

Can the incorporation of disinfectants or fungicides to the hot water treatment regime have an improved efficacy against Petri disease pathogens in nursery vines?

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Young vine decline

Petri disease

- *Phaeoconiella chlamydospora*
- *Phaeoacremonium* spp.
- *Cadophora luteo-olivacea*
- *Pleurostoma richardsiae*

Significant economic impact:

- Fewer certifiable vines
- Lower productivity
- Stunted growth and delayed budding
- Premature death

Important infection pathways

- Infection of wounds of rootstock mother vines (Pruning wounds) or during the propagation process
- Latent infection of propagation material through systemic infection from mother-vines



Propagation process

Scion cuttings



Rootstock cuttings



HWT: 50°C for 30 min



Cooldown bath: 30 min



Grafting and waxing



Callusing



Planting



Uplift dormant vines



Certify and sell



Hot Water Treatment (HWT)

To eliminate:

- Crown gall
- Aster yellow phytoplasma

To reduce:

- Root-knot nematodes

For other Grapevine Trunk Disease (GTD) pathogens:

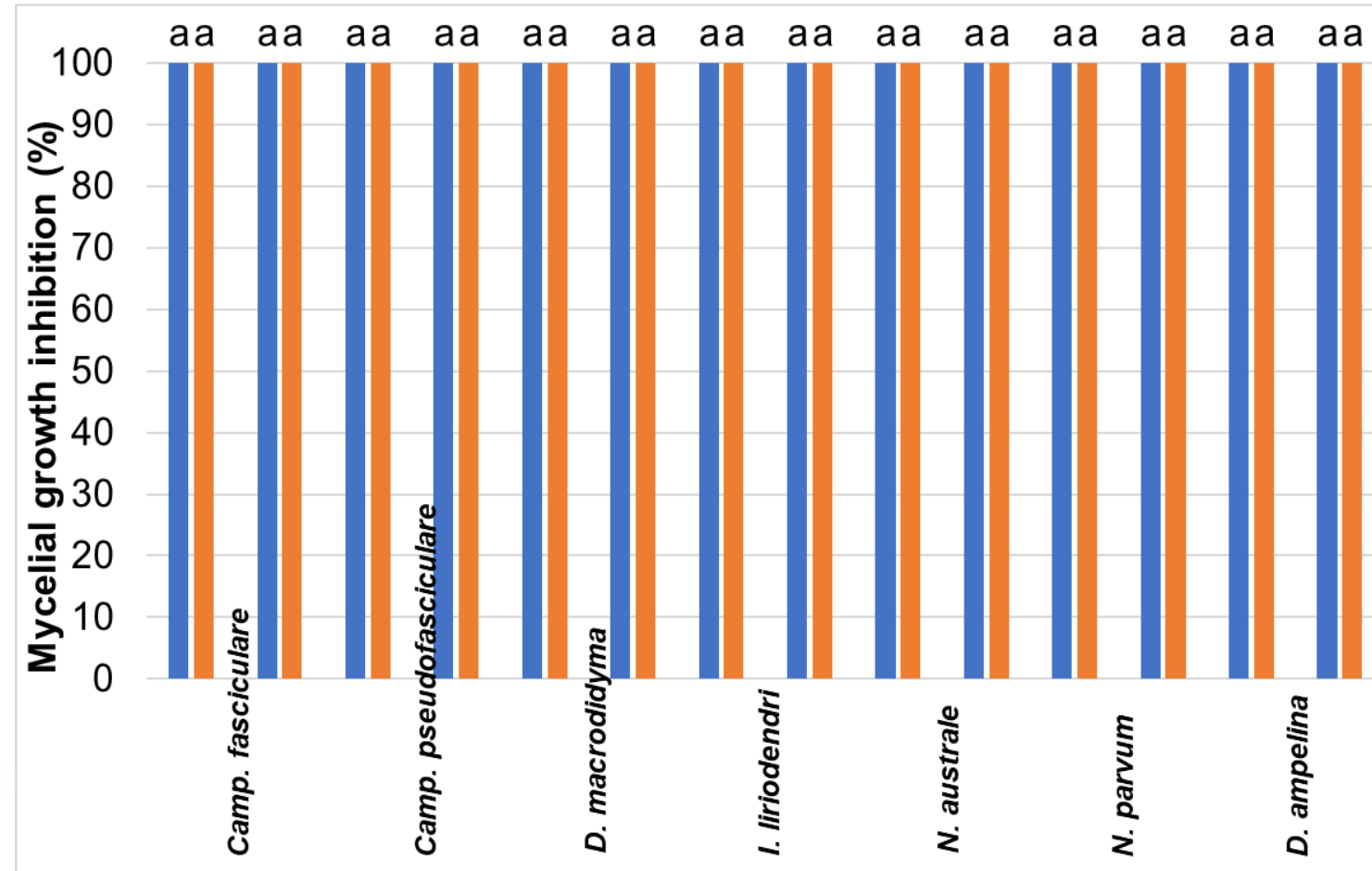
Tested the sensitivity of several pathogens to HWT

