

Climate change alters disease severity in the *Endoconidiophora polonica*-Norway spruce pathosystem

Riikka Linnakoski^{1,2}, Junko Sugano³, Samuli Junttila², Michael J. Wingfield⁴, Fred O. Asiegbu², Pertti Pulkkinen⁵, Kristian M. Forbes⁶

¹Natural Resources Institute Finland (Luke), Helsinki, Finland; ²Department of Forest Sciences, University of Helsinki, Finland; ³Department of Microbiology, University of Helsinki, Finland; ⁴Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, South Africa; ⁵Natural Resources Institute Finland (Luke), Läyliäinen, Finland; ⁶Department of Virology, University of Helsinki, Finland

Introduction

- Climate change is having significant impacts on forest ecosystems and forestry.
- In addition to direct negative impacts on tree health, climate change has the potential to impair plant responses to other environmental stressors, such as pathogens and pests.
- Few rigorous experimental studies have focused on interactions between biotic agents and climate change-associated environmental perturbations.
- To shed light into these implications, we conducted two powerful inoculation experiments^{1,2} to test *in vivo* the effects of changed growing environment on Norway spruces seedlings infected with *Endoconidiophora polonica*, a pathogenic fungus commonly vectored by *Ips typographus*, a major forest pest insect in Europe.



Fig. 1. Norway spruce (*Picea abies*) seedlings infected by an ophiostomatoid fungus *Endoconidiophora polonica*. The majority of seedling mortality occurred during the initial two months of the experiments.

Materials and methods

- 2-year-old Norway spruce (*Picea abies*) seedlings were inoculated with different strains of *E. polonica* isolated from *I. typographus* or mock-inoculated (control).
- In the first experiment¹, seedling performance was compared under ambient temperatures and CO₂ levels with those predicted for the years 2030 and 2100 in Finland.
- The second experiment² compared seedling performance under high and low water availability treatments.
- In total 450 (the first experiment) and 737 (the second experiment) seedlings were inoculated.
- Seedling mortality was monitored at monthly intervals, and seedling growth and lesion length indices were measured at the end of the experiments.

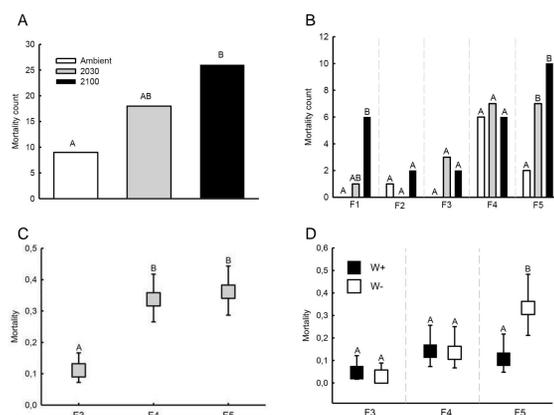


Fig. 2. Seedling mortality counts when (A) all fungal strains combined and (B) between the fungal strains under different climate change scenarios, and under high (W+) and low (W-) water availability treatments during the first (C) and second (D) month of the experiment.

Results

- Increased temperatures coupled with elevated CO₂ concentration¹, and reduced water availability² can both enhance disease severity in *P. abies*.
- Higher temperature increases are likely to be most detrimental to tree health.
- Disease severity was not universally greater under the most distant climate change expectations or for water restricted seedlings, but varied markedly among the fungal strains (Fig. 2b-d).

Conclusions

- We show that predicted climate changes have the potential to alter the damage caused to Norway spruce by *E. polonica*.
- Our results highlight the importance for a strain-specific level of understanding of the disease agents.
- There is an urgent need for systems-based research to better understand the impacts of interactions between biotic agents and climate change.
- For more information, visit our special issue in *Frontiers in Plant Science* for outstanding research addressing the multifaceted effects of climate changes on forest pests and pathogens and their interactions.

Acknowledgements

This study was financially supported by the University of Helsinki and the Natural Resources Institute Finland (Luke). Travel and participation (RL) to IMC11 was funded by LukeLEADS MushValue-project.



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

References

- Linnakoski R, Forbes KM, Wingfield MJ, Pulkkinen P, Asiegbu F (2017) Testing projected climate change conditions on the *Endoconidiophora polonica* / Norway spruce pathosystems shows fungal strain specific effects. *Front Plant Sci* 8:883, doi:10.3389/fpls.2017.00883
- Linnakoski R, Sugano J, Junttila S, Pulkkinen P, Asiegbu F, Forbes KM (2017) Effects of water availability on a forestry pathosystem: fungal strain-specific variation in disease severity. *Sci Rep* 7:13501. doi:10.1038/s41598-017-13512-y