Did stubble retention influence in-canopy temperature and frost risk during 2017?

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Key points

- The 2017 season was significantly colder than average with about 500 hours below zero.
- While stubble management may influence in-canopy temperatures, the differences between management practices were minimal during 2017.
- Differences in frost damage of grains were significant between treatments at both the Coreen and Yarrawonga sites, with the burnt treatment showing the greatest frost damage at Coreen, while the no-till stubble retained (NTSR) treatments showed the greatest damage at Yarrawonga.
- Stubble management per se did not influence frost damage in wheat during 2017, with frost damage not necessarily related to in-canopy temperatures.
- Stubble management practices can influence the rate of crop development and may lead to changes in flowering time. This change in rate of development can influence crop susceptibility to frost at different times throughout the growing season.

Background

The Grains Research and Development Corporation (GRDC) investment *Maintaining profitable farming systems with retained stubble in the Riverine Plains region* project is primarily focussed on maintaining the profitability of stubble-retained systems. However, since the establishment of the project growers have frequently asked about the influence of retained stubble on frost risk. While there is a perception retained stubble will decrease in-canopy temperatures and increase the risk and severity of frost, most frost-related research has been done in Western Australia in regions with lighter soils, where yields, and stubble loads are less than those experienced in the Riverine Plains region.

Additional funding was secured from the GRDC during 2015 to measure the impact of different stubble treatments on in-canopy temperatures at three large-plot stubble trial sites for the 2015–17 field plot trials. This funding links the project into the GRDC *National Frost Initiative*, with all results generated using protocols and analysis comparable to those being used in associated projects.

Aim

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

Method

The 2017 sites at Coreen, NSW and Yarrawonga and Dookie, Victoria were all established into wheat stubble. While the Coreen and Yarrawonga sites were flat and relatively uniform, the Dookie site sown to canola was located on the side of a hill. Therefore, it would be expected the Coreen and Yarrawonga sites would have a high relative frost risk, while the Dookie trial site would be subject to less frost and higher variability in temperature due to the change in altitude across the site.

Site, crop and treatment details are listed in the report *Active stubble management to enhance residue breakdown and subsequent crop management — focus farm trials*, page 12). Each treatment was replicated four times at each site. Treatments specific to each site are outlined in Table 1, along with the height placement of temperature loggers in each trial.

Tinytag temperature loggers (battery-powered temperature sensors) were installed during May in each plot, at two different heights and were removed before harvest.

The Tinytag loggers were used to record the temperature every 15 minutes for the length of the growing season (Figures 1a and 1b). The loggers faced north and were not shielded from direct sunlight. As a result, they recorded higher daytime temperatures compared with the temperatures recorded from a Stevenson screen (weather station) located at each site.

Each site weather station also included a one metre deep soil moisture probe, which measured local climatic conditions to support the temperature data. These were placed alongside trials to reduce the potential for mechanical damage, with the moisture probe recording moisture use by the commercial crop surrounding the trial site.

The temperature data was statistically analysed using Genstat, with statistical analysis determined at 5%

TABLE 1 Sites, selected treatments and temperature monitoring carried out during 2017

Site	Treatments	Measurements
Coreen, NSW (wheat)	• Stubble retained (NTSR) • Stubble burnt • Stubble incorporated	• Loggers at 300mm height • Loggers at 50mm height
Yarrawonga, Victoria (wheat)	• NTSR — long (30cm) • NTSR — short stubble (15cm) • Stubble burnt • Stubble incorporated	• Loggers at 300mm height • Loggers at 50mm height
Dookie, Victoria (canola)	• NTSR — long stubble (33cm) • NTSR — short stubble (15cm) • Stubble burnt • Stubble incorporated	• Loggers at 300mm height, moved to 600mm on 21 July, moved to 900mm on 17 August • Loggers at 50mm height • Loggers buried 50mm below the soil surface

FIGURE 1A The Yarrawonga Victoria site on 27 July 2017, showing yellow 50mm and 300mm Tinytag temperature loggers attached to the PVC tube (left foreground) and weather station (back left)

FIGURE 1B Tinytag temperature loggers and weather station at the Dookie, Victoria site, 27 July 2017. Note, the slope at the site is likely to increase the temperature variation between replicates

variance. 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 the 300mm height.

