patterns (PAMPs) which induces general defense responses (PAMP-triggered immunity) in plants. Subsequently, pathogens can acquire effectors to decrease or suppress defense activity, allowing host colonization (Effector-triggered immunity). We previously demonstrated that a PAMP of *P. infestans* (a Concentrated Culture Filtrate; CCF) primes defense responses [3]. This induction is genotype-dependent, and the metabolites produced after induction by CCF (chlorogenic acid and rutin) decrease pathogen growth *in vitro* but not *in vivo* [4, 5]. We postulated that (i) *P. infestans* could escape or modulate the activity of defense metabolites and (ii) induced defense responses in potato could impact life-history traits (and hence fitness) in *P. infestans*.

Objectives

To test these hypothesis, we confront two *P. infestans* strains which differ by their growth speed with four potato genotypes modulating various life-history traits of this pathogen.

The questions raised in my PhD work are:

(1) Which life history traits of *P. infestans* (growth speed, colonization, sporulation…) are impacted by induced resistance in potato? What is the involvement of *P. infestans* effectors?

(2) Is the interaction between induced defenses, life history traits and effectors of *P. infestans* genotype- and strain-dependent?

Our strategy is to use an integrative approach in linking plant physiological responses analysis and microbial ecology. Potato defense genes involved in main metabolic pathways are analyzed after induction by CCF with specific primers by transcript analysis (qRT-PCR). We assess simultaneously *P. infestans* behavior by measuring necrosis area, quantifying mycelial DNA *in planta* and counting sporangia on infected leaflets.

Results

- **Defenses induced by a 48h pretreatment with CCF in potato cv. BF 15 decrease after inoculation with *P. infestans* and growth speed is involved**

	Salicylic acid		Jasmonic acid		Phenylpropanoids		Antioxidant system		Ethylene
Inoculation post induction (48h)	**PR1**	**PR2**	**PR3**	**PR4**	**PAL**	**THT**	**POX**	**POTLX3**	**EIN3**
S+ 3 dpi									
S- 3 dpi									
S+ 4 dpi									
S- 4 dpi									

+3 Fold induction
0
-3 Fold repression

***Figure 1** : Effect of CCF on genes implicated in various signaling pathways in potato cv. BF 15 with two strains of P. infestans (fast strain S+ ; slow strain S-, Heatmap : Relative expressions of defense genes in potato leaflets after treatment with CCF/sterile water (control) without or with P. infestans inoculation. Two independent experiments; dpi : days post inoculation*

After inoculation with *P. infestans*, the expression of defense genes decreased 3 dpi with **S+** and 4dpi with **S-** (**Figure 1**). The similarity in the gene expression profiles for **S+** and **S-** with a delay of one day suggests the involement of growth speed in the interaction.

- **Defenses induced by CCF impact *P. infestans* behavior depending on pathogen growth speed**

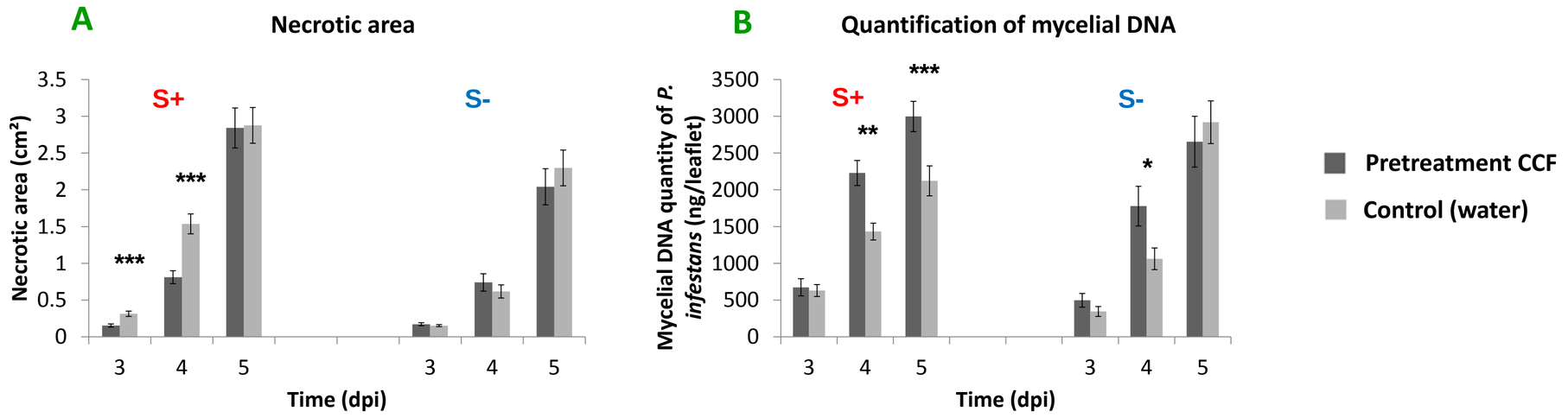


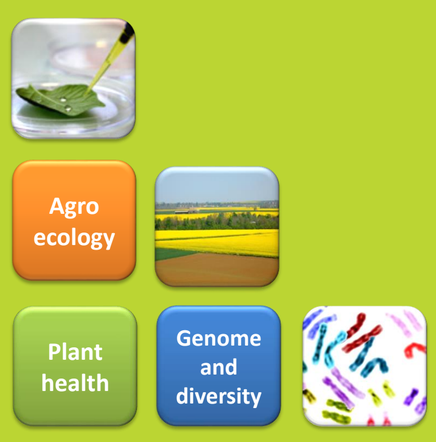
***Figure 2**: P. infestans behaviour : necrosis area (A), mycelial DNA quantity (B) and sporangia number (C) on potato leaflets cv. BF 15 after treatment with either CCF or sterile water (control) Two independent experiments except for sporangia number; dpi : days post inoculation; ANOVA : * p-value < 0,05; ** p-value < 0,01%; *** p-value < 0,001.*

After treatment with CCF, the necrotic area significantly decreased compared to the control only for **S+** and until 4dpi (**Figure 2A**), while sporangia production decreased only for **S-**. DNA quantity increased until 5dpi for **S+** and until 4dpi for **S-** (**Figure 2B**).

Perspectives

Our results show that CCF had a greater impact on **S+** development compared to **S-** on cv. BF 15. This suggests that the efficiency of induced resistance depends on life-history traits of each strain of *P. infestans.* We are now studying the interaction between two strains of *P. infestans* differing in their growth speed with three other potato cultivars with various resistance levels. We will also investigate the potential implication of *P. infestans* effectors in this interaction. For further qRT-PCR analysis we will use a high output tool : SmartChip Real-Time PCR WAFERGEN BIOSYSTEM.

Keywords
Concentrated culture filtrate
PAMP-Triggered Immunity
Solanum tuberosum
Late blight
Effectors



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