Black Foot Disease

Bot. Canker

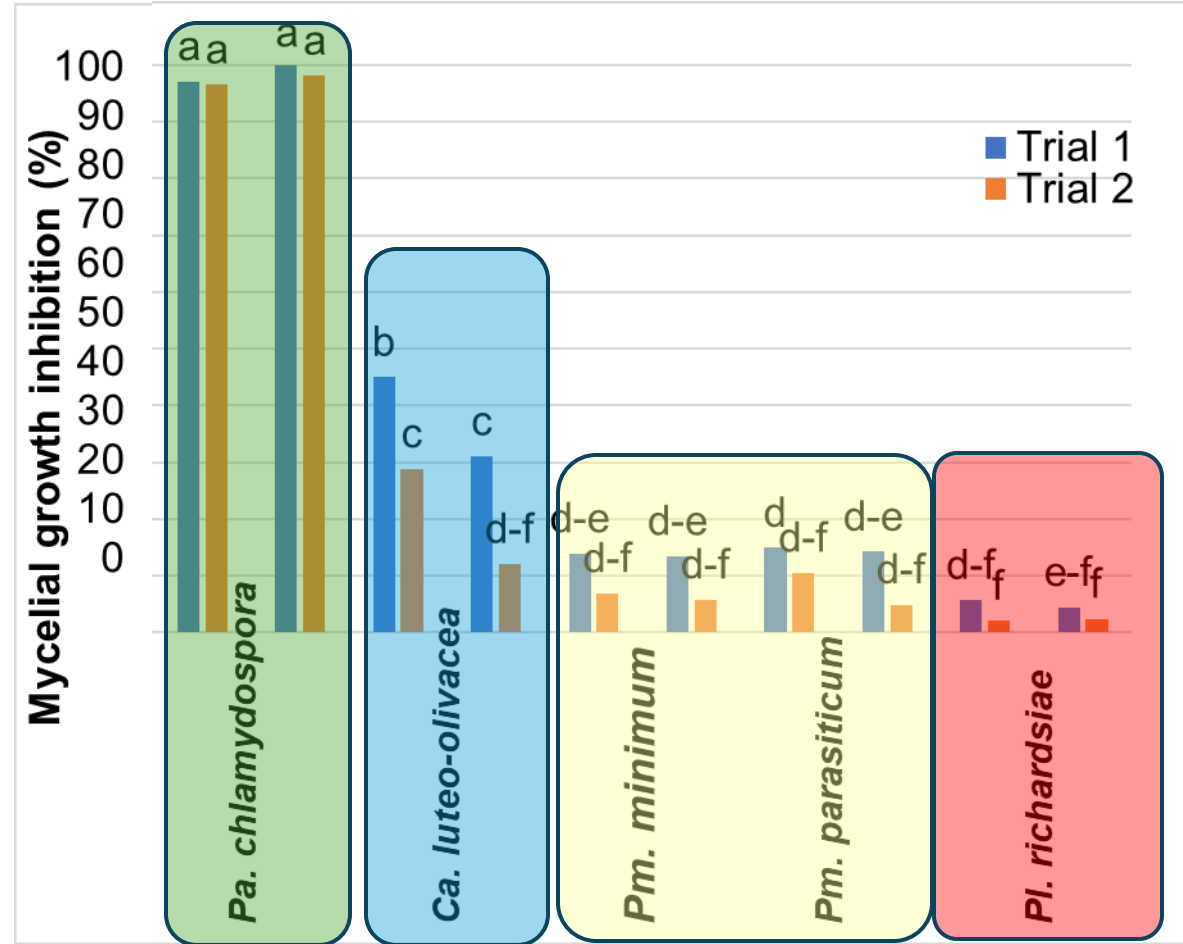
Phomopsis Dieback

Complete Inhibition



Hot Water Treatment (HWT)

Petri disease pathogens



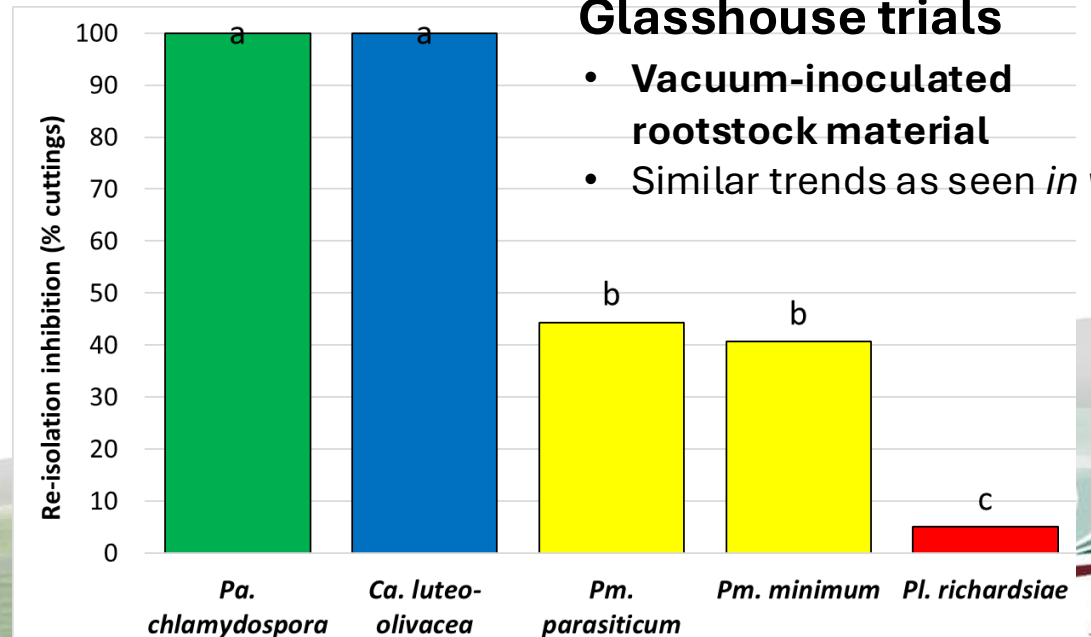
At 50°C

> 50°C

<i>Phaeomoniella chlamydospora</i> Very strong inhibition (>97%)	Complete inhibition at 51°C
<i>Cadophora luteo-olivacea</i> Moderate inhibition (12-45%)	Complete inhibition at 52°C
<i>Phaeoacremonium spp.</i> Moderate-low inhibition (5-14%)	Strong inhibition at 53°C (73-94%)
<i>Pleurostoma richardsiae</i> Tolerant (2-5% inhibition)	Tolerant even at 60°C (5.3-6.2% inhibition)

Glasshouse trials

- Vacuum-inoculated rootstock material
- Similar trends as seen *in vitro*



Problem statement

Pleurostoma richardsiae is considered heat-tolerant and is not effectively controlled by HWT

Aim

Improve the efficacy of HWT (50°C for 30 min) in grapevine nurseries by adding chemicals (fungicides or disinfectants) to the HWT regime to reduce Petri disease infections

