Does stubble retention influence in-canopy temperature and frost risk?

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Key points

- Stubble management can influence in-canopy temperatures.
- The in-canopy temperature of long stubble was colder than short stubble.
- All trial sites experienced fewer temperature extremes during 2016 than in previous years of this trial.
- There were no measured frosts during flowering in 2016. Further research is needed to determine the physiological significance of the observed temperature differences.

Background

The *Maintaining Profitable Farming Systems with Retained Stubble in the Riverine Plains Region* project is primarily focussed on maintaining the profitability of stubble-retained systems. After much interest and feedback from growers in the region, understanding the influence of frost on retained stubble systems became a priority. While there has been a perception that full stubble retention may increase the risk and severity of frosts, there has also been a lack of research directly relevant to the Riverine Plains region, as much of the frost-related research has been carried out in Western Australia, where yields and stubble loads are normally lower.

Additional funding was secured from the Grains Research and Development Corporation (GRDC) during 2015, to measure the impact of different stubble treatments on in-canopy temperatures across three large plot trials at Corowa/Coreen, Yarrawonga and Dookie from 2015 – 2017. This funding links the project into the GRDC *National Frost Initiative*, with all data generated being submitted for review and statistical analysis in conjunction with other *National Frost Initiative* projects.

The 2015 results showed that the no-till stubble retention (NTSR) — long stubble treatment measured the lowest minimum temperatures and stayed colder the longest. However, no difference in physiological frost damage was seen between the different treatments.

Aim

The aim of this work was to better understand the impact of stubble management on in-canopy temperatures and the associated risk of frost in cropping environments with high yields and high stubble loads.

Method

The 2016 sites at Coreen, New South Wales, and Yarrawonga and Dookie, Victoria were chosen for this trial as they were on a second-cereal rotation in areas that were flat, relatively uniform and therefore had a higher frost risk. Site, crop and treatment details are listed in the previous report (*Active stubble management to enhance residue breakdown and subsequent crop management — focus farm trials,* page 12). Treatments specific to each site are outlined in Table 1, along with the placement of temperature loggers in each trial (installed during May and removed before harvest).

Each site had four replicates of each treatment, with temperature loggers installed in every plot at two different heights.

The temperature loggers used were Tinytags, which are battery-powered temperature sensors, which recorded the temperature every 15 minutes for the length of the growing season (Figure 1). The Tinytag loggers faced north and were not shielded from direct sunlight. As a result, they recorded higher daytime temperatures compared with the temperatures recorded in a Stevenson screen at a weather station.

There was also a weather station, with a one-metre-deep soil moisture probe, located at each site to measure local climatic conditions to support the temperature data.

The temperature data was statistically analysed using Genstat. Measures of least significant difference (LSD) were used to determine which, if any, treatments were significantly different.

Results

The following results are from the temperature loggers installed at a height of 300mm, which were moved up to 600mm at the dates listed in Table 1 (unless otherwise stated).

TABLE 1 Sites, selected treatments and temperature monitoring carried out during 2016

Site	Treatments	Measurements
Coreen, NSW	• Stubble retained (NTSR) • Stubble burnt • Stubble incorporated (disc)	• Loggers (300mm height and moved to 600mm on 25 August) • Loggers at 50mm height
Yarrawonga, Victoria	• NTSR — long stubble (300mm) • NTSR — short stubble (150mm) • Stubble burnt • Stubble incorporated (disc)	• Loggers (300mm height and moved to 600mm on 25 August) • Loggers at 50mm height
Dookie, Victoria	• NTSR — long stubble (330mm) • NTSR — short stubble (150mm) • Stubble burnt • Stubble incorporated (disc)	• Loggers (300mm height and moved to 600mm on 26 August) • Loggers at 50mm height • Loggers buried 50mm below the soil surface

FIGURE 1 Tinytag temperature loggers installed in the burnt treatment at Yarrawonga 26 May 2016
Note: The yellow 50mm and 300mm loggers are attached to the PVC tube.

