

Tactics to Minimise Frost Damage on the Eyre Peninsula (GRDC AIP2203-001SAX). Tooligie Trial Site

Aim: Increase the knowledge and confidence of growers in Eyre Peninsula's frost prone areas to adopt and implement practices which minimise the impact of frost on their profitability.

The Tooligie Frost site was established under the GRDC funded AIREP project (AIP2203-001SAX) and consists of two sub trials located in different parts of the landscape which represent both a moderate frost risk zone (MRZ) and a high frost risk zone (HRZ).



Figure 1. View south over high-risk site, 16th August 2023.

Treatments

In consultation with the project steering committee a range of treatments were selected to compare their effectiveness at mitigating crop damage from frost events.

- a) **Crop phenology** – Treatments designed to manipulate the timing of crop maturity to minimise crop vulnerability during times of peak frost risk. Treatments included sowing different cereal species (wheat vs barley), varieties with different maturity characteristics (Table 3), mixtures of varieties (which have the same quality classification but different phenologies) and varying time of sowing (TOS). Each variety/mix was sown at two different TOS (TOS 1 -24th April, TOS2 – 18th May).
- b) **Crop nutrition** – application of potassium to improve crop health and protect against damage.
- c) **Novel products** – application of novel products designed to protect crops from the damaging effect of frost events.

Given recent work suggesting that modification of sandy soils by ripping can help to mitigate damage from frost events several demonstration sites were also established in 2023 in frost prone paddocks at Tooligie, Wharminda and Moody.

Site Description and Soil test results

The site is located on Kay Road approx. 18 km east of Tooligie. The district is frost prone with crops suffering moderate to severe frost damage in many years. The site is located within a dune-swale landscape to the southeast of nearby Tooligie Hill with frost tending to settle in the lower parts of this landscape. The moderate-risk zone is located on the mid-slope of a broad dune (Figure 2), whilst the high-risk site is situated within the swale of the adjacent paddock. The soil profile at both sites consists of a sand over clay which was delved in 2020. Cowell Potassium levels were 160mg/kg in the moderate risk site and 94 mg/kg in the high-risk site.



Figure 2. View southeast over moderate risk site, 22nd August 2023.

Plant tissue test results

Plant tissue test results taken from wheat controls (TOS2 at flag leaf emergence) indicated adequate levels of nutrition in crops on both the high and moderate risk zones (Table 1).

Table 1. Plant tissue test (YMB's at flag leaf) results.

Tooligie Frost Phenology - YMB's	Nitrate -		Phosphorus	Potassium	Calcium	Magnesium	Sodium	Sulfur	Boron	Copper	Zinc	Manganese	Iron	Aluminium	Molybdenum	Chloride
	N	Nitrogen														
	mg/kg	%	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
High Risk Zone	65	5.1	0.35	3.9	0.30	0.16	0.02	0.38	25	2.2	23	60	120	6.4	0.75	1.8
Moderate Risk Zone	43	5.3	0.36	3.8	0.25	0.15	0.01	0.38	32	1.7	23	31	120	9.3	1.4	1.5

Canopy Temperatures

Temperature sensors were placed within both frost risk zones, both within a Stevenson Screen at 1.2 m and in canopy, to record frost events as they occurred. Results showed that during the period 12th July to 12th September 2023 air temperatures at 1.2 m above ground level dropped below 0°C on 6 occasions in the moderate risk and 14 occasions in the high-risk zone (Figures 3 and 4). Data from the logger at canopy level in the high-risk zone recorded temperatures below 0°C 19 times during this period.

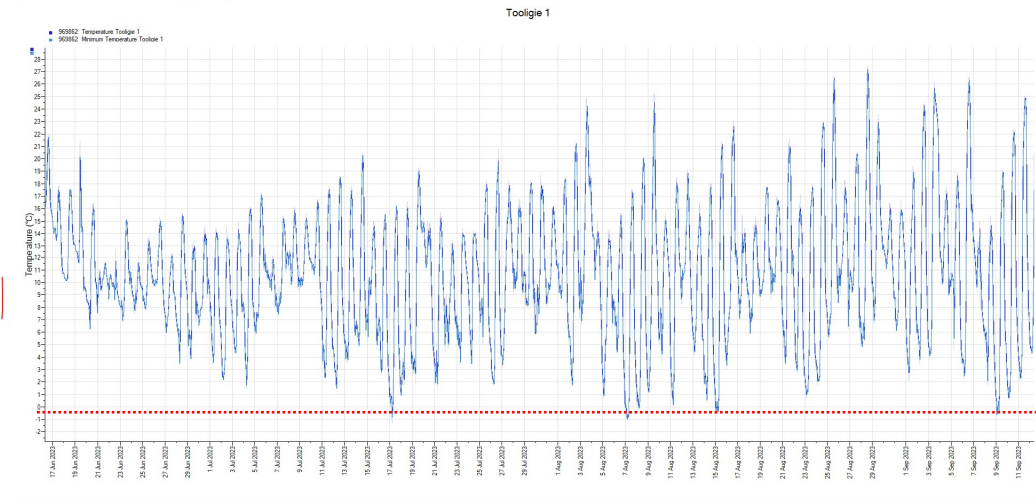


Figure 3. Temperate logger data 1.2 m above ground level (T1 – Stevenson Screen). on moderate risk zone 12th July to 12th September 2023

