A ground-based mobile platform to measure and map canopy thermal indices in a nectarine orchard

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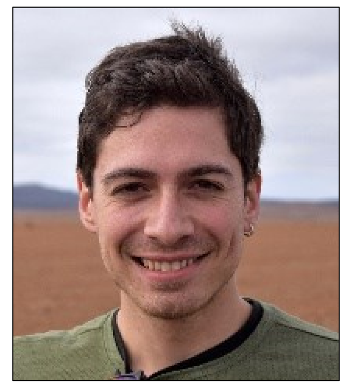

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Aims

i. Measure canopy temperature (T_c) and estimate canopy dT and CWSI in a nectarine orchard subjected to deficit irrigation using a ground-based mobile platform.
ii. Develop and validate an alternative method to the reference theory for CWSI calculation.
iii. Determine the relationships of thermal indices with plant water status and irrigation levels.

Materials and methods

- Nectarine orchard (Tatura SmartFarm, 0.6 ha, 2222 trees / ha, Open Tatura V system.
- Four irrigation treatments (100, 40, 20 and 0 % ET_c).
- Ground-based platform: Green Atlas Cartographer + Infrared sensors EnviroTherm™ (Everest Interscience) to measure T_c.
- 15 scans in 2020–21 and 2021–22; scan time = 8–10 minutes.
- QGIS used to extract and join data point with experimental plot information.
- dT calculated using T_a from an onsite weather station.
- CWSI calculated using two T_{wet} and T_{dry} derivations in the CWSI equation $CWSI = (T_c - T_{wet}) / (T_{dry} - T_{wet})$:
  - ❑ CWSI-I: T_{wet} and T_{dry} calculated using the lower and upper dT bounds empirically obtained by plotting the relationship between dT and VPD.
  - ❑ CWSI-II: T_{wet} and T_{dry} calculated using the 99% prediction intervals of the relationship between T_c and VPD.
- Ψ_{leaf} measured with a pressure chamber (ICT Intl, Armidale, Australia) as an indicator of plant water status.

Figure 1 Ground-based platform (Green Atlas Cartographer) equipped with Enviro-Therm™ infrared sensors (Everest Interscience).

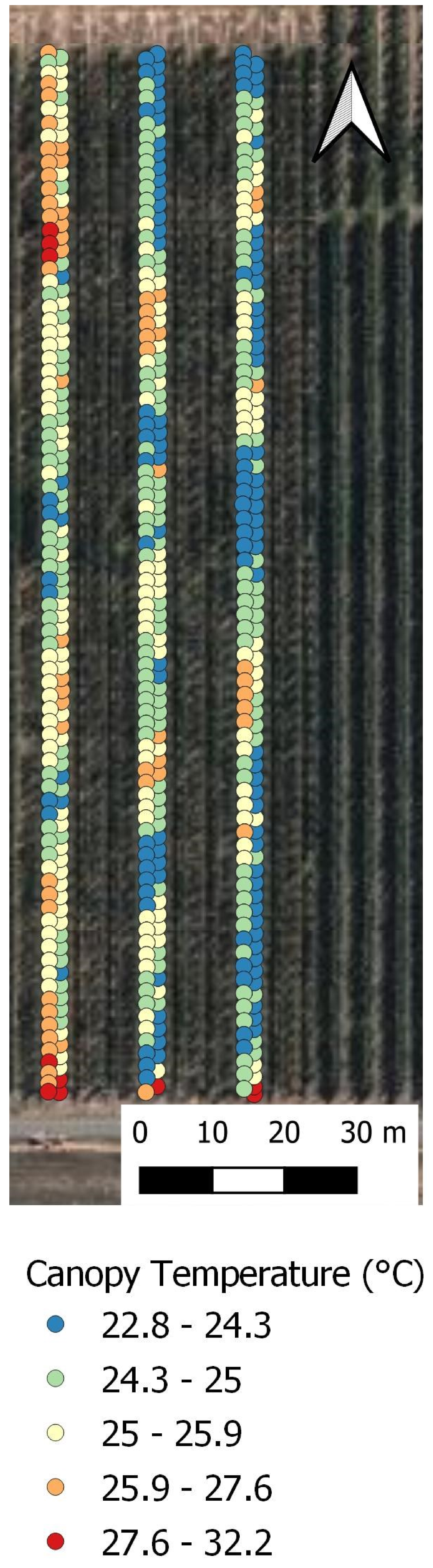

Figure 2 Canopy temperature map in spring 2020–21.