Site 1: Coreen, NSW

The temperature profile of the Coreen site is displayed in Figure 2 and shows the range and extremes of temperatures reached within the crop canopy. The amount of data presented in this graph makes it difficult to identify clear trends, however it is useful when looking at the intensity and duration of frost events throughout the season.

As the Tinytags were not shaded, the recorded maximum temperatures are higher than those measured by a weather station fitted with a Stevenson screen (which protects the temperature sensor from direct sunlight). The minimum temperatures measured in the canopy are also colder than those measured by the weather station at a height of 1.2m, more accurately reflecting the conditions the growing plant is exposed to. The coldest minimum in-canopy temperature during the 2017 season was -7.96°C at 7am on 1 July 2017. In comparison, the temperature recorded by the site weather station at the same time was -1.81°C.

Frost risk is determined by the duration and severity of frost events, with duration describing the amount of time the crop experiences sub-zero temperatures, while severity describes how cold it actually gets. The minimum temperatures were analysed to determine if the stubble treatments influenced the amount of time the crop experienced temperatures below zero (time threshold). As seen in Figure 3, the 2017 season was extremely cold, with about 500 hours below 0°C. However, there were no significant differences in the amount of time each stubble treatment spent below each threshold temperature at the Coreen site.

Wheat head samples were collected before harvest to determine the frost damage to individual florets. Based on a subsample of 90 grain heads per replicate (360 heads per treatment), the burnt treatment had significantly more frosted florets than the cultivated treatment, which in turn had more frosted florets than the stubble retained treatment (Table 2).

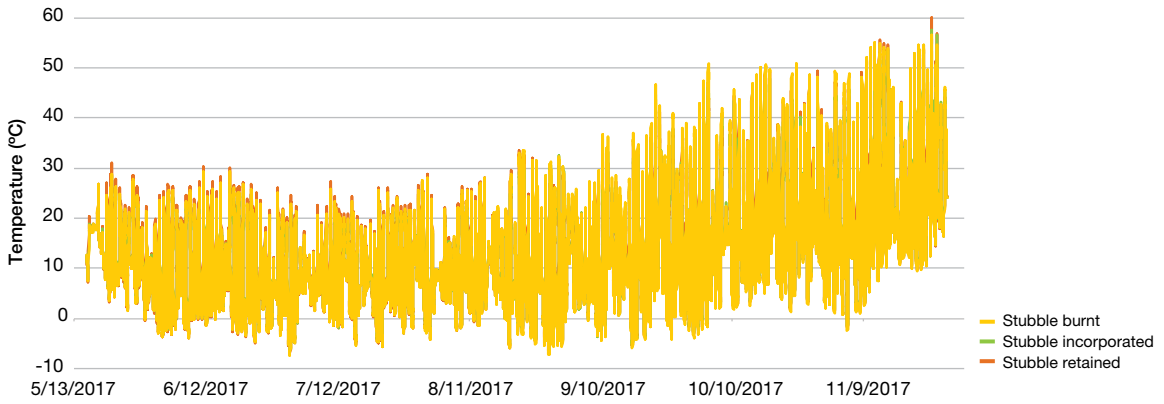

FIGURE 2 Averaged in-canopy temperatures measured by the 300mm loggers at the Coreen NSW site from 16 May – 27 November 2017

