Needle disease strategy Research Programme

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Technical Note

Pinus radiata photosynthesis and growth allocation by trees impacted by needle disease: a first look at Phytophthora infected grafts in the field

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Summary: In order to understand and quantify the reduction of growth caused by foliar disease, 32 grafts from two susceptible radiata pine genotypes were placed under the canopy of a radiata pine plantation affected by red needle cast disease (RNC). A paired set of 32 grafts was kept growing in the Scion nursery in the absence of RNC disease. All the grafts were measured for photosynthetic rate and height. After one month of treatment, 16 field-grown and 16 control grafts were re-measured. *Phytophthora pluvialis* was isolated from adjacent trees when the plants were placed in the field and monitored to confirm the presence of the pathogen. *Phytophthora pluvialis* was not isolated from the needles, nor RNC symptoms observed in the first month of exposure despite the presence of the pathogen. The photosynthetic rate remained similar for both growing conditions indicating similar rates of carbon assimilation, but the growth of the field exposed grafts was remarkably lower. This reduction in the growth could be explained by an increase of carbon allocated to other carbon sinks such as defence and storage. The second set of 16 grafts have been retained in the field and have since become infected. These are being assessed and compared to the controls in the same way as the first set. At the completion of the trial, the non-structural carbohydrate allocation will be analysed to better understand the physiological process of growth reduction, and test the hypothesis that radiata pine increases the allocation of carbohydrates from structural growth to carbon storage and resilience under infection pressure by foliar *Phytophthora* species.

Introduction

Given the considerable level of defoliation observed in some areas impacted by red needle cast (RNC), it is difficult to imagine it is not producing significant growth loss in radiata pine plantations. However, little is known about the physiological process leading to growth reduction and the magnitude of productivity loss as a function of infection. There are three main allocations for carbon within the plant once the carbon is captured by photosynthesis: growth, defence, storage. Needle disease, and RNC in particular, causes defoliation and consequently reduction in the total leaf area of the plant. Net photosynthesis at the canopy level may be reduced unless there is an upregulation of photosynthesis in the remaining needles.

We hypothesise that, after infection, uninfected needles can upregulate net photosynthesis for a short period of time with moderate infection, but this will decrease as the infection progresses within the canopy whereby negatively impacting plant growth.

Method

Thirty two one-year-old radiata pine grafts, from two susceptible genotypes were placed under the canopy of an infected radiata pine plantation. A further set of 32 grafts was retained as controls in the Scion nursery under similar shaded conditions as those in the field. Net photosynthesis and height were measured before the plants were deployed. *Phytophthora pluvialis* was isolated from adjacent trees when the plants were placed in the field and monitored at two week intervals, confirming the

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presence of the pathogen in the canopy of the surrounding trees.

The expression of RNC, growth and photosynthetic activity of the remaining 16 grafts (8 per genotype) from both the field and control treatments, have been measured periodically throughout October and November. The onset of RNC has being confirmed with isolations of *P. pluvialis* in the laboratory on Phytophthora-selective media.

Results and further work

One month into the trial, the percentage of symptomatic needles present in both control and field-grown grafts was similar: 20% of the canopy. The main symptoms observed were typical of Dothistroma needle blight. No *Phytophthora* was isolated from needles at this stage, however, low levels of pre-symptomatic infection cannot be ruled out.

The photosynthetic rate was similar in both control and field-grown grafts (Figure 1A). This suggests growing conditions in both the field and nursery were similar with regard to photosynthetic activity. Surprisingly, although carbon assimilation by the plants were similar in both treatments, control grafts increased their height significantly more than those exposed to RNC in the field gaining an average of 19% with respect to their initial height in contrast to 9% for those in the field (Figure 1B). This can be explained by a different carbon allocation pattern between treatments. Whilst photosynthesis activity was not affected by the treatment, field-grown grafts appear to have significantly reduced carbon allocated to growth. The fate of this carbon is not yet known but will be investigated further through laboratory analyses at the end of the trial. Instead of growth, carbon may have been allocated to either defence with the stress of exposure to additional disease pressures or to storage in an effort to increase resilience with prolonged infection pressure, or both.

