Responses of some European *Quercus* species to *Phytophthora cinnamomi* A1 and A2 mating types isolated from native and non-native areas.

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INTRODUCTION

Globalization has favoured the movement of plant pathogens at worldwide range. Many of these plant pathogens are well established in non-native areas and are causing important economic and ecological losses. Among them, *Phytophthora cinnamomi* Rands is a very aggressive pathogen, originated in Asia, which belongs to the Oomycete genus and is considered a cosmopolitan species with over 1000 host species. It has a heterothallic mating system (i.e. sexual reproduction only when pairing the two compatibility mating groups A1 and A2). Currently, there are very scarce studies where both A1 and A2 mating types of *P. cinnamomi* were compared in pathogenicity trials using European tree species. It is also unknown whether the aggressiveness varies between an invasive strain established for decades in European forests and a strain isolated from its natural ecosystems which could be introduced in Europe in the next years. This study aims to i) compare *Quercus* species plants infested with A1 and A2 mating types of *P. cinnamomi* and ii) study the effects of the origin of the strains (i.e. isolated in native Asian areas and in non-native European areas) at tree physiological level and in terms of mortality.

Fig. 1. Methodology. a) Plant distribution within the trial, (b) inoculation of plants growing in vermiculite, (c) infestation of plants with the inocula containing the respective *Phytophthora* isolate followed by 2 days-waterlogging, (d) spectral reflectance measurements, (e) gas exchange measurements, (f) washing of the root systems, (g) reisolations of the *Phytophthora* isolates from root simples, (h) fixation of roots in FAA and subsequently in ethanol and (i) root sampling for metabolomic analyses.

METHODOLOGY

In this trial of four months duration, six-month-old plants of *Quercus suber*, *Quercus robur* and *Quercus cerris* species were raised from seeds in 15 cell-seed trays containing vermiculite as substrate. Seven replicates of 15 cell-seed tray (3-5 seedlings per tree species and tray) per each combination of *Quercus* spp.-isolate were used for the inoculations. Plants were inoculated with an isolate of A1 mating type of *P. cinnamomi* from Asia, an isolate of A2 mating type of *P. cinnamomi* from Asia and an isolate of A2 mating type of *P. cinnamomi* from Europe (Fig. 1). Inoculations were carried out following the soil infestation method (Jung et al., 1996). During this experiment, measurements of different ecophysiological parameters, metabolomic samplings and assessment of mortality were performed (Fig. 1). Net photosynthesis and stomatal conductance measurements were taken with a portable Li-Cor CO2 analyzer. Content in chlorophyl and flavonols was calculated through a portable leaf-clip Dualex device. Steady-state leaf fluorescence (maximum quantum yield of photosystem II, Fv/Fm) and leaf reflectance were measured using FluorPen FP100 and PolyPen RP 400 UVIS instruments, respectively. Three reflectance-based physiological indices were obtained from the Polypen dataset considering light absorption by chlorophyll and carotenoids pigments: the Normalized Difference Vegetation Index (NDVI), the Photochemical Reflectance Index (PRI) and the Carotenoid Reflectance Index (CRI1). To confirm the presence of Phytophthora, re-isolations from root tissue were made three weeks post-inoculation using selective PARPNH agar and fixation of roots were performed at the end for obtaining images of the hyphae using a scanning electron microscope. observation of the hyphae within the root tissue.

RESULTS

In *Q. cerris* and *Q. suber* plants, the content in chlorophyl and flavonols did not differ between treatments while *Q. robur* plants showed a higher content when they were infested with A2 *P. cinnamomi* comparing to control plants. Maximum quantum yield of photosystem II did not show any stress in the photosynthetic apparatus of plants. Late responses related to a higher stomatal conductance were only observed in Asian A2 *P. cinnamomi* infested *Q. robur* plants. In general, in *Q. robur* and *Q. suber* plants, photosynthesis increased if plants were infested with A1 *P. cinnamomi* comparing to control plants (Fig. 2). Photosynthesis increased if *Q. cerris* plants were infested with A2 *P. cinnamomi* from Europe and if *Q. robur* plants were infested with A2 *P. cinnamomi* but only at the end of the trial (Fig. 2). Early detections of lower PRI and NDVI were observed in *Q. cerris* plants infested with A1 *P. cinnamomi* (Fig. 3). In *Q. robur* plants, early detections of lower PRI were observed for all infested plants (Fig. 3). *Q. suber* plants showed only a higher CRI1 when they were infested with A2 *P. cinnamomi* from Asia. In terms of aboveground biomass, height did not differ between treatments. Percentages of mortality for *Q. cerris* plants infested with A1 *P. cinnamomi*, A2 *P. cinnamomi* from Asia, A2 *P. cinnamomi* from Europe and control plants were 0, 20.0, 15.8 and 0, respectively. For *Q. suber* plant,s percentages of mortality were 45.9, 27.6, 29.0 and 6.7 and for *Q. robur* plants were 45.5, 34.3, 32.4 and 40, respectively.