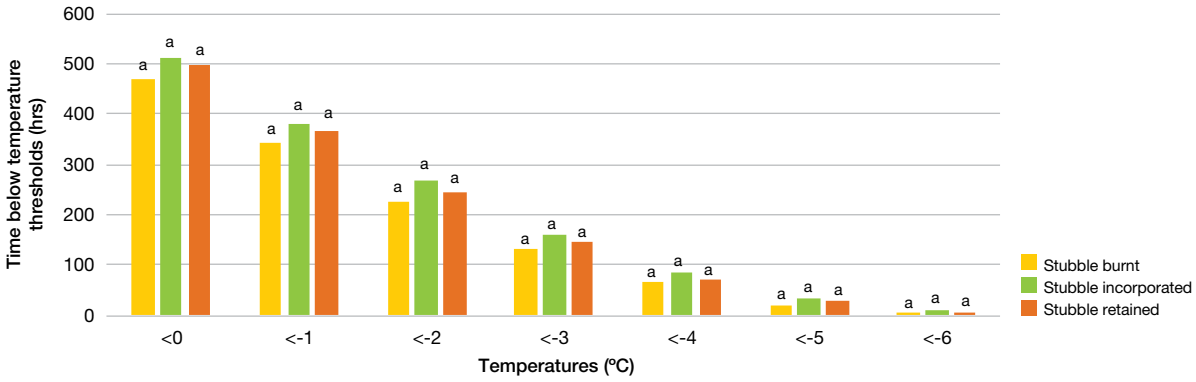

FIGURE 3 The effect of stubble treatment on the duration of in-canopy temperatures at zero degrees and each degree below, measured by the 300mm loggers at the Coreen site

Letters denote statistical significances between treatments at each temperature.

TABLE 2 Frost score at harvest (GS99) at Coreen, 2017

Treatment	Frost score (%) *
Stubble retained	3.366[a]
Stubble incorporated	5.415[b]
Stubble burnt	7.882[c]
Mean	**5.554**
LSD	1.366

* Frost score calculated as: number of frosted florets per head/total florets per head x 100.

Figures followed by different numbers are regarded as statistically significant.

This indicates that actual temperatures are not the only driver for differences in frost damage between treatments.

Site 2: Yarrawonga, Victoria

The Yarrawonga site experienced similar temperature ranges to the Coreen site, with the coldest minimum temperature of -7.87°C measured at 7am on 1 July 2017. At the same time the temperature recorded by the on-site weather station was -1.25°C (Figure 4).

While the Coreen site included just one NTSR treatment, the Yarrawonga site included both NTSR — long stubble and NTSR — short stubble treatments. Significant differences in canopy temperatures between treatments were observed at the Yarrawonga site, as described by the duration of time below specific temperature thresholds (Figure 5). The duration of time below the 0°C, -1°C, -2°C and -4°C thresholds was significantly less in the burnt stubble treatment compared with the incorporated and NTSR — long stubble treatments, while the NTSR — short stubble treatment was similar to all treatments.

While statistically significant differences were measured at this trial site, the actual difference in the number of hours at each threshold is still relatively small. For example, the number of hours the stubble burnt and NTSR — long stubble treatment spent below -4°C was 52 hours and 86 hours respectively, which is not a big difference when the crop spent about 500 hours below 0°C across the season.

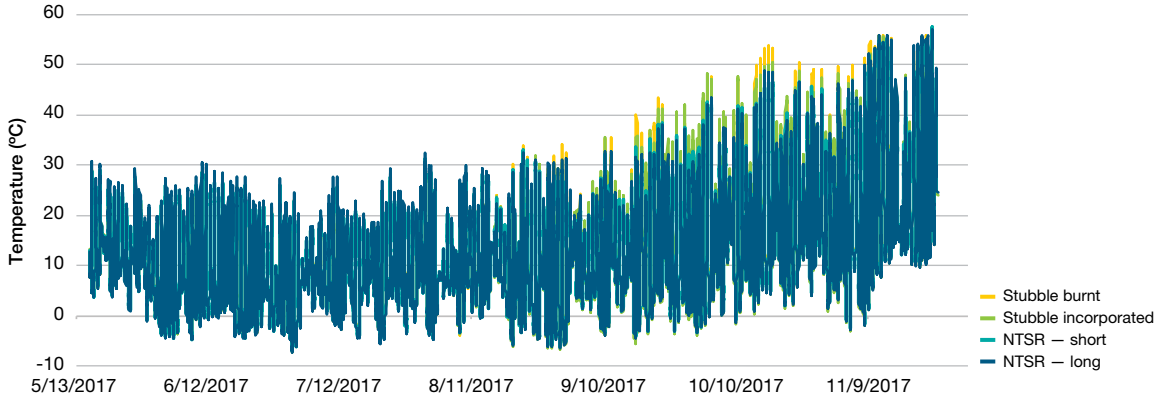

FIGURE 4 In-canopy temperatures measured at the Yarrawonga Victoria site from 16 May – 24 November 2017