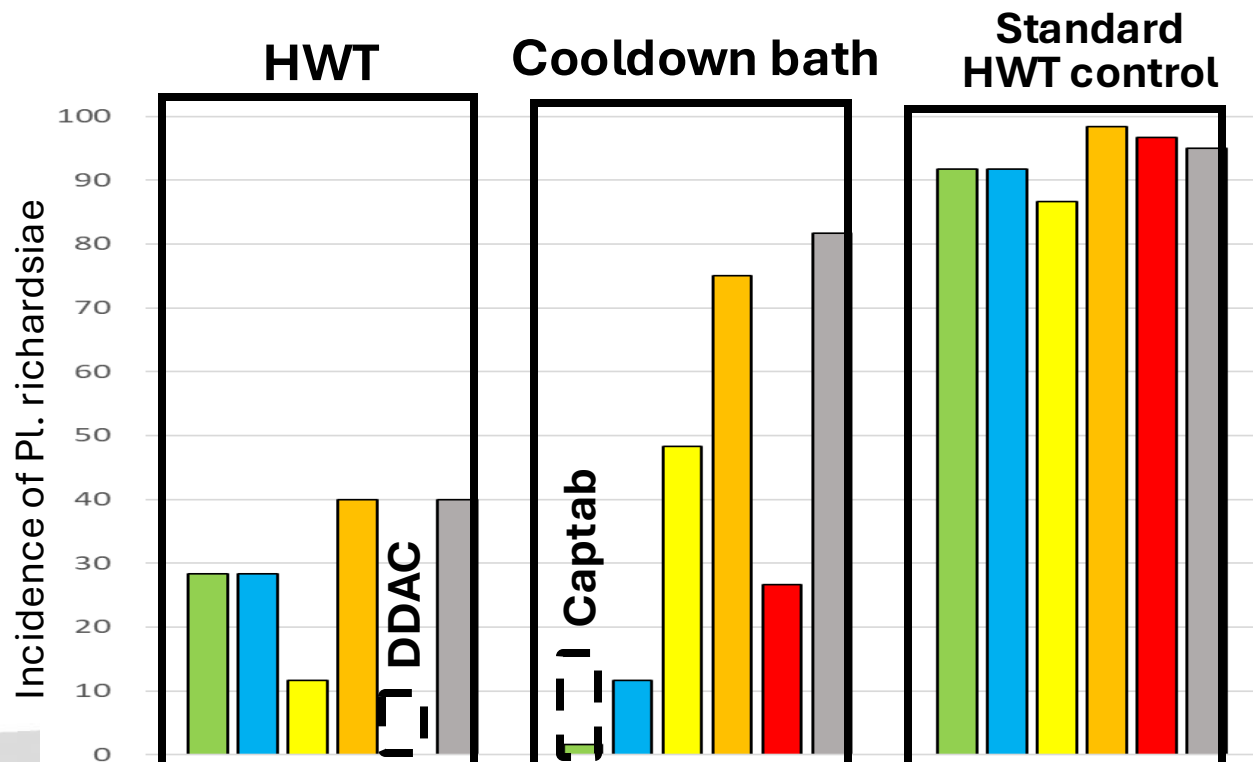
Chemical selection

In vitro screening of chemicals against Petri disease pathogens

- 17 fungicides + 1 disinfectant:
 - Conidial and mycelial inhibition

Screening of chemicals with HWT in detached rootstock assays

- 6 best performing chemicals



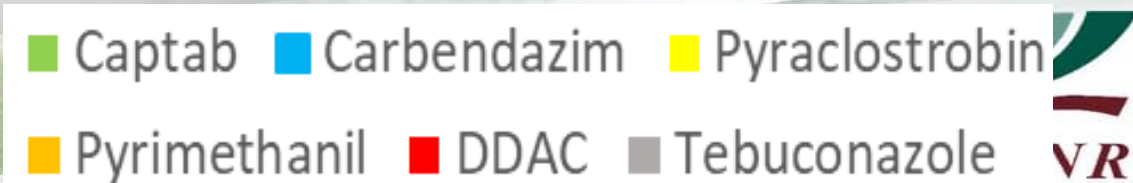
Best performing treatments

Hot water bath

Didecyldimethylammonium chloride (DDAC)

Cooldown bath

Captab



Semi-commercial field trial - Season 1

Semi-commercial field trial - Season 1

- Scion: **Sweet Celebration (YJ 8728)**
- Rootstock varieties: **Ramsey (SC 18 AB)** and **1103 Paulsen (PS 28 I)**

Treatment	HWT	Cooldown bath
1	No	Yes
2	Yes	Yes
3	Yes + DDAC	Yes + Captab
4	Yes + DDAC	Yes + DDAC
5	Yes + DDAC	Yes

Non-HWTed control
HWT control

DDAC applied at 50mL/100L of water

Captab applied at 200g/100L of water

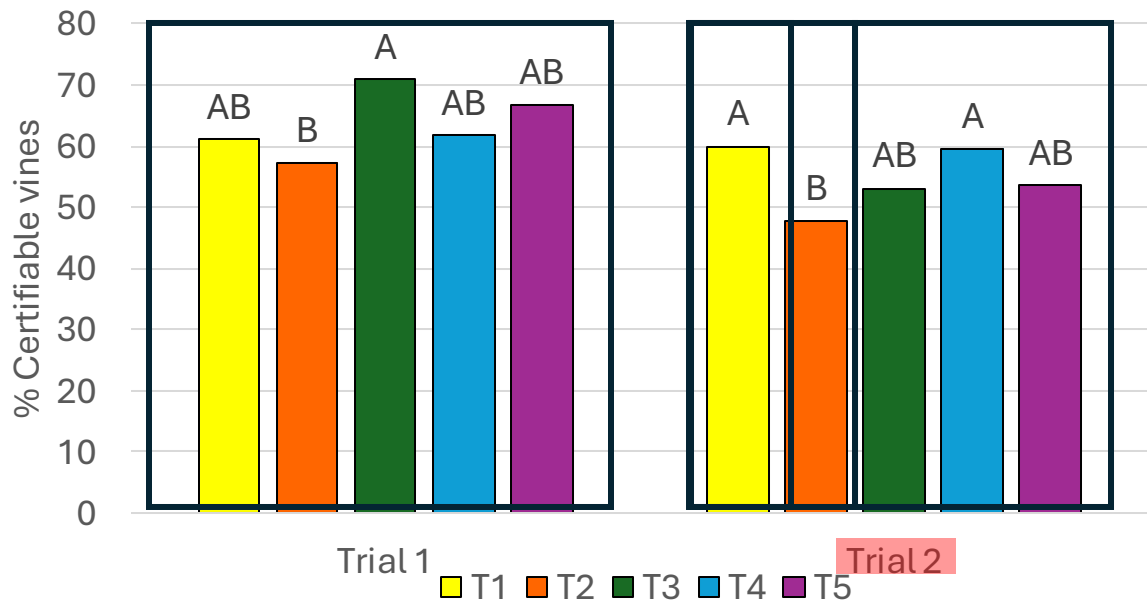
- Standard nursery practice followed post-HWT
- Relied on natural infection
- 4800 vines planted and evaluated

- After 8 months in soil:
 - Percentage certifiable plants
 - Wet shoot and root mass
 - Fungal isolations and pathogen identification