Site 1. Coreen, NSW

The temperature profile of the Coreen site is displayed in Figure 2. This graph shows the range and extremes of temperatures reached within the crop canopy. It is important to note the Tinytags were not shaded when they recorded daytime temperature data. This is in contrast to the ambient temperature measured in the weather station's Stevenson screen. Therefore, temperatures as high as 53.4°C were recorded by the loggers, while the highest daily maximum recorded by the weather station at the site was 42.3°C.

The Tinytags also demonstrated the differences between the minimum temperatures reached within the crop canopy and those measured by the weather stations, which measure the temperature at a height above-ground level of 1.2m. The lowest temperatures recorded in the crop canopy for the burnt, incorporated and standing stubble treatments were -3.7°C, -3.6°C and -4.0°C respectively. At the same time the temperature recorded by the weather station was 4.75°C (7:30am, 26 August 2016).

Frost risk is determined by the amount of time a crop experiences sub-zero temperatures and the minimum

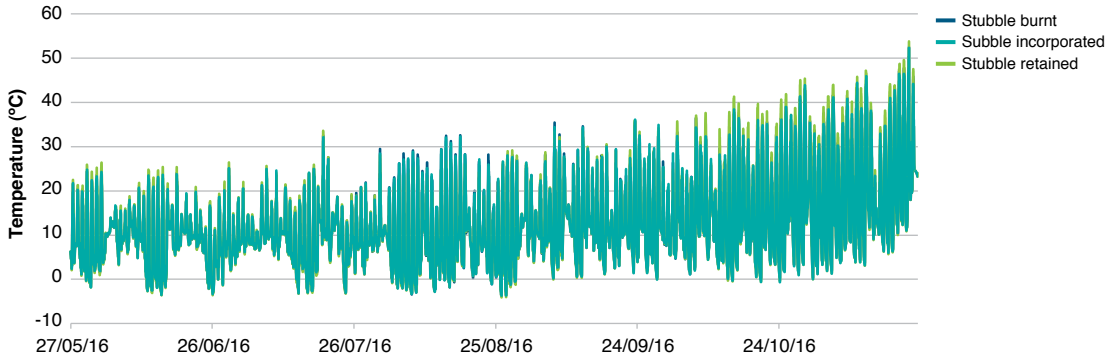

FIGURE 2 In-canopy temperatures measured at the Coreen site from 27 May – 21 November 2016
Flowering at this site occurred on 19 September 2016.

temperatures reached. In Figure 3, these indicators were used to determine if the different stubble treatments influenced the amount of time the crop experienced temperatures below 0°C (time threshold). While there was a trend for the standing stubble to be colder at the Coreen site, there were no significant difference between each of the three treatments (Figure 3).

There were three distinct frost events during the first two weeks of temperature recording (29, 30, and 31 May) when the wheat was at the seedling growth and early tillering stages (Figure 4). During this time of development wheat plants can withstand sub-zero temperatures, with frost events serving to 'harden' the crops, helping them withstand subsequent frost events (Agriculture Victoria, 2009).

The 50mm high loggers are particularly useful in capturing the conditions under the retained-stubble treatment. The frost event that occurred on the 29 May (Figure 4) demonstrated a significant difference between the minimum temperature reached between the burnt stubble and the standing stubble, with the standing stubble being the colder of the two. There was no statistical difference between the incorporated (disc) treatment and the burnt or standing treatments.

In these early vegetative stages, the Coreen site spent far less time below 0°C. In the first two weeks the stubble retained treatment spent around 12 hours (cumulatively) below 0°C, compared to 26 hours and 47 hours at Yarrawonga and Dookie respectively (Figures 4, 7 and 10).

Site 2. Yarrawonga, Victoria

The coldest temperature recorded by a Tinytag at the Yarrawonga site was -4.29°C, recorded on 27 July 2016 in the NTSR — long stubble treatment (Figure 5).

