The role of stubble management on frost severity and its effects on the grain yield of wheat – Tootool 2014 and 2015

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Key findings

- Stubble retention increased the severity of frost events in experiments over two years.
- There was no difference in floret sterility due to stubble treatment, but grain yield was highest where stubble was removed by burning.
- Stubble retention reduced the amount of heat stored in the soil during spring. With less heat stored there is less capacity for energy release at night to buffer against frost damage.
- Consider management strategies that avoid frost (e.g. crop choice, sowing date, variety choice) where high stubble loads are retained at sowing.

Introduction

Stubble retention is an important component of no-till farming systems. The main benefits of stubble retention are increased water infiltration rates and reduced evaporation from the soil surface. There are challenges with stubble retention that are well recognised, including disease and weed management. Stubble retention has helped producers buffer against variable climatic conditions, especially by maintaining seedbed moisture and hence widening sowing windows. There has, however, been little research on the effect of stubble on the crop canopy climate. These experiments aimed to determine the effect of stubble management on crop canopy temperature (especially during frost events) and the associated effects on sterility and grain yield of wheat.

Site details

Location	Tootool, approximately 10 km west of The Rock
Soil type	Sodic red–brown chromosol
2013 crop	Canola (with retained wheat residue)
2014 variety	Bolac$^{\Phi}$ wheat
2015 variety	Whistler wheat
Plot size	36 metres (comprising three passes of a 12 metre seeder) by 200 metres

Treatments

Stubble management

1. Removed – burnt just before sowing.
2. Reduced – mulched using a K-Line stubble cutter just before sowing.
3. Retained – sown directly into the previous crop residue using inter-row sowing.

Methodology

In early May 2014, each stubble treatment was imposed on the grower's existing controlled traffic operation before sowing. Plot size was 0.72 ha with three replicates of each treatment. The treatments were imposed on the same plots in late April 2015.

Weed, disease and nutrient management were at the discretion of the grower, but decisions were made so that yield potential was optimised.

Canopy temperature was measured using unshielded Tinytag Plus 2 data loggers with two loggers in each plot. The loggers were set around the height of the canopy and moved up through the season as the crop grew taller. Temperature was logged every 15 minutes.

Just before crop maturity, 30 heads were collected from three separate locations within each plot. Heads were frozen and later assessed for floret sterility.

Grain harvest was completed using the grower's existing machinery. Yield data came from the grower's yield maps and were assigned to specific plots using the software Ag Leader® SMS™ Basic.

Results

Stubble biomass

In 2014, stubble biomass was similar for the Reduced and Retained treatments (approximately 3.2 t/ha). Stubble biomass in the Removed treatment was nil.

In 2015, stubble biomass was greatest for the Retained treatment (6.1 t/ha), reducing to 5.7 t/ha for the Reduced treatment and nil for the Removed treatment.

Crop establishment

There was no difference in crop establishment between treatments in 2014. In 2015, there was a slightly higher established plant population from the Reduced treatment, however, the differences were small (less than 10 plants/m^2) and likely to be inconsequential.

Crop development

There were slight differences in plant development across the different treatments. The Removed treatment was generally the most advanced and the fastest to reach anthesis. The Retained treatment was on average 2–3 days slower to anthesis than the Removed treatment, and the Reduced treatment was intermediate between these.

Canopy temperature

2014

From September to early November, the Removed stubble canopy had less time below the thresholds of –2.0 °C, –3.0 °C and –4.0 °C than either the Reduced or Retained treatments (Figure 1). The Removed treatment had less time below –1.0 °C than the Reduced stubble treatment, and there was no treatment difference below the 0, –5.0 °C and –6.0 °C thresholds.

There were 31 separate frost events from early September to early November (events where temperature dropped below 0 °C in any treatment). There were treatment effects on canopy temperature in 18 of the 31 events. In 16 of the 18 instances, the Reduced and Retained treatments were colder than the Removed treatment.

For the events where there was a difference between Removed and Retained stubble, the temperature difference averaged 0.45 °C.