Growth parameters

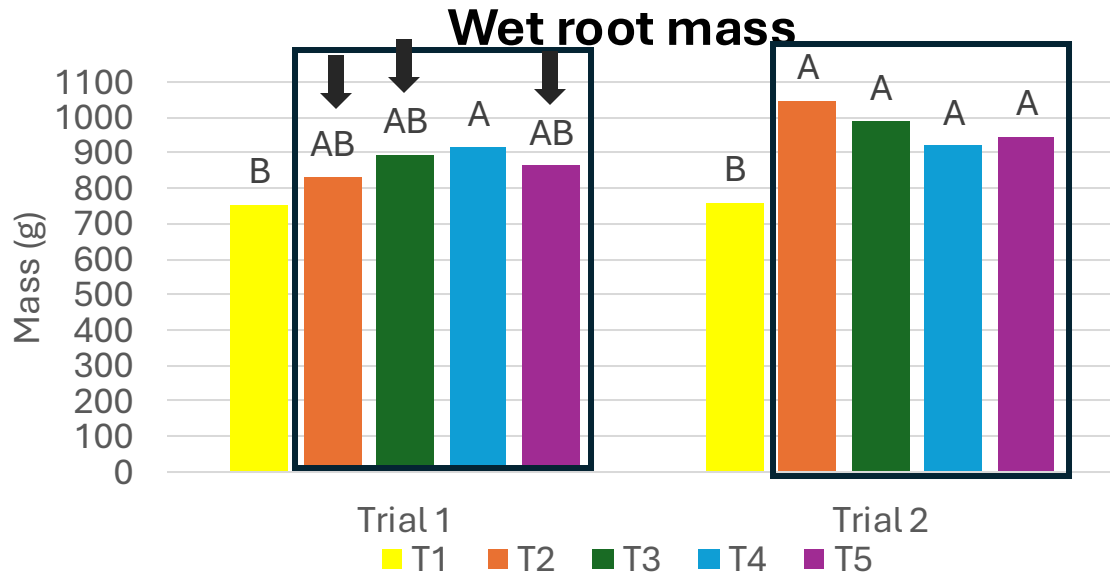
Certifiable vines (%)



	Treat.	HWT	Cooldown bath
Non-HWTed control	1	No	Yes
HWT control	2	Yes	Yes
	3	Yes + DDAC	Yes + Captab
	4	Yes + DDAC	Yes + DDAC
	5	Yes + DDAC	Yes

- HWT + chemicals did not negatively affect % certifiable vines compared to non-HWTed control
- Trial 2: Standard HWT has lower % certifiable vines compared to non-HWTed control

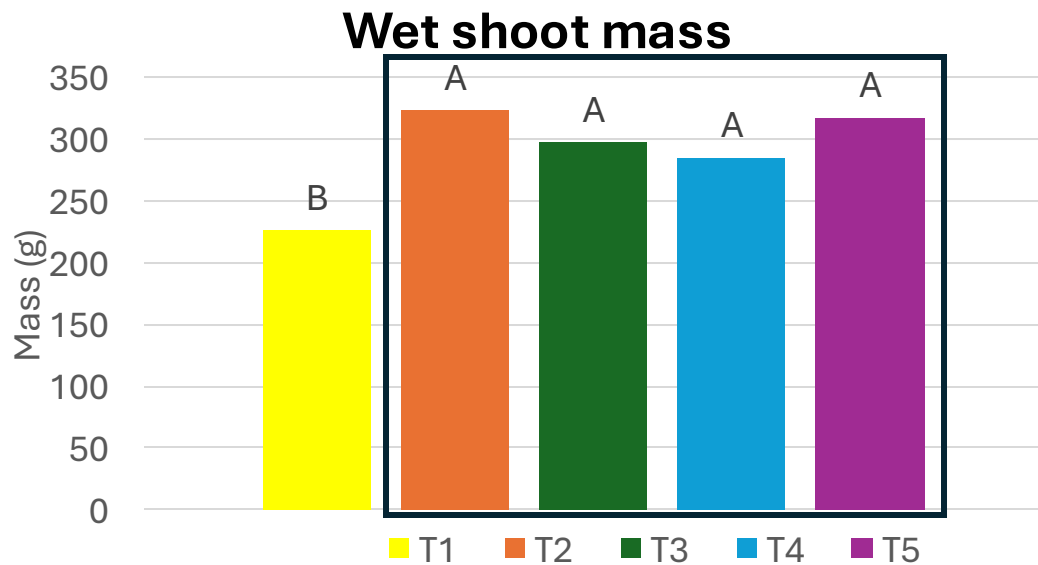
Growth parameters



Non-HWTed control

HWT control

Treat.	HWT	Cooldown bath
1	No	Yes
2	Yes	Yes
3	Yes + DDAC	Yes + Captab
4	Yes + DDAC	Yes + DDAC
5	Yes + DDAC	Yes



- HWT with or without chemicals did not negatively affect root or shoot mass compared to the non-HWTed control
- **Only root mass of T2, T3 and T5 not greater than non-HWTed control (Trial 1)**
- The addition of chemicals did not differ from the standard HWT control