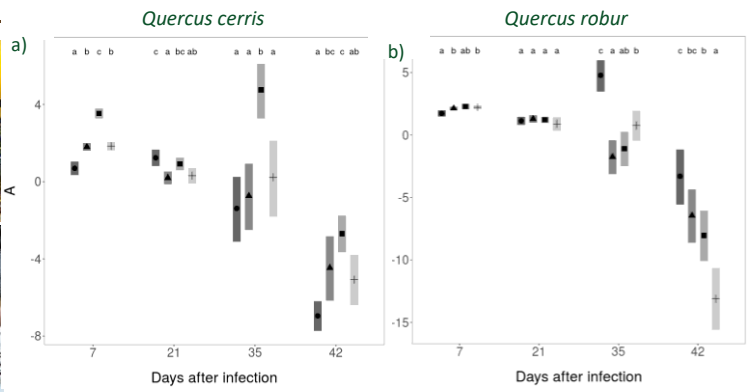

Fig. 2. Differences in mean values of net photosynthesis (A) between the Phytophthora inoculation treatments within each *Quercus* species measured in different dates.

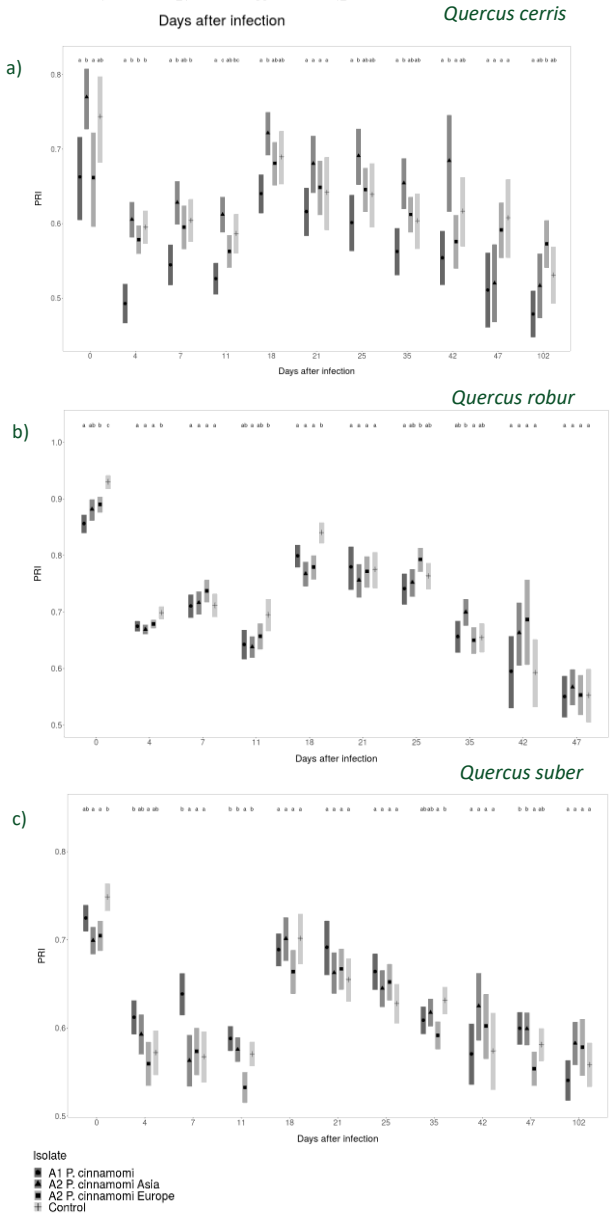

Fig. 3. Differences in mean values of the Photochemical Reflectance Index (PRI) between the Phytophthora inoculation treatments within each *Quercus* species measured in different dates.

CONCLUSIONS

Quercus species plants were affected by infestations of A1 *P. cinnamomi* and A2 *P. cinnamomi* in terms of physiology and mortality. Early detections of infestations were observed when measuring mainly photosynthesis and PRI, which are parameters related to the photosynthetic capacity of the plants. Mortality rates differed among combinations of trees species-*Phytophthora* isolates. More research is needed to clarify possible differences between *Phytophthora* isolates and origin in terms of aggressiveness.

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