Due to the low rate of infection, the remaining 16 pine grafts were moved to a second, wetter site at which high levels of infection were recorded on potted plants in the interim. While the final harvest of these is still to be completed they have been recently assessed for disease and are expressing a high percentage of RNC symptoms. In contrast, the grafts in the nursery have remained healthy. The trial is to be completed by the end of the year with photosynthetic rate, diameter and height measurements to be performed the coming weeks. Samples of non-structural carbohydrates have been collected and will be analysed in the laboratory in the new-year.

This study will provide the first clear insight of the impact of RNC on carbohydrate allocation within radiata pine. In turn, this will help to refine a strategy for increasing the resilience of plants challenged by RNC infection in the field.

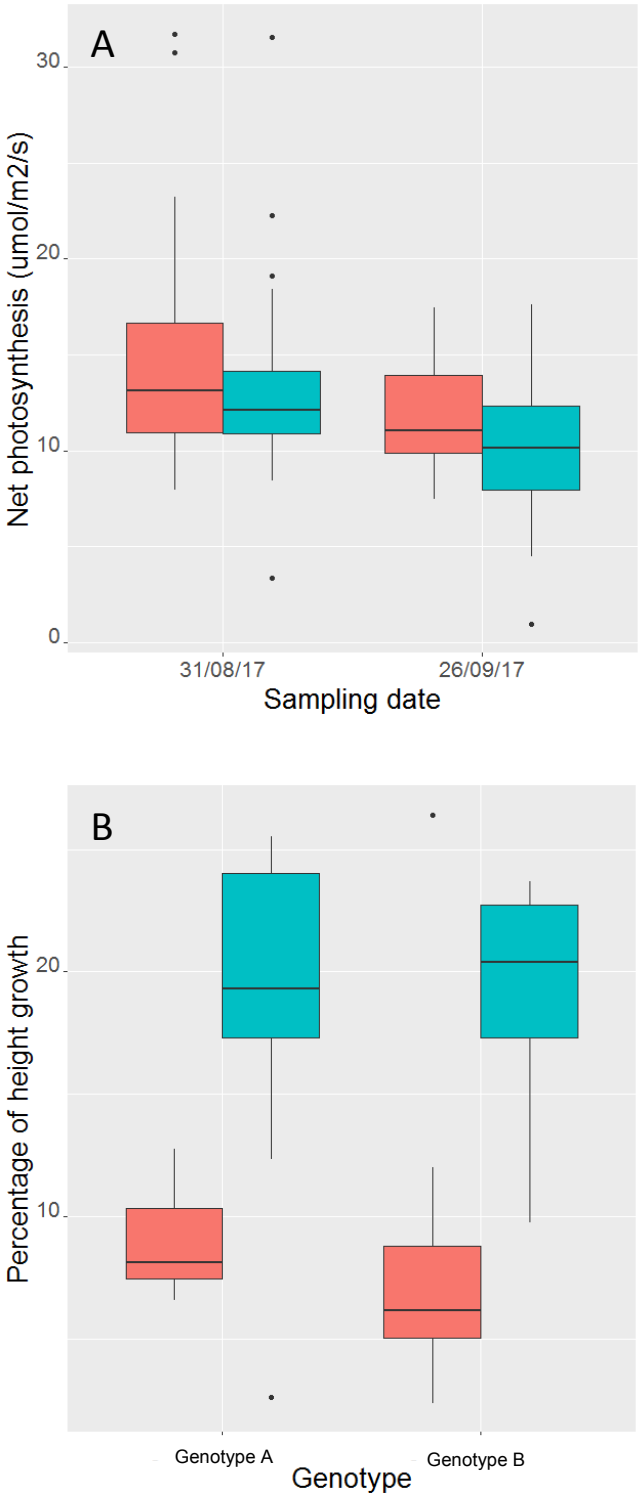

Figure 1. (A) Net photosynthesis in grafts growing in the field under infected canopy (red) and those growing in the nursery (blue) before deployment (31/08/17) and one month after growing in different conditions (26/09/17). (B) Net percentage of height growth in the field-exposed (red) and control (blue) plants for each of the two genotypes teste