Pathogen incidence

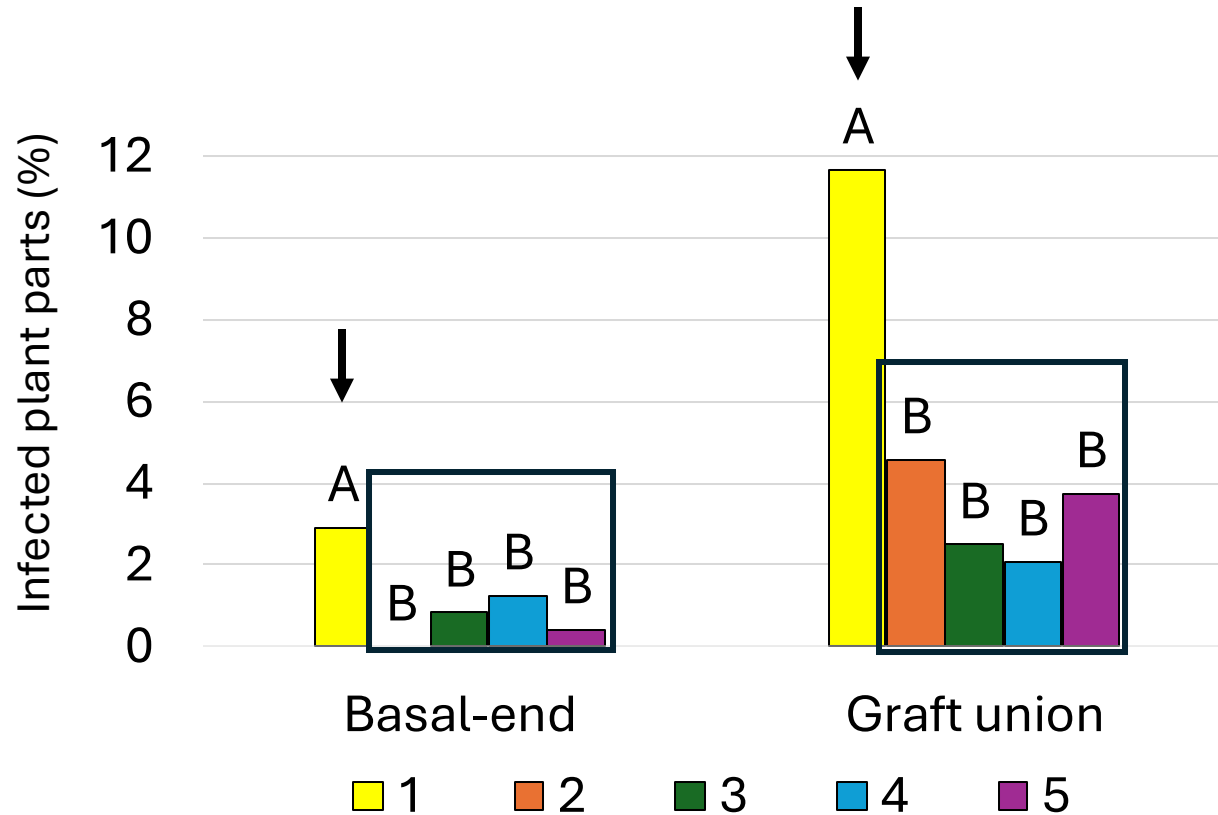
Phaeomoniella chlamydospora

Low incidences (1.7 – 5%) and no significant differences between treatments

Cadophora luteo-olivacea

Very few isolates were recovered, and statistical analyses were not possible

Phaeoacremonium spp.



	Treat.	HWT	Cooldown bath
Non-HWTed control	1	No	Yes
HWT control	2	Yes	Yes
	3	Yes + DDAC	Yes + Captab
	4	Yes + DDAC	Yes + DDAC
	5	Yes + DDAC	Yes

Non-HWTed had significantly more infection than all HWT treatments

Chemical amendment to HWT did not further reduce infection incidence

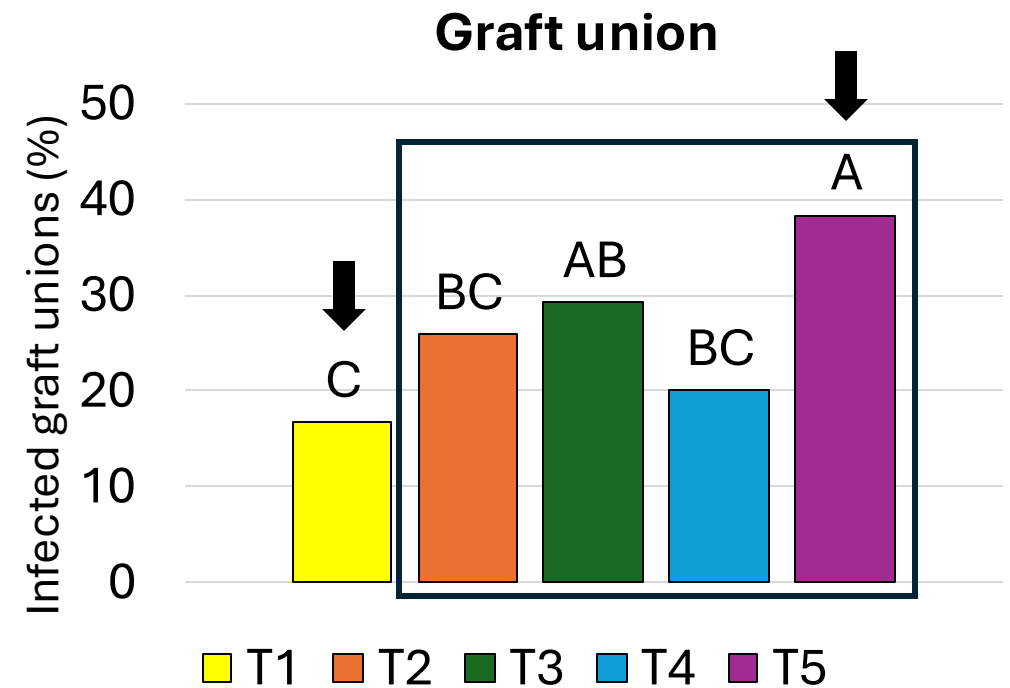
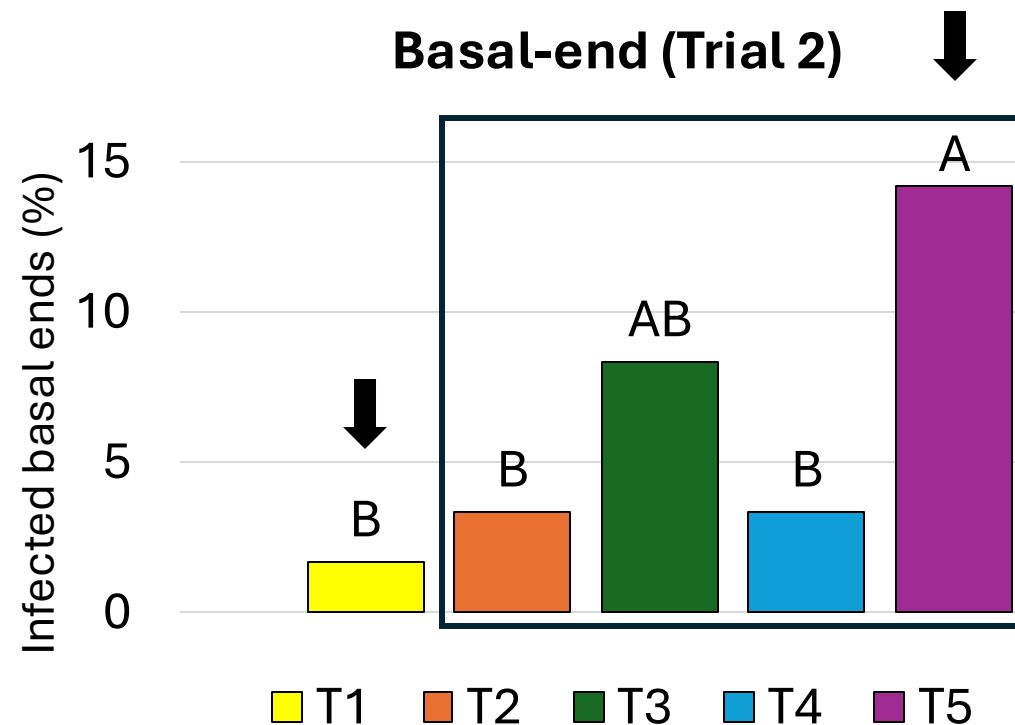
Pleurostoma richardsiae