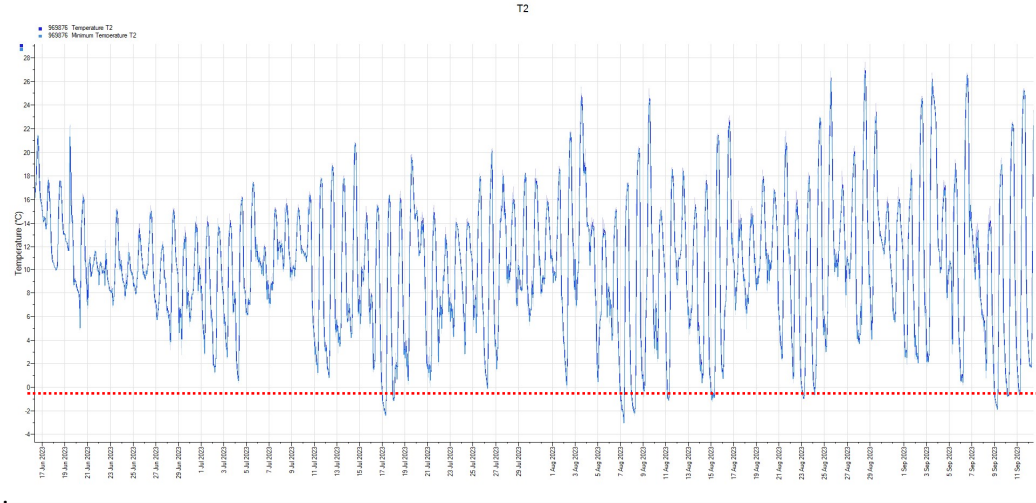


Figure 4. Temperate logger data 1.2 m above ground level (T2 – Stevenson Screen) on high-risk zone 12th July to 12th September 2023

It is important to not just note the number of times temperatures fell below 0°C but also the length of time that it remained below 0°C. Results showed that the high-risk zone not only recorded more events where temperatures were below 0°C at 1.2 m than on the moderate risk zone but that the duration of these events was much longer (Table 2). From this we can see that the most severe frost events were experienced at the high-risk site on 17th July, several events in the week between the 7th and 8th of August, and on 9th September, where air temperatures at 1.2 m were well below 0°C with durations lasting from four to almost ten hours.

Table 2. Minimum temperatures and duration of frost event

Date	Moderate risk zone - (1.2 m Stevenson screen)		High risk zone - (1.2 m Stevenson Screen)	
	Minimum Temperature (°C)	Hours temp below 0°C	Minimum Temperature (°C)	Hours temp below 0°C
17/07/2023	-1.3	2.25	-2.5	9.25
18/07/2023	0.9	n.a	-1.2	4

26/07/2023	1.8	n.a	-0.2	1.75
2/08/2023	1.6	n.a	-0.2	0.5
7/08/2023	-1.1	8	-3.1	9.75
8/08/2023	-0.3	1.25	-2.5	9.25
9/08/2023	1.1	n.a	-0.9	4.25
11/08/2023	-0.1	0.5	-1.2	4.75
15/08/2023	-0.6	4.5	-1.3	8.5
23/08/2023	0.6	n.a	-1.0	6.5
24/08/2023	1.6	n.a	-0.7	2.75
9/09/2023	-0.8	2.75	-1.9	7.75
10/09/2023	0.6	n.a	-0.8	4.25
11/09/2023	2.1	n.a	-0.7	3.25

Crop development and damage.

Frost damage with the potential to reduce yields typically occurs between stem elongation (GS31) and the end of flowering (GS69). Weekly assessments of crop maturity have been undertaken on replicate 1 of both the moderate and high-risk sites beginning mid-July (when the earliest treatments reached GS31). This data captured comparative dates for head/ear emergence (GS51-59) for the different varieties and times of sowing (Table 3).

Table 3. Varieties trialled, relative development speed and date head emergence recorded at Tooligie site in 2023.