The temperature threshold results showed no significant differences between the NTSR — short stubble and NTSR — long stubble treatments, unlike the previous year where the NTSR — long stubble treatment spent more time below 0°C than the NTSR — short stubble treatment (Figure 6).

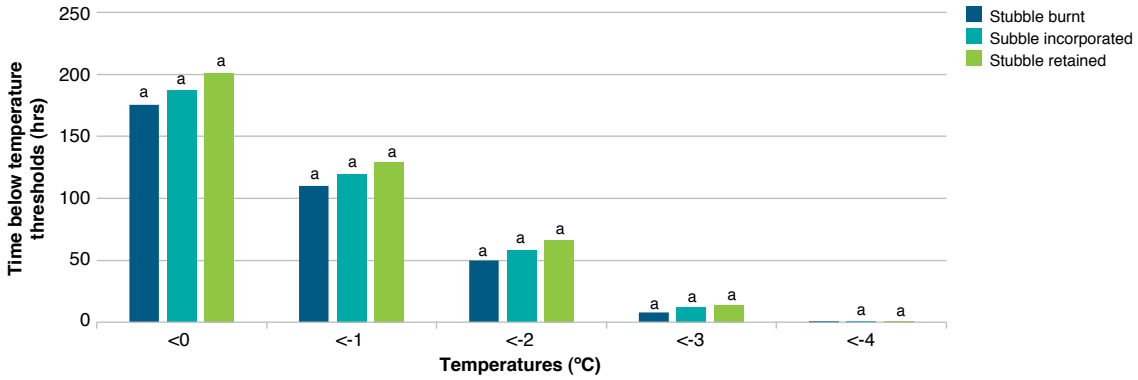

FIGURE 3 The effect of stubble treatment on the duration of in-canopy temperatures at zero and each degree below, at the Coreen site

Letters denote statistical significant between treatments at each temperature.

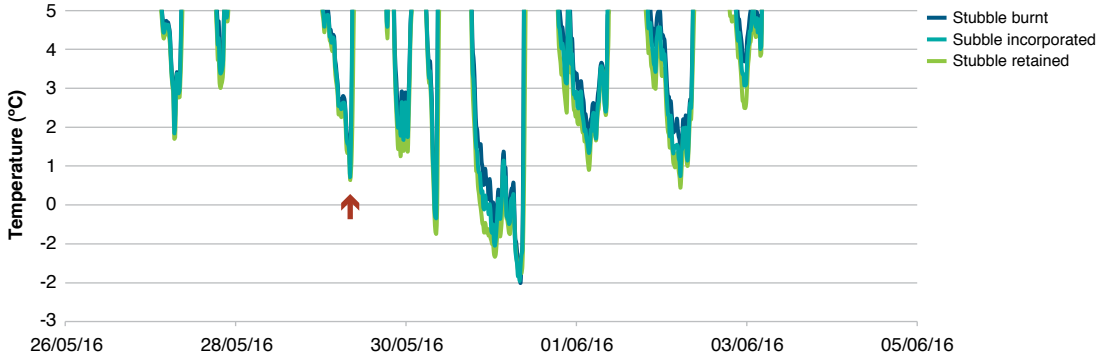

FIGURE 4 In-canopy temperatures measured at 50mm above the soil surface for the first 10 days of the Coreen site trial (arrow represents the time when there was a significant difference between treatments)