- No significant differences between treatments in Trial 1
- HWT with and without chemicals did not reduce infections relative to non-HWTed control
- In some cases, HWT + chemicals had higher incidences than non-HWTed and standard HWT controls

Treat.	HWT	Cooldown bath
1	No	Yes
2	Yes	Yes
3	Yes + DDAC	Yes + Captab
4	Yes + DDAC	Yes + DDAC
5	Yes + DDAC	Yes

Non-HWTed control

HWT control



Semi-commercial field trial - Season 2

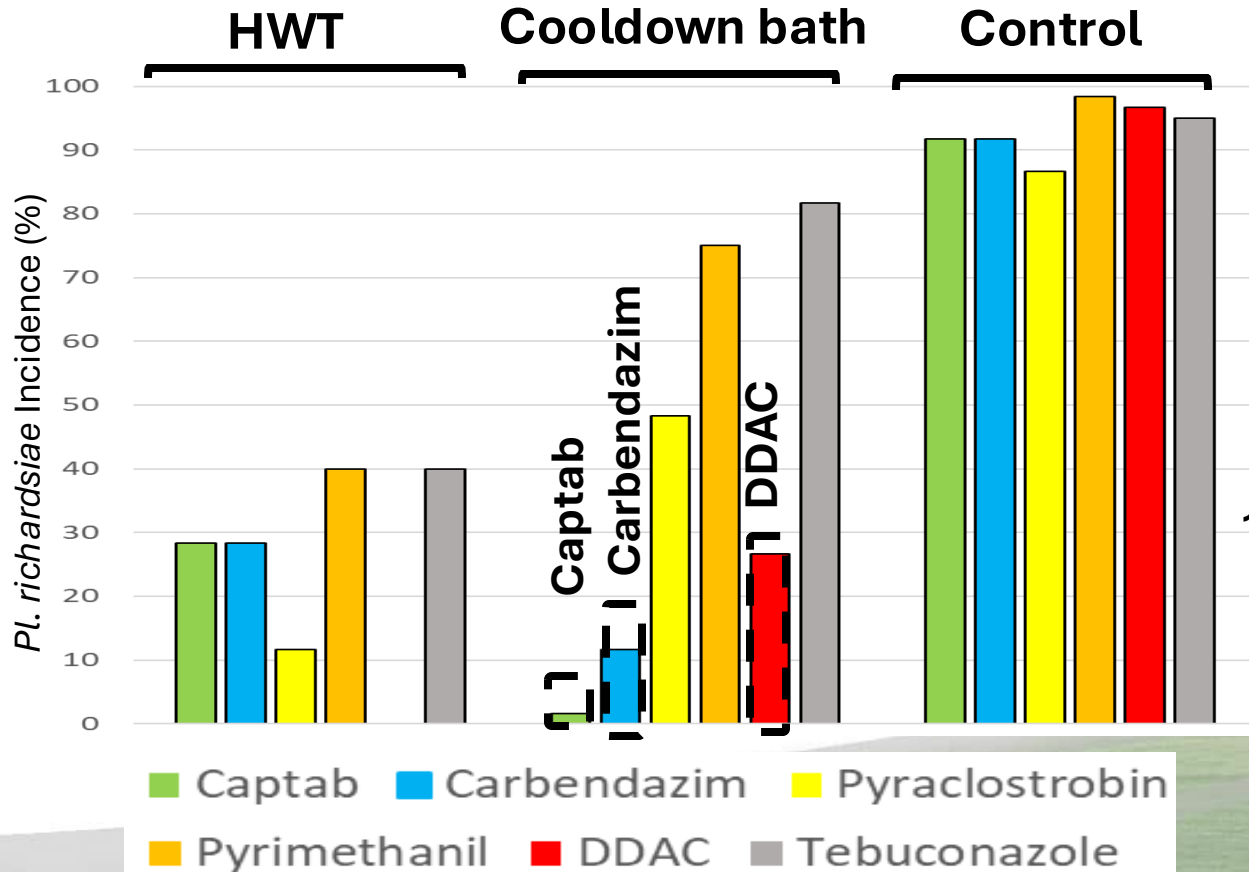
Treatment selection

Hot water bath: Increased concentration

- DDAC: **100 mL/ 100L** water for **T5-10**
- DDAC: **150 mL/ 100L** water for **T12**

Cooldown bath:

- Captab, Carbendazim and DDAC



Non-HWTed control

HWT control

100mL/100L

HWT control

150mL/100L

T.	HWT	Cooldown bath
1	No	Yes
2	Yes (Clean water)	Yes
3	Yes	Yes + Captab
4	Yes	Yes + Carbendazim
5	Yes	Yes + DDAC + Carbendazim
6	Yes + DDAC	Yes
7	Yes + DDAC	Yes + Captab
8	Yes + DDAC	Yes + DDAC
9	Yes + DDAC	Yes + DDAC + Captab
10	Yes + DDAC	Yes + Carbendazim
11	Yes (Dirty water)	Yes
12	Yes + DDAC	Yes