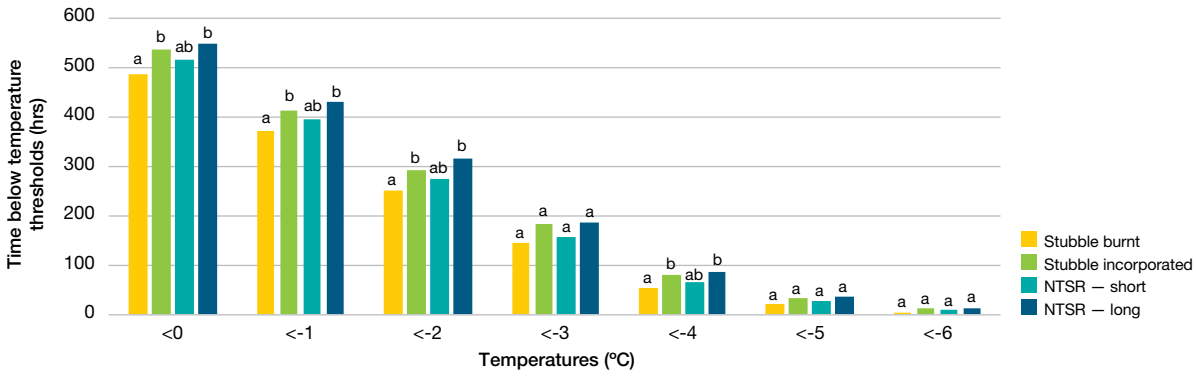

FIGURE 5 The effect of stubble treatment on the duration of in-canopy temperatures at zero and each degree below, at Yarrawonga, 2017

Letters denote statistical significance between treatments at each temperature.

TABLE 3 Frost score at harvest (GS99) at Yarrawonga, 2017

Treatment	Frost score (%) *
Stubble burnt	11.1[b]
Stubble incorporated	12.5[b]
NTSR — short stubble	17.2[a]
NTSR — long stubble	15.4[a]
Mean	**14.1**
LSD	2.78

* Frost score calculated as: number of frosted florets per head/total florets per head x 100.

Figures followed by different numbers are regarded as statistically significant.

While the cumulative temperature totals can provide some indication of differences in-crop, the key element missing from this analysis is the timing of these frost events. This becomes important given actual frost damage to the wheat head (specifically the floret) requires a frost event to occur during flowering.

Physical assessment of the number of frosted florets in each head showed that the burnt and cultivated treatments had significantly less frost damage than both the NTSR — short stubble and NTSR long — stubble treatments (Table 3). Given the relatively small difference in temperatures observed between the stubble treatments, the significant difference in frost damage between treatments could be caused by differences in the timing of flowering, which may be influenced by stubble management strategy.

Site 3: Dookie, Victoria

The Dookie 2017 trial was situated on the side of a hill, with replicated blocks positioned at increasing elevation. This change in elevation between the replicates had a significant effect on the in-canopy temperatures measured. Being situated on a high point in the landscape also meant the trial site was not be subject to the same number or intensity of frost events that would be measured in a flat paddock.

The coldest temperature recorded at the Dookie site was -3.83°C at 7am on 1 July 2017. While this was a significant frost event, the Coreen and Yarrawonga sites recorded much lower temperatures at the same point in time (-7.96°C and -7.87°C respectively), which highlights the differences in micro-climate between the field sites during 2017. The in-canopy temperature data from the Dookie site show there were a number of frost events at Dookie during 2017, although this was a lot lower compared with the other sites (Figure 6).