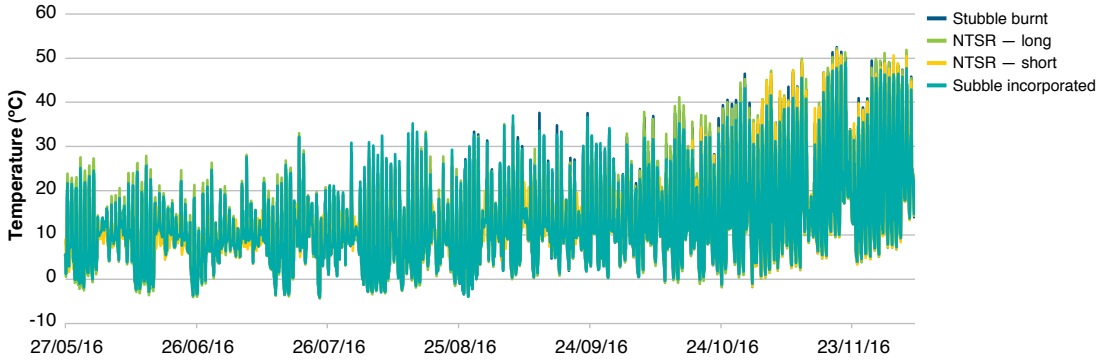

FIGURE 5 In-canopy temperatures measured at the Yarrawonga site from 27 May – 7 December 2016
Flowering at this site occurred on 26 September 2016.

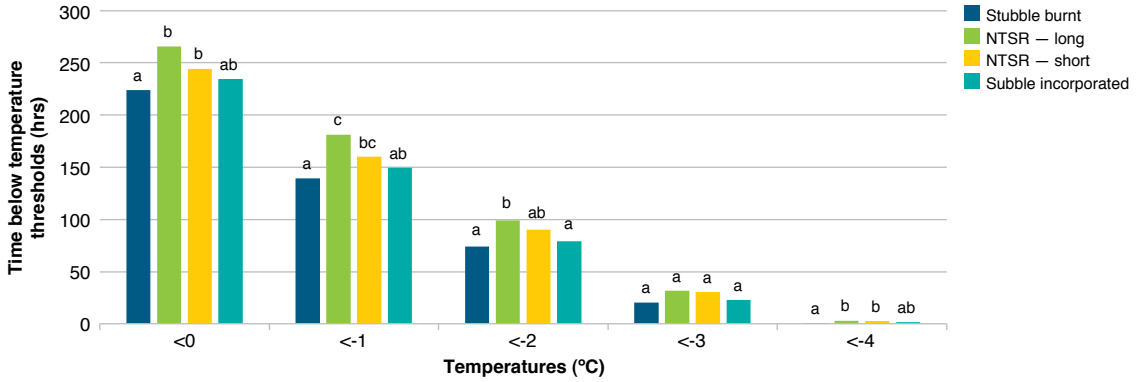

FIGURE 6 The effect of stubble treatment on the duration of in-canopy temperatures at zero and each degree below, at the Yarrawonga site
Letters denote statistical significance between treatments at each temperature.

Moreover, during the first two weeks of temperature recording the NTSR — short stubble plots were found to be reaching colder temperatures and maintaining this lower temperature for longer periods (Figure 7). This occurred during four frost events which were recorded between the 28 and 31 May. Rather than being due to a stubble height effect, the colder temperatures in the NTSR — short stubble treatment may have been due to chopped stubble straw lying on the ground, which can stop warm air moving from the soil into the canopy overnight. This insulating effect was caused by cutting the tall stubble to create the short stubble treatments.

Despite this, the NTSR — short stubble treatment was not significantly different to the burnt and incorporated treatments when comparing time spent at 0°C and -2°C, while the NTSR — long stubble treatment spent significantly more time between 0 and -2°C compared with the incorporated and burnt treatments (Figure 6).