Standard nursery practices and trial evaluation as in Season 1

11520 vines planted and evaluated

Growth parameters

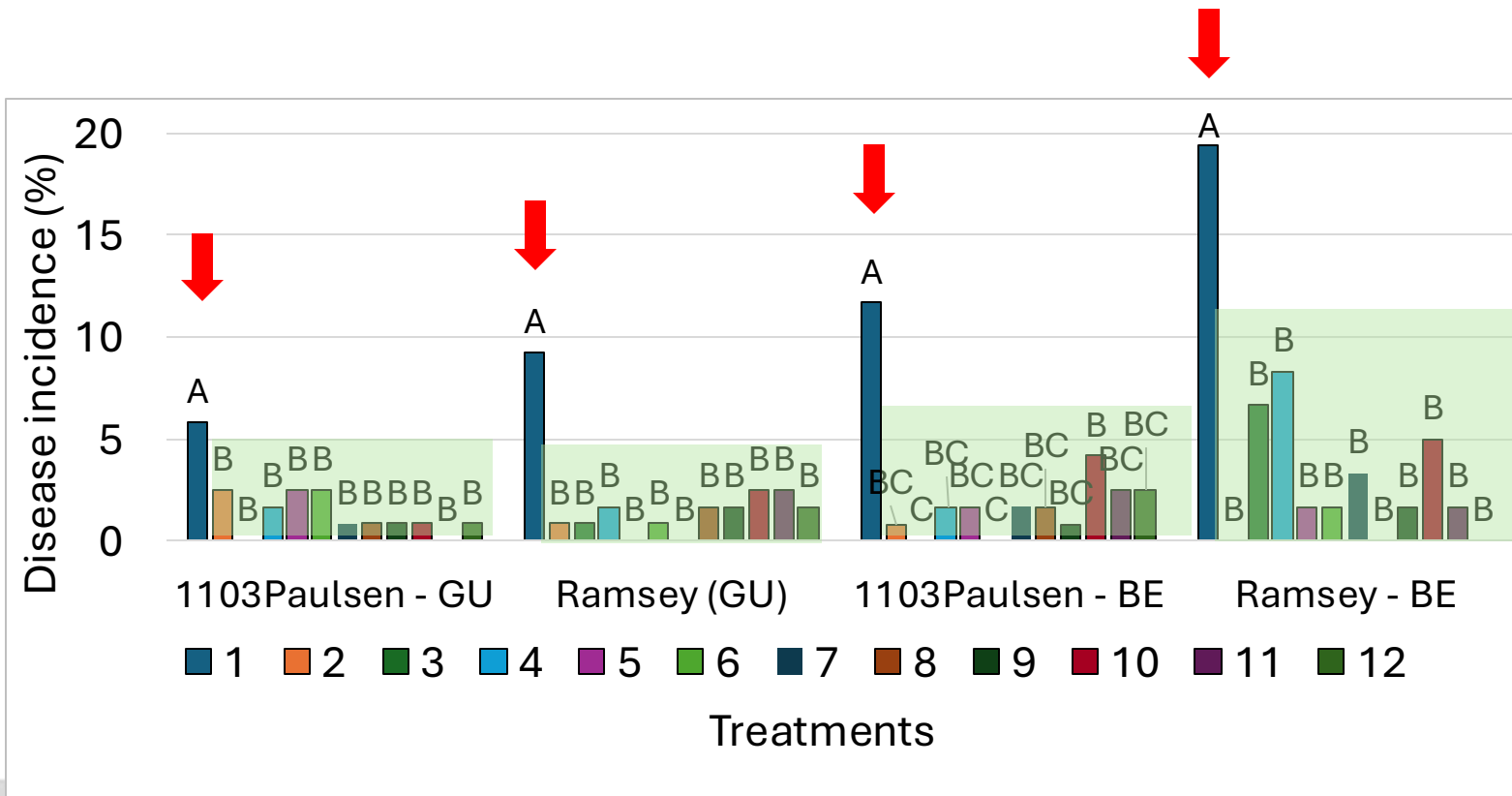
- For all growth parameters, no significant differences between treatments were observed
 - Shoot mass
 - Root mass
 - Number of certifiable vines
- HWT, with and without the addition of chemicals, did not negatively affect growth parameters of nursery vines

Cadophora luteo-olivacea

No isolates recovered

Phaeomoniella chlamydospora

- Non-HWTed control had significantly more infections than all treatments that received HWT
- Chemicals did not further increase the efficacy of HWT



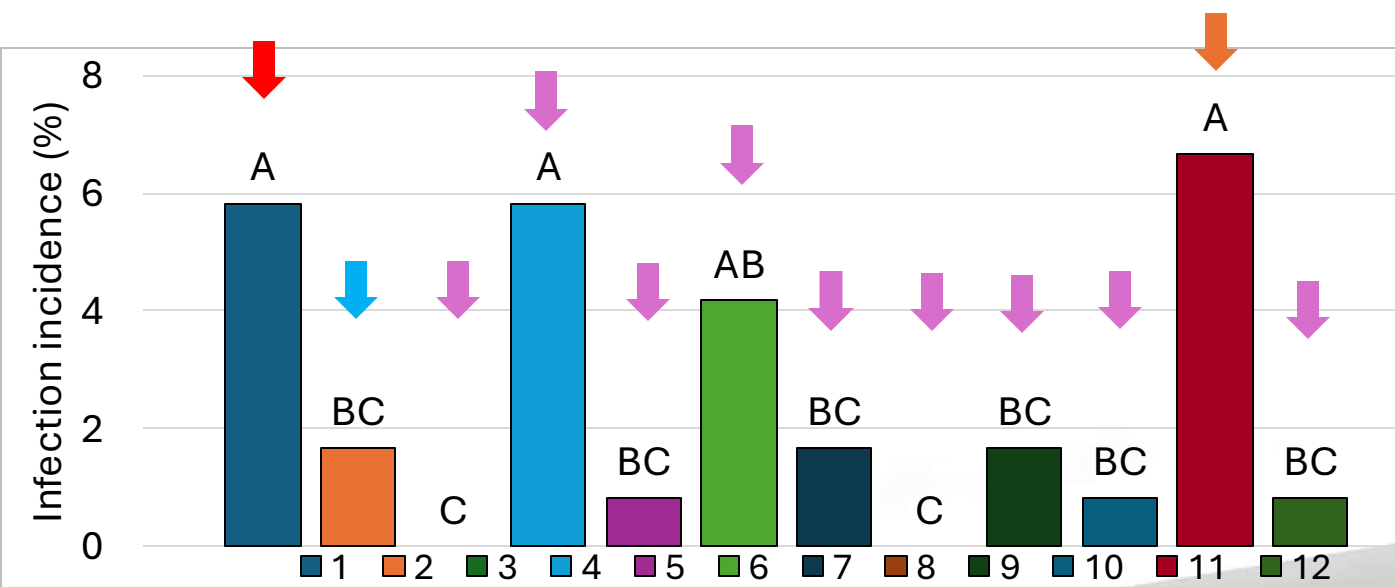
Treat.	HWT	Cooldown bath
1	No	Yes
2	Yes (Clean water)	Yes
3	Yes	Yes + Captab
4	Yes	Yes + Carbendazim
5	Yes	Yes + DDAC + Carbendazim
6	Yes + DDAC	Yes
7	Yes + DDAC	Yes + Captab
8	Yes + DDAC	Yes + DDAC
9	Yes + DDAC	Yes + DDAC + Captab
10	Yes + DDAC	Yes + Carbendazim
11	Yes (Dirty water)	Yes
12	Yes + DDAC	Yes

Basal end: No significant differences between treatments

Phaeoacremonium spp.