			Date head emergence recorded			
			TOS1		TOS2	
Crop	Variety	Phenology	Moderate Risk	High risk	Moderate risk	High Risk
Wheat	Vixen	Very Fast	29-July	6-Aug	27-Aug	27-Aug
	Calibre	Fast	6-Aug	6-Aug	2-Sep	2-Sep
	Scepter	Fast-Medium	29-July	13-Aug	2-Sep	9-Sep
	LRPB Matador	Medium	13-Aug	13-Aug	2-Sep	9-Sep
	LRPB Bale (awnless dual purpose)	Slow	9-Sep	2-Sep	15-Sep	15-Sep
	Denison	Slow	25-Aug	13-Aug	9-Sep	9-Sep
	LRPB Mowhawk	Fast winter	2-Sep	9-Sep	Not emerged	Not emerged
	DS Bennett	Long winter	Not Emerged	Not emerged	Not emerged	Not emerged
Barley	Commodus CL	Fast-Medium	13-Aug	13-Aug	27-Aug	27-Aug
	Maximus CL	Fast-Medium	13-Aug	19-Aug	2-Sep	2-Sep
	Neo	Medium	27-Aug	13-Aug	2-Sep	2-Sep
Oats	Oat mix		27-Aug	27-Aug	9-Sep	9-Sep

Symptoms of frost damage was reported on emerged heads on the earliest maturing wheat treatments (TOS1 – Vixen, Scepter, LRPB Matador and Calibre) on 16th August (Figures 4 and 5).



Figures 4 and 5. Frost damage to head of Calibre and Vixen wheat on 16th August 2023 (GS57 – ear emergence).

In late August it was observed that all wheat treatments on the high-risk site where heads had emerged prior to 20th August showed symptoms of frost damage in the emerged head. On the moderate-risk site, despite similar dates for head emergence on the corresponding treatments, there was no significant damage observed on this site from August frosts.



Figure 6. Aerial image of Moderate Frost Risk Phenology trial site – 14 September 2023

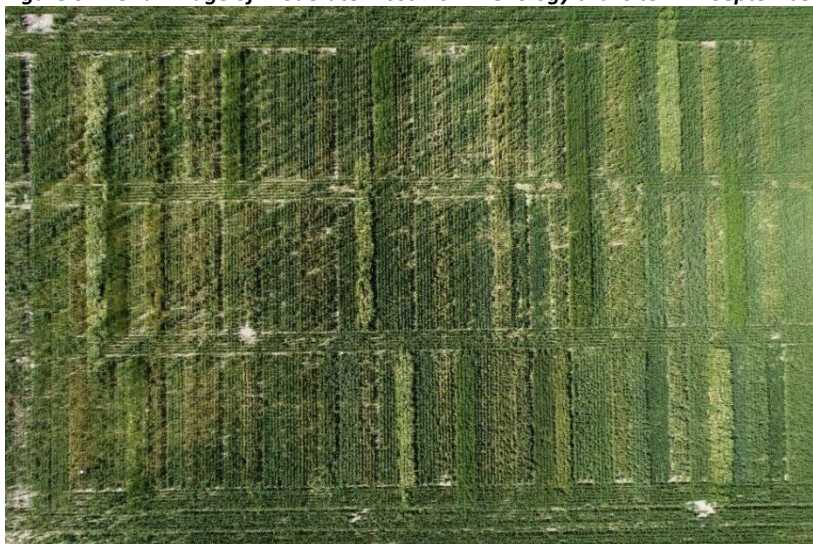


Figure 7. Aerial image of High Frost Risk Phenology trial site – 14th September 2023

Key Discussion Points

- Multiple frost events were recorded at the sites during the period 12th July to 12th September.
- The most severe frost events were recorded on the high-risk site on 17th July, 7th and 8th August and 9th September with air temperatures at 1.2 m at or below -2.0°C each event longer than 7 hours duration.
- Despite some early sown (TOS1) treatments being near or at GS31 (where plants begin to be more prone to damage by frost events) there was no obvious damage observed at this stage.
- Following the severe frosts on 7th and 8th August significant frost symptoms were observed in emerged head on early sown faster maturing wheat varieties on the high-risk site.
- There did not seem to be significant frost damage on the moderate risk site despite similar crop maturity to comparative treatments on the high-risk site when frost events were recorded.
- The delayed maturity of TOS2 treatments seemed to avoid the frost events recorded so far but what is the penalty from pushing maturity into higher heat risk.

Site 2 Effects of soil amelioration on canopy temperatures.

The 2022 site was able to demonstrate that soil amelioration, in this case with a Bednar ripper to a depth of 40cm, was able to maintain higher canopy temperatures in a high-risk zone, also reducing the yield damage from frost.

The same site was monitored in 2022 to evaluate if the differences in temperature were maintained for a 2nd season and why soil amelioration was causing the change in canopy temperature, with new ripping conducted in early 2023.

This resulted in 34 frost (below zero) events occurring in the high-risk zone between 16 June and 19 September.

Where the soil was not ripped across frost events in this between 16 June and 19 September the minimum temperature was -2.61°C and the number of hours below zero was 8.8.

Where the was ripped in 2022 across frost events between 16 June and 19 September the minimum temperature was -0.6°C and the number of hours below zero was 7.

Where the was ripped in 2023 across frost events between 16 June and 19 September the minimum temperature was -1.1°C and the number of hours below zero was 5.7.

This demonstrates that soil amelioration can have an effect on canopy temperature and potentially the damage incurred from frost events, however how long it lasts to an effective level still needs to be determined.

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