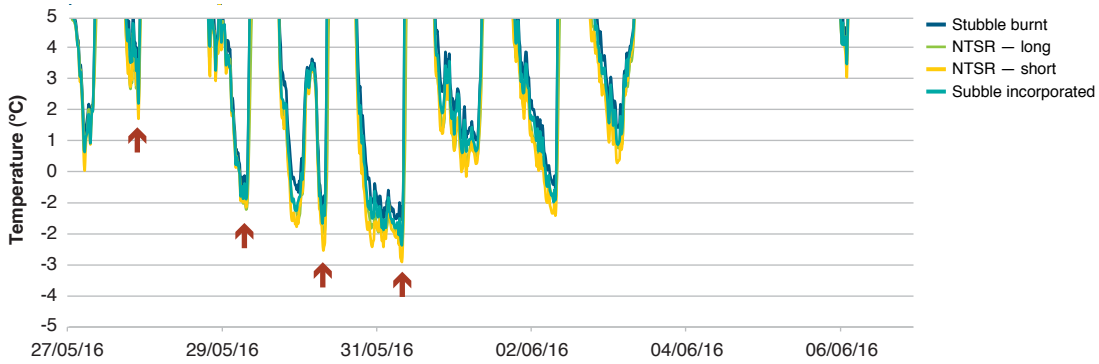

FIGURE 7 In-canopy temperatures measured at 50mm above the soil surface for the first 10 days (27 May to 6 June) of the Yarrawonga site trial (arrows represent periods of significant differences between treatments)

All treatments reached temperatures below -4°C, however the duration of time at these temperatures was much less than during 2015, which also saw temperatures fall below -5°C and -6°C. This year at the Yarrawonga site, the time spent below -4°C ranged from 0.25 hours in the burnt treatment to 3.56 hours in the NTSR — long treatment compared with a range of 17.6 hours and 25.1 hours in the burnt and cultivated treatments in the 2015 season.

Despite minimum temperatures being less severe during 2016, similar trends can be observed between treatments from 2015. The main difference in these trends is the significant difference between the NTSR — long treatment and cultivated treatments in the -1°C and -2°C thresholds in the 2016 season (Figure 6).

Site 3. Dookie, Victoria

The results shown in Figure 8 demonstrate a similar pattern of temperatures as those experienced at the Coreen and Yarrawonga sites. The coldest temperature reached at this site during 2016 was -4.35°C in the NTSR — long stubble treatment on 24 July at 7:15am.

Following trends similar to those from 2015, the burnt treatments spent significantly less time below each temperature threshold compared with the NTSR — long treatment except below the -1°C and -3°C thresholds. There was no significant difference between the burnt, incorporated and NTSR — short treatment below the 0°C, -1°C and -4°C thresholds. Both NTSR treatments spent significantly more time below the -2°C threshold when compared to the other treatments, but below -3°C no statistical difference was seen between any treatments (Figure 9).

During the first two weeks of temperature recording at the Dookie site, treatments can be seen to have dropped below 0°C on six occasions. As marked on Figure 10, the NTSR — long treatment was significantly colder on the 11 June when compared with both the burnt and incorporated treatments and significantly different to all treatments on 12 June. Furthermore, the NTSR — short treatments were significantly colder than the burnt treatment on the 11 June frost event. Throughout the entire year, there were four more frost events in which

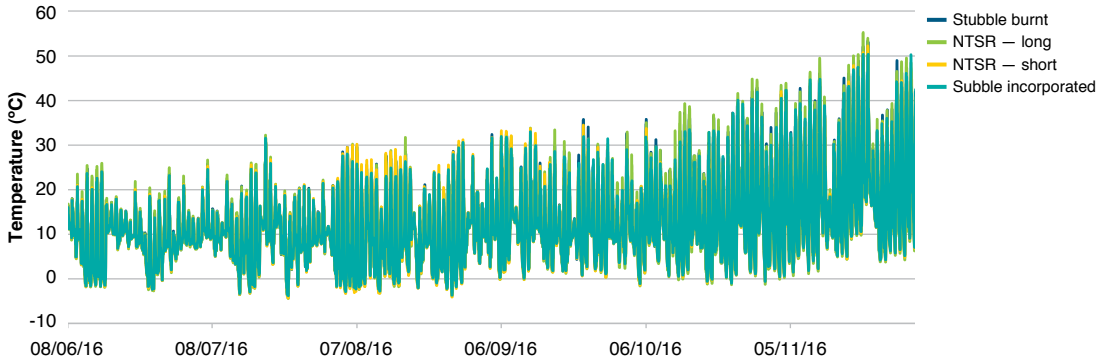

FIGURE 8 In-canopy temperatures measured at the Dookie site during 8 June – 1 December
Flowering at this site occurred on 10 October 2016.