- **Graft unions:** Non-HWTed control had significantly more infections than the standard HWT regime
- **HWT + chemicals:** majority of treatments had lower infections than the non-HWTed control, however, did not differ from the standard HWT control
- **Outliers:** T4 and T6 had similar infection incidence to non-HWTed control
- HWT with dirty water resulted in similar infection incidence to the non-HWTed control

Treat.	HWT	Cooldown bath
1	No	Yes
2	Yes (Clean water)	Yes
3	Yes	Yes + Captab
4	Yes	Yes + Carbendazim
5	Yes	Yes + DDAC + Carbendazim
6	Yes + DDAC	Yes
7	Yes + DDAC	Yes + Captab
8	Yes + DDAC	Yes + DDAC
9	Yes + DDAC	Yes + DDAC + Captab
10	Yes + DDAC	Yes + Carbendazim
11	Yes (Dirty water)	Yes
12	Yes + DDAC	Yes

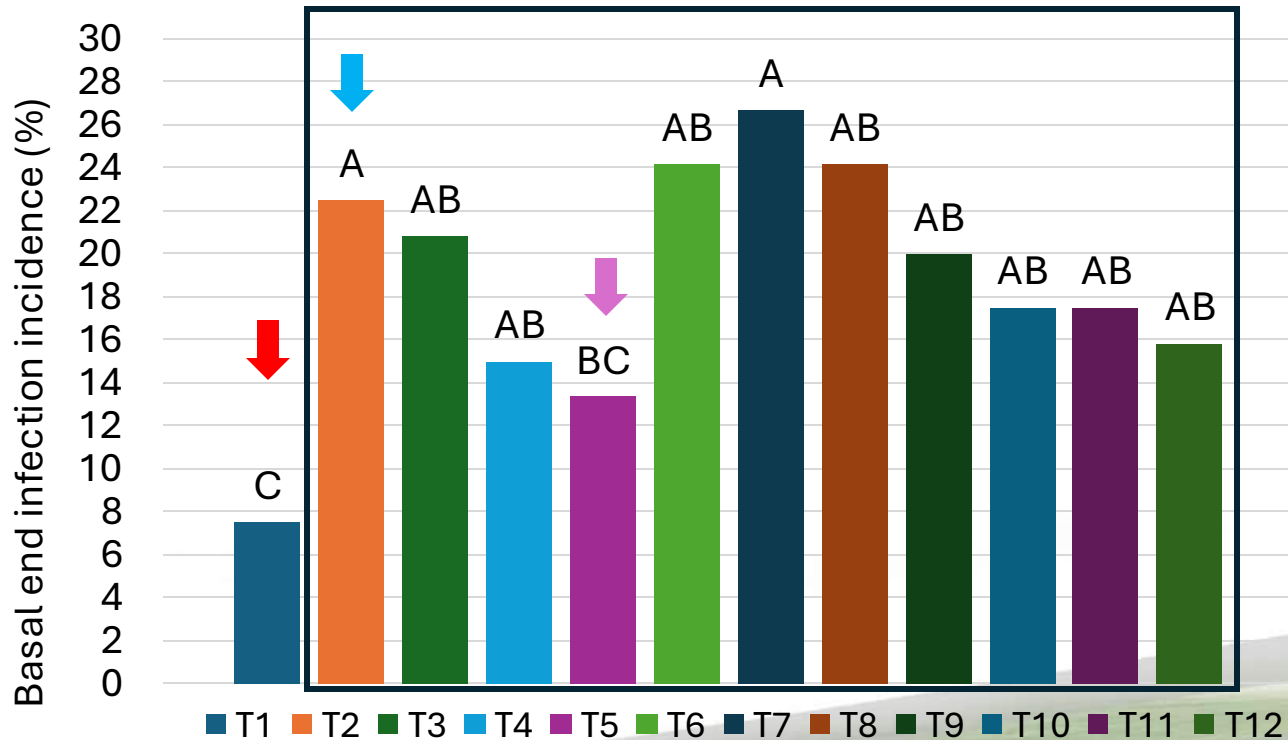


Graft unions: No significant differences between treatments

Pleurostoma richardsiae

Basal ends: Standard HWT regime had significantly higher infection incidence than non-HWTed control

- HWT + chemicals did not differ to the standard HWT regime control (T2)
- Outlier: T5 was statistically similar to the non-HWTed control



Treat.	HWT	Cooldown bath
1	No	Yes
2	Yes (Clean water)	Yes
3	Yes	Yes + Captab
4	Yes	Yes + Carbendazim
5	Yes	Yes + DDAC + Carbendazim
6	Yes + DDAC	Yes
7	Yes + DDAC	Yes + Captab
8	Yes + DDAC	Yes + DDAC
9	Yes + DDAC	Yes + DDAC + Captab
10	Yes + DDAC	Yes + Carbendazim
11	Yes (Dirty water)	Yes
12	Yes + DDAC	Yes

Take home message

- HWT (50°C for 30 min), with or without chemical additives, had no adverse effect on vine growth
- The standard HWT protocol (50°C for 30 min) remains effective in reducing *Pa. chlamydospora* and *Phaeoacremonium* spp.
 - Chemical additives did not further increase the efficacy of HWT
 - Water should be regularly changed to maintain efficacy

Heat-tolerant *Pleurostoma richardsiae*

- HWT did not reduce infection incidence or severity
 - Chemical amendment to HWT did not affect efficacy against *Pl. richardsiae*
 - In some cases, higher infection levels were observed compared to untreated controls

Take home message

Incidence of *Pl. richardsiae* in plant parts:

- 43.68% graft union vs 18.19% basal-end

Infection likely occurs during grafting after HWT was conducted:

- The suppression of other pathogens by HWT may inadvertently create a favourable niche for *Pl. richardsiae* establishment

A study investigating *Pl. richardsiae* inoculum sources within the propagation process, and specifically during grafting, is highly recommended in order to improve integrated strategies to prevent and effectively control trunk pathogen infections in nurseries

- Develop a detection tool to identify inoculum sources and high-risk infection points within the propagation process

Acknowledgements

- Thank you to our funding bodies



agriculture

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