While about 500 hours below 0°C were recorded at the Coreen and Yarrawonga sites, about 80 hours below 0°C were recorded at the Dookie site. The high and variable altitude at the Dookie site contributed towards the high data variability at the Dookie site, with no significant differences in temperatures measured between the different stubble management treatments (Figure 7). Potential frost-related damage to the canola seed pods was not assessed as canola will continue to flower to compensate for flowering stress, with the variation in altitude also meaning that any damage could not be clearly attributed to stubble management.

Comparison of temperatures recorded at different positions at Dookie

As noted in Table 1, the Dookie site was instrumented with Tinytag temperature loggers at 50mm below the soil surface in addition to the 50mm and 300mm above-surface in-canopy loggers.

An example of this data, from the NTSR — short stubble treatment, is presented in Figure 8 and clearly demonstrates the different temperatures recorded at the different logger positions. In this example, the 50mm loggers measured

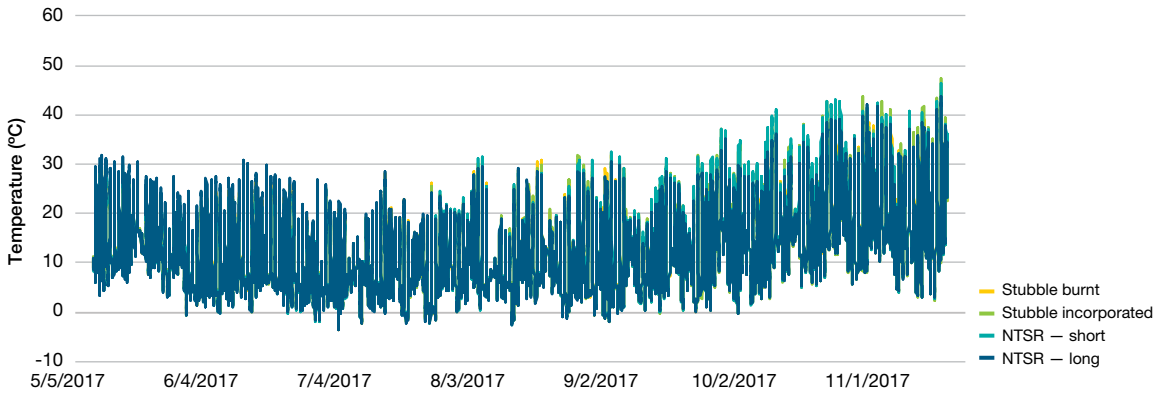

FIGURE 6 In-canopy temperatures measured at the Dookie site between 9 May – 10 November 2017

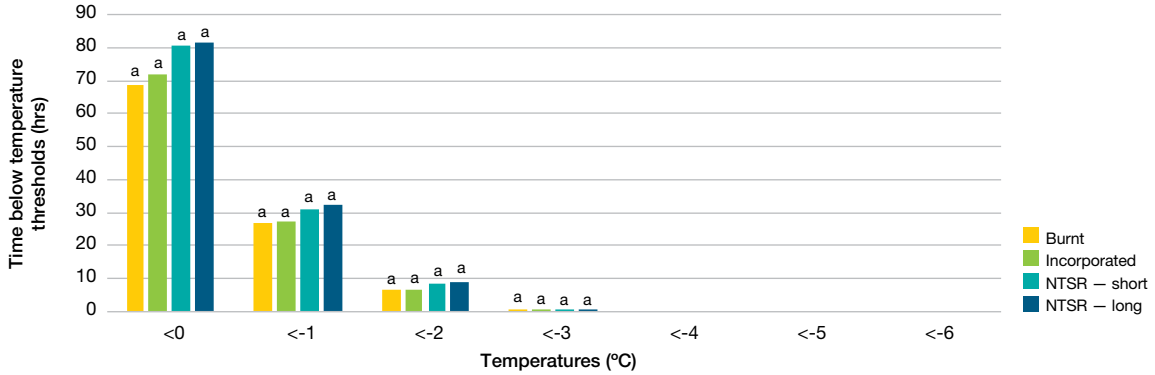

FIGURE 7 The effect of stubble treatment on the duration of in-canopy temperatures at 0°C and each degree below, at Dookie, 2017

Letters denote statistical significance between treatments at each temperature.

comparable temperatures to the 300mm loggers during the early part of the season. As the plants grew taller there were some differences between the temperatures logged at different heights, with the 50mm loggers not measuring the same extremes of cold or heat as the 300mm loggers (which were moved up to 600mm and 900mm during the season to stay in the upper part of the canopy).

