Multi-pathogen interactions in American ginseng

Andrew G. Rabas[1], Andrea Ong[1], Mark A. Bernards[1]

[1] Biology Department, University of Western University, London, ON

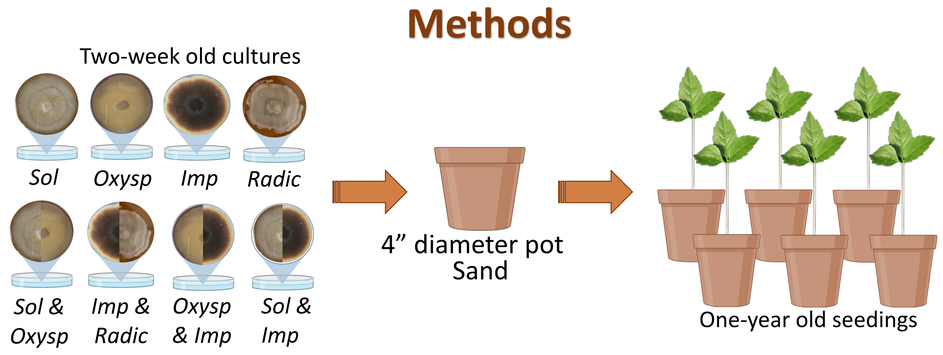
Introduction

Ginseng is a perennial herbaceous crop cultivated for three to four years before a single harvest [1]. The biggest issue facing ginseng growers is a soil condition known as ginseng replant disease (GRD), resulting in reduced growth and severe root rot in ginseng planted in soil previously used for ginseng cultivation. GRD can often persist for decades in ginseng garden soil [1]. The fungus *Ilyonectria mors-panacis* (*Imp*) is the primary source of root rot in ginseng, however other fungal pathogens are found in ginseng garden soil [2]. This suggests there may be interaction between pathogens on ginseng roots in GRD soil.

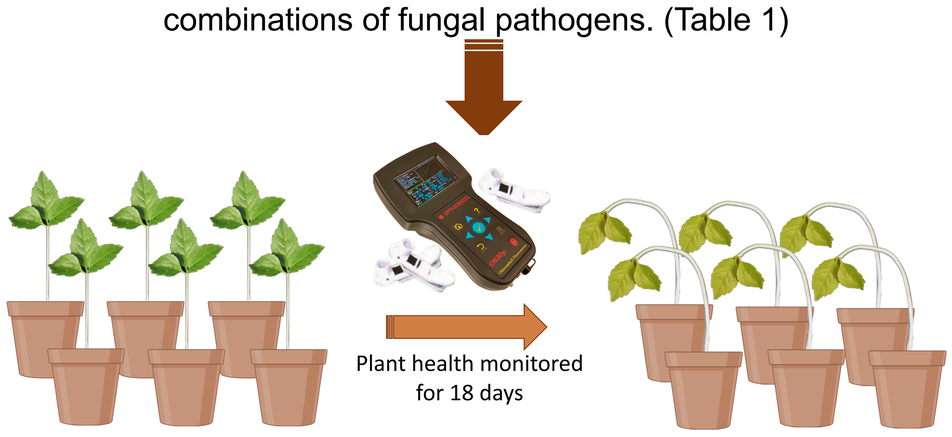
Research Objective

Determine whether co-inoculation of ginseng plants with *Imp* in combination with other fungal pathogens isolated from ginseng garden soil, increases the severity of *Imp* root rot, and if so, with which species.

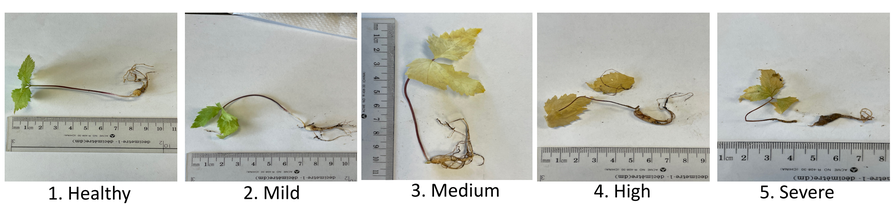
Methods



One-year old seedlings planted into pots that were inoculated with different combinations of fungal pathogens. (Table 1)



Plants health was monitored using a chlorophyl fluorometer every 3-days until plants died, after which plants was carefully collected for root assessment using a five-point disease severity index.