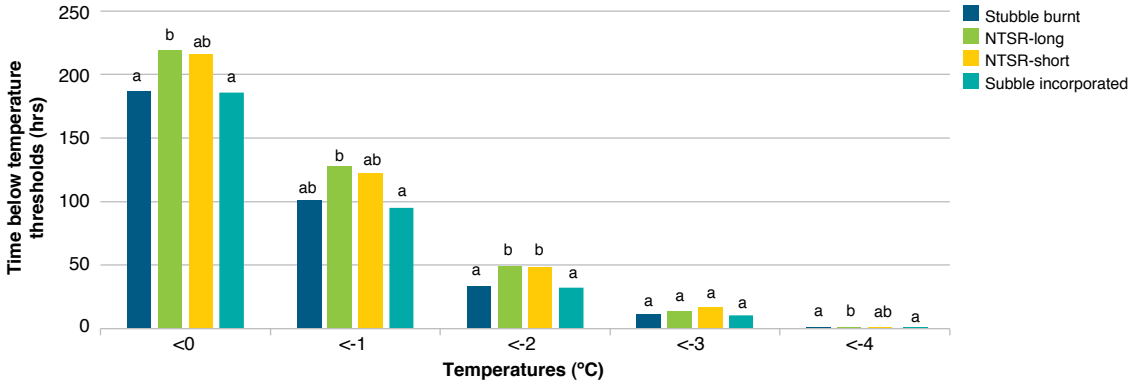

FIGURE 9 The effect of stubble treatment on the duration of in-canopy temperatures at zero and each degree below, at the Dookie site
Letters denote statistical significance between treatments at each temperature.

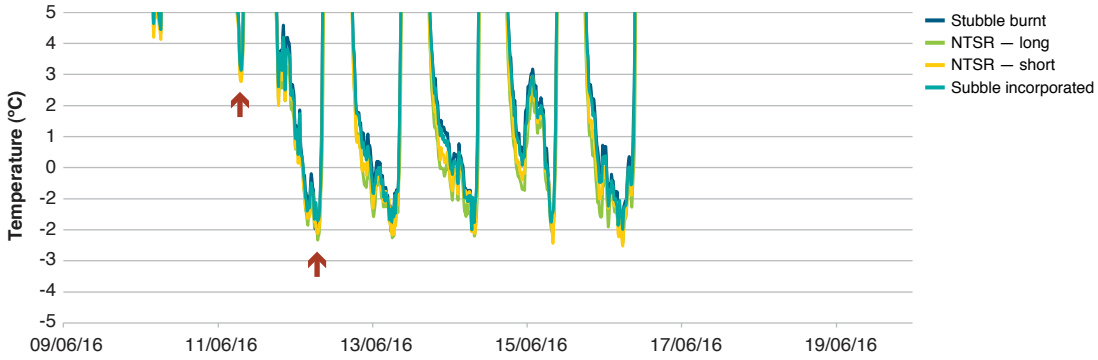

FIGURE 10 In-canopy temperatures measured at 50mm above the soil surface for the first 10 days of the Dookie site trial (arrows represent periods of significant differences between treatments)

the NTSR — long treatment was significantly colder than both burnt and incorporated treatments (24 June, 25 June, 27 June and 19 October).