Results

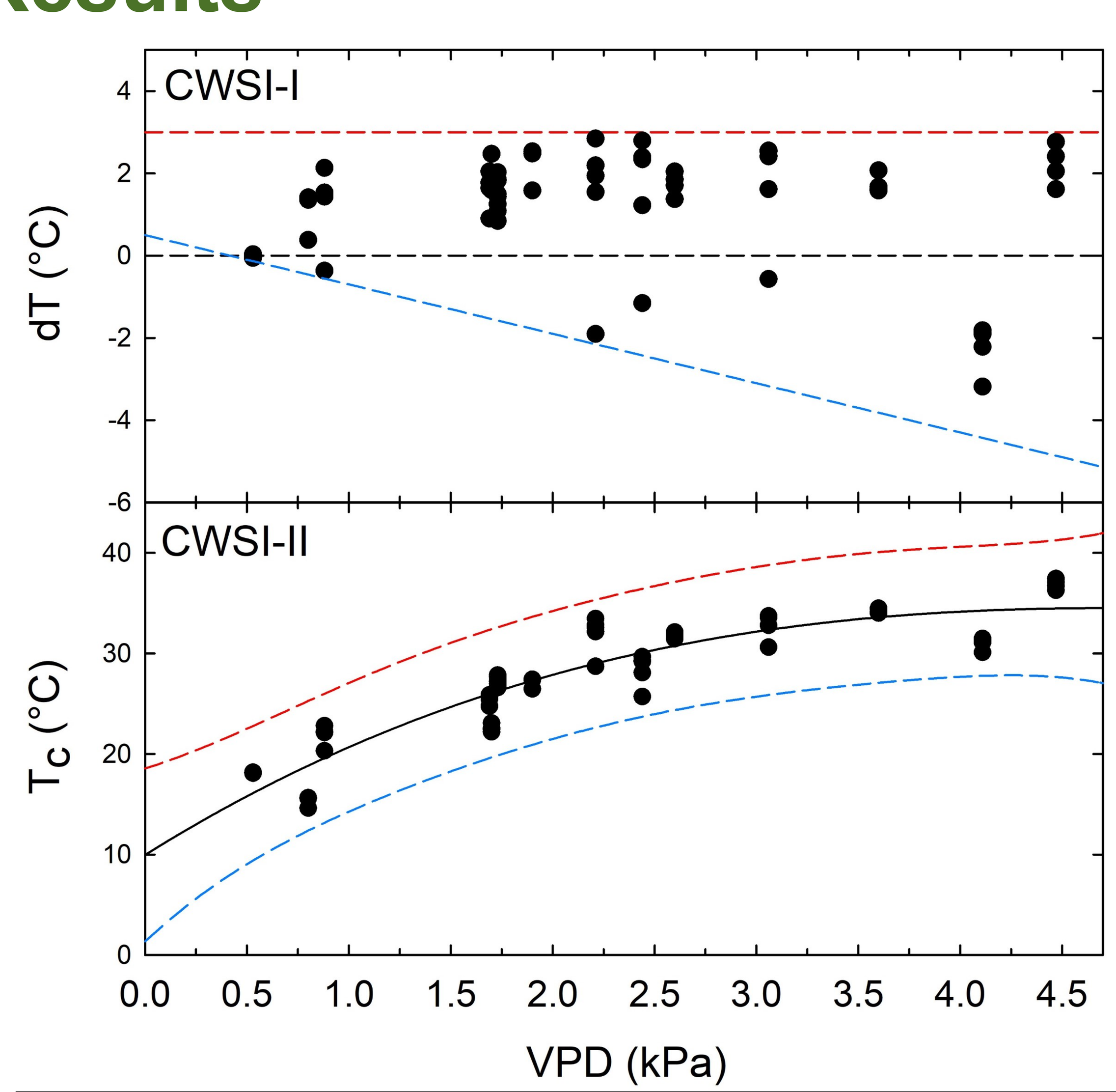

Figure 3 Upper and lower bounds to calculate T_{wet} and T_{dry} for CWSI-I and CWSI-II.