Disease Severity Index [3]

Table 1: Fungal pathogens used in study

Fungal Pathogens	Source
Ilyonectria mors-panacis (*Imp*)	Canadian Collection of Fungal Cultures (CCFC)
Ilyonectria radicicola (*Radic*)	
Fusarium solani (*Sol*)	Field isolates obtained from the Ontario Ginseng Growers Association (OGGA) and confirmed using Sangar sequencing
Fusarium oxysporum (*Oxysp*)	

Results

Plants inoculated with *Oxysp* along with the *Control* plants remained healthy throughout the study, while inoculated with *Sol* and *Radic showed* some infection. All ginseng inoculated with *Imp* died within 12 days of inoculation (Figure 1A). Plants inoculated with fungal pathogens in combination with Imp showed a decreased survival compared to those inoculated with fungi individually, especially the combination of *Sol* + *Imp* (Figure 1B).

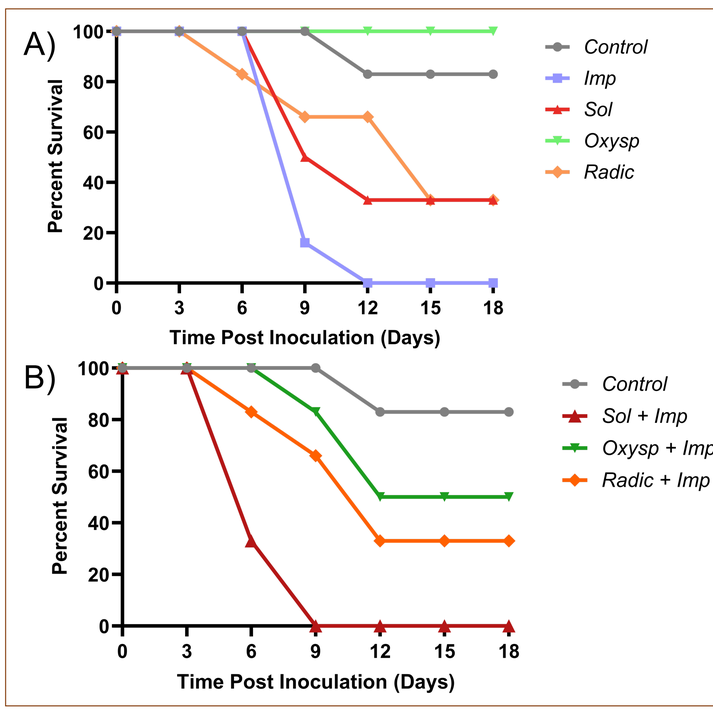


Figure 1: Survival of one-year old ginseng inoculated with different combinations of fungal pathogens. (A) Plants inoculated with individual fungi, (B) plants inoculated with fungi in combination with Imp.

The root assessment showed that both the *Control* and *Oxysp* inoculated roots remained healthy, while those inoculated with *Radic* and *Radic* + *Imp* had a mild but not significant degree of root rot compared to each other. The roots from *Oxysp* + *Imp* inoculated plants showed a medium but significant level of root rot compared to the *Oxysp* [$F(7,40)= 20.05$, $P<0.0001$]. Lastly *Sol, Imp* and *Sol* + *Imp* inoculated plants showed severe but not significant degree of root rot compared to each other. (Figure 2).

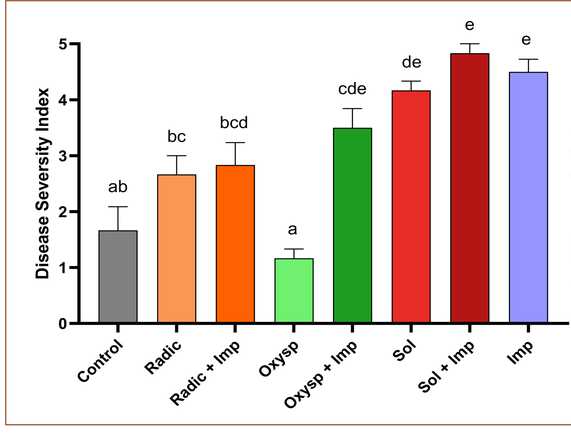


Figure 2: Disease severity on one-year old ginseng inoculated with different combinations of fungal pathogens. Bars with the same letters are not significantly different from each other.

Conclusion

The earlier onset of root rot on plants inoculated with *Sol + Imp*, relative to either *Sol* or *Imp* alone, indicates a synergistic interaction between these two fungi.

Future Work

Investigate the interaction between *F. solani* and *Imp*, to determine which of the two pathogens is the primary cause of the root rot.

Literature Sited

[1] Westerveld, S. M. & Shi, F. The history, etiology, and management of ginseng replant disease: a Canadian perspective in review. *Can. J. Plant Sci.* **101**, 886–901 (2021).

[2] Ji, L. et al. Outbreaks of root rot disease in different aged American ginseng plants are associated with field microbial dynamics. Front. Microbiol. **12**, 676880 (2021).

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Acknowledgements

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