The buried loggers showed even less variation in temperature throughout the season (Figure 8). While the 300mm logger measured -3.83°C on 1 July 2017, the minimum temperature recorded in the logger buried at 50mm was 4.64°C.

Observations and comments

Considering there were about 500 hours below 0°C at the Yarrawonga and Coreen sites during the 2017 season (2016 measured 160–270 hours; 2015 measured 230–270 hours), there was only a small amount of variability measured within each treatment.

Moreover, even at the Yarrawonga site, where there were statistically significant differences in temperature between treatments, these differences were not large and were unrelated to differences in measurable frost damage. If the stubble treatments were a large driver for in-canopy temperatures, this should have been clearly seen during the 2017 season, but it was not. Therefore, it appears that in particularly cold winters, stubble management has little effect on in-canopy temperature.

From the data, in-canopy temperature differences during the flowering period *per se* did not drive the difference in frost damage between burnt and stubble retained crops during the 2017 season. While differences in in-canopy temperatures were also measured during 2016, the mild temperatures measured during 2016 meant that damage attributable to frost was not detected. The 2017 season is the first in which significant differences in head damage were measured, with these results not clearly related to any trends in in-canopy temperatures.

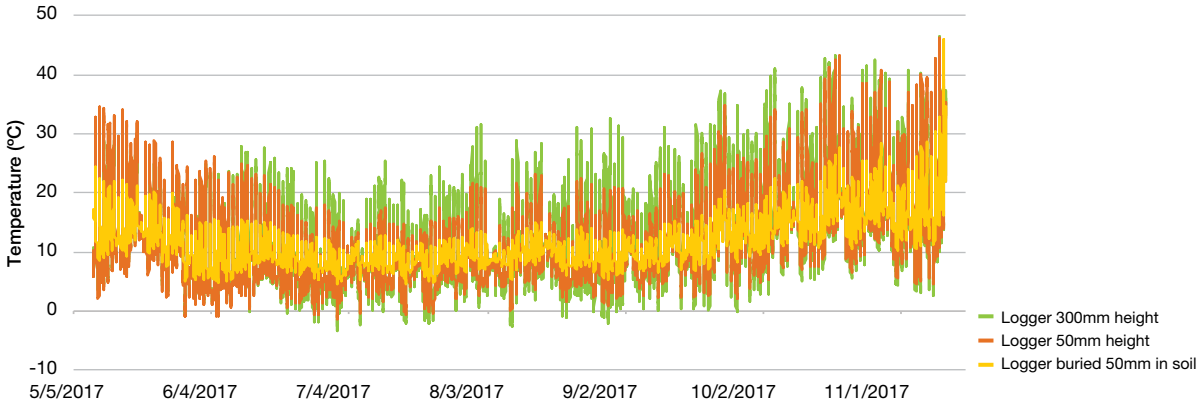

FIGURE 8 Temperatures measured at 300mm, 50mm and soil surface for NTSR — short stubble at Dookie, Victoria between 9 May – 10 November 2017

Rather, it is highly likely the early-season shading measured in crops under retained stubble, (which can cause delays in early dry matter (DM) production and crop development — see *Active stubble management to enhance residue breakdown and subsequent crop management —focus farm trials* article on page 12), resulted in differences in the timing of phenological development. The resulting delay in flowering in NTSR treatments is the most likely reason for differences in frost damage observed between treatments (i.e. whichever stubble treatment was flowering at the time of the frost event was the treatment most severely affected).

Acknowledgements

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