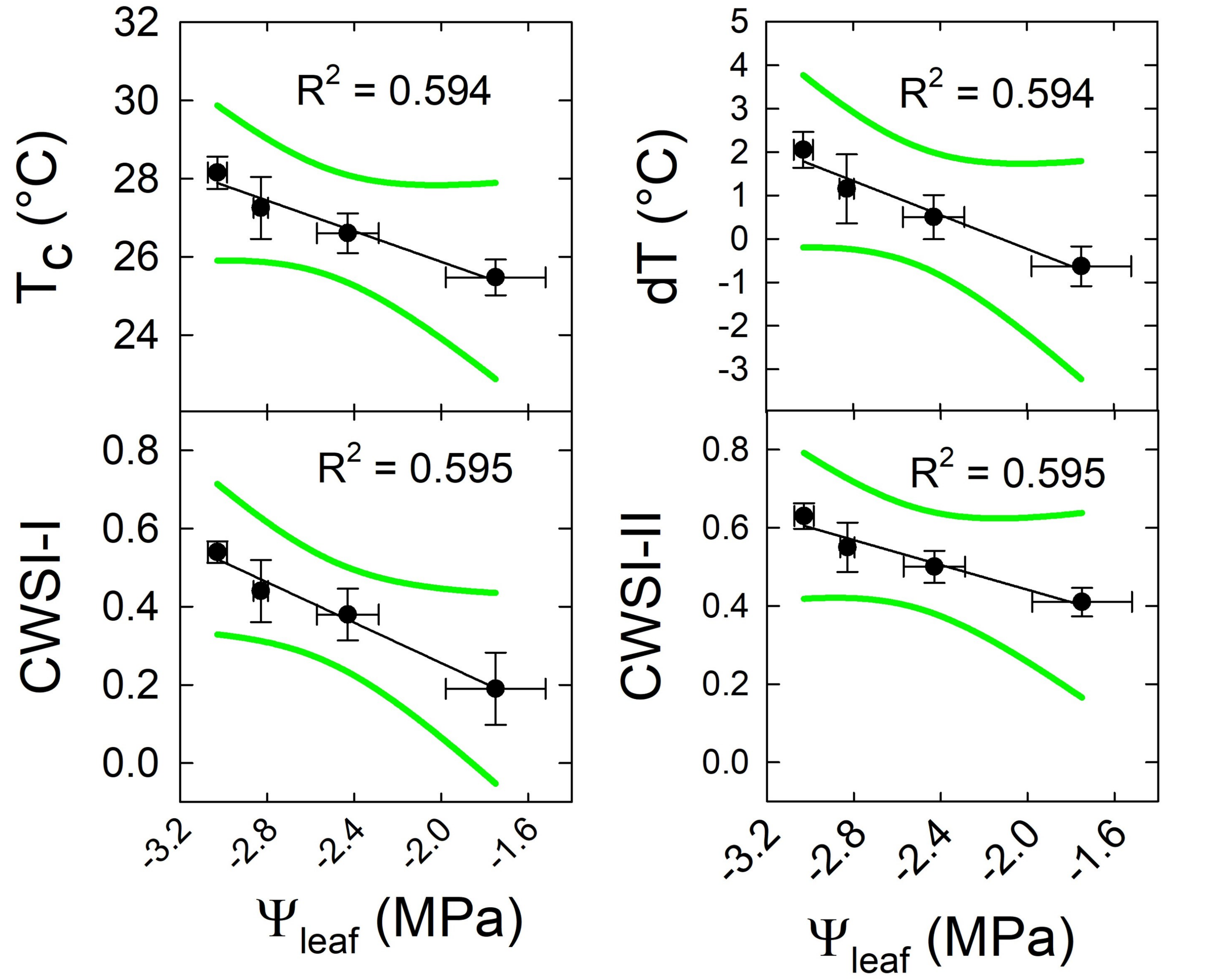

Figure 4 Relationships between thermal indices and Ψ_{leaf} (n = 4; 3 replicates).

- A linear relationship was observed between thermal indices and Ψ_{leaf} (Figure 4).
- Thermal indices were negatively correlated ($p < 0.05$) with irrigation levels in 10 out of 15 measurement times (Table 1).
- T_c, dT, CWSI-I and CWSI-II had equal correlation coefficients with irrigation levels since measurements were collected in < 10 minutes — i.e., constant T_a and VPD.
- Measurements from 715 to 1315 (AEDT) h showed no consistently significant evidence of T_c responses to irrigation.
- Significant differences were always observed in measurements between 1330 and 1915 (Table 1).

Table 1 Correlation coefficients (Pearson's r) between thermal indices and irrigation levels (n = 24 per date).

Date	30/11/20	2/12/20	12/01/21	12/01/21	12/01/21	18/02/21	16/11/21	14/12/21	14/12/21	14/12/21	14/12/21	14/12/21	28/12/21	31/01/22	25/02/22
Time (AEDT, h)	1130	1415	1000	1300	1600	1115	1300	715	1015	1315	1615	1915	1400	1330	945
Ta (°C)	23.8	20.6	25.8	30.1	31.2	24.9	14.2	18.1	25.7	32.4	34.7	33.3	26.9	30.6	20.7
VPD (kPa)	1.7	1.7	1.7	2.6	3.1	1.9	0.8	0.5	1.7	3.6	4.5	4.1	2.4	2.2	0.9
Sig. level	*	*	*	*	**	***	n.s.	n.s.	n.s.	n.s.	***	*	***	*	n.s.
Pearson's r	−0.469	−0.458	−0.416	−0.503	−0.530	−0.702	−0.301	−0.236	−0.267	−0.117	−0.649	−0.443	−0.784	−0.602	−0.408

n.s.: not significant ($p > 0.05$), *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Grey cells show measurements at 715–1315 h; orange cells show measurements at 1330–1915 h.

Conclusions and perspectives

- Ground-based T_c mapping carried out in short time (≤ 10 minutes) described spatial variability of plant water status.
- CWSI can be calculated with an alternative method (CWSI-II) that relies on Big Data and statistical inferences.
- dT, CWSI-I or CWSI-II can be used to detect temporal variations of plant water status.
- Afternoon scans provided the most reliable detection of canopy temperature responses to deficit irrigation.

Acknowledgements

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