Comparison of temperatures recorded at different positions at Dookie

As noted in Table 1, the Dookie site was instrumented with Tinytag temperature loggers 50mm below the soil surface in addition to the 50mm and 300mm above-surface in-canopy loggers. The two above-ground loggers showed more fluctuation in recorded temperature than the logger positioned below the soil surface (Figure 11). The NTSR — short stubble treatment has been used as an example to show how the temperatures recorded by the 50mm and 300mm were similar during the early part of the season.

As the plant canopy increased in height above the 50mm logger, the temperature differences between it and the 300mm logger became more significant. As the 300mm loggers remained exposed at the top of the canopy, they tended to record more extreme temperatures when compared with the 50mm loggers.

Compared to the above-ground loggers, the sub-surface logger recorded less fluctuation in temperature. While the 300mm loggers measured a minimum temperature of -4.25°C on 24 July, 5:30am, the in-soil logger only dropped to 5.32°C at the same time (Figure 11).

Observations and comments

The 2016 season had less extreme temperatures than those measured during 2015, with all of the sites and treatments recording average minimum temperatures only to the -4°C threshold or warmer. During 2015 the Corowa and Yarrawonga sites recorded minimum temperatures down to the -6°C threshold, with -7°C measured at the Dookie site.

The mildness of the 2016 season was due to the high amount of in-season rainfall (decile 10 in Yarrawonga and Dookie, decile 9 in Corowa) and associated high cloud cover. These clouds had an insulating effect, which prevented temperatures from plummeting overnight. Victoria experienced its fifth warmest year on record, which was partly the result of mean minimum

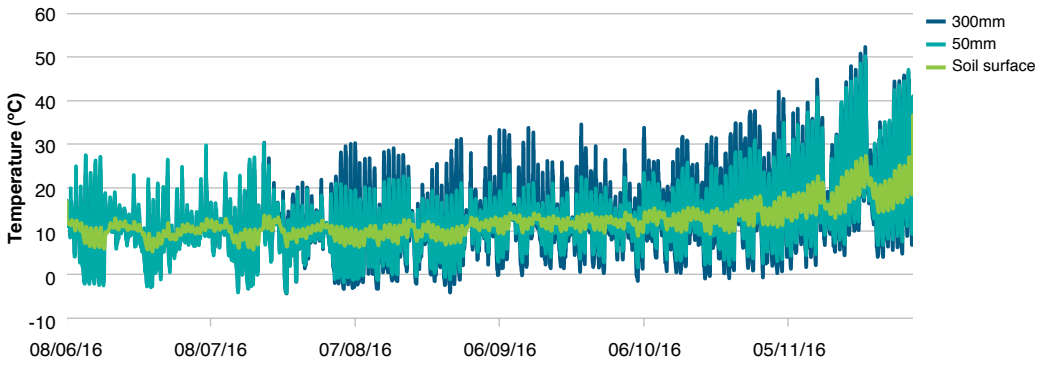

FIGURE 11 Temperatures measured at 300mm, 50mm and soil surface for NTSR — short stubble at the Dookie site between 8 June and 1 December 2016

temperatures being 1.06 degrees warmer (and mean maximum temperatures 0.74 degrees above average). However, October and November temperatures were cooler than average due to a number of cold fronts, which spared crops from heat events such as those seen during early October in 2015 (Bureau of Meteorology, 2017).

Despite the mild temperatures of the 2016 season, there were still clear trends in temperature difference between the stubble treatments. In general, the NTSR — short stubble treatment appears to be a viable option to reduce the risk of frost by maintaining a warmer canopy than the NTSR — long stubble treatment, while still retaining stubble. As well as reducing the risk of frost, the NTSR — short stubble treatment has the same benefits as full stubble retention while increasing the ease of sowing operations.

Although the effect of stubble treatments on in-canopy temperature has been shown to be statistically different, most notably between NTSR — long stubble and burnt treatments, the physiological importance of these differences on plant development and the potential to reduce frost damage during flowering, is still unknown. Due to the lack of frosts during flowering, the importance of the differences in temperature between each treatment requires further study, with monitoring continuing through the 2017 season.

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