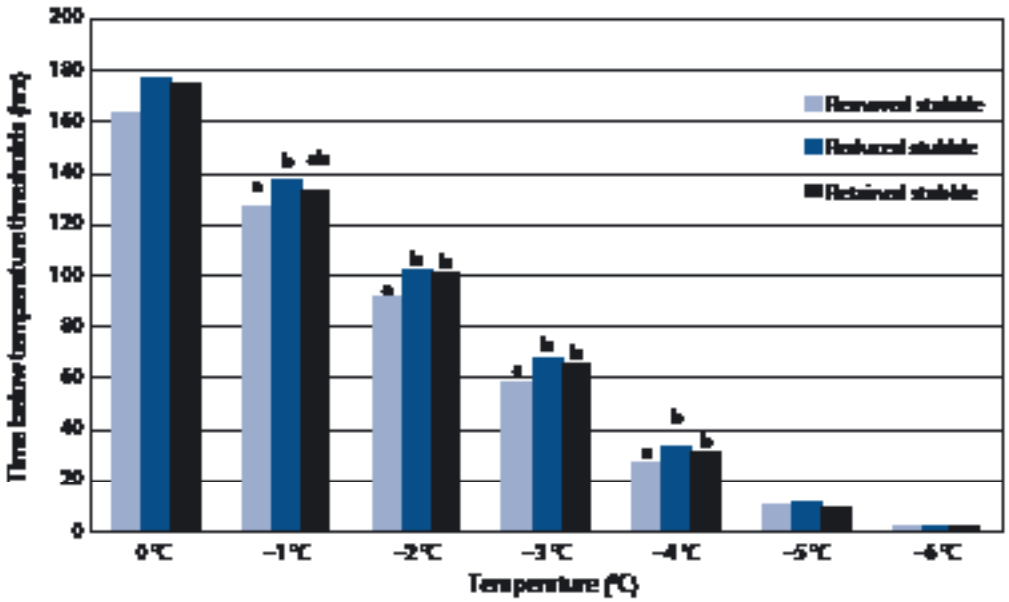

Figure 1. The number of hours below specific threshold canopy temperatures of three treatments from September to early November at Tootool, New South Wales in 2014. Significant difference is indicated by different letters (P<0.05).

2015

From late August to October, the Removed treatment had less time below each threshold from 0 °C to −6.0 °C than either the Reduced or Retained treatments (Figure 2). The Reduced treatment had less time below −2.0 °C or −3.0 °C than the Retained treatment, but these treatments were similar for all other temperatures.

There were 41 frost events (events where temperature dropped below 0 °C in any treatment) between 29 August and the last frost event on 2 October. In 35 (Retained) and 33 (Reduced) of 41 events, minimum temperature was less than the minimum temperature of the Removed treatment (data not shown).

For the events where there was a difference between Removed and Retained stubble, the temperature difference averaged 0.79 °C.

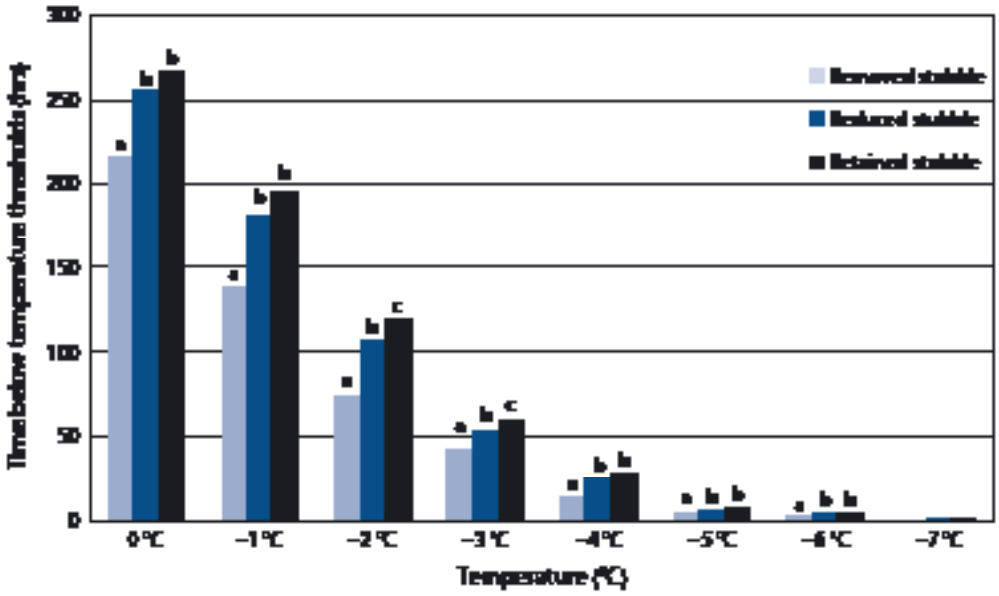

Figure 2. The number of hours below specific threshold canopy temperatures of three treatments from late August to October at Tootool, New South Wales in 2015. Significant difference is indicated by different letters ($P<0.05$).

Soil temperature

The effect of stubble management (Retained and Removed only) on soil temperature (at 5 cm depth) was measured in 2015. An analysis of the soil heat sum during the night (sum of the hourly mean soil temperature between 6 pm and 5 am) from 5 September to 9 November showed that the soil was warmer overall ($P = 0.028$) where stubble was Removed (12880 °C) compared with Retained (12605 °C).

Floret sterility

Floret sterility (FS) was not affected by the stubble treatments in 2014 and 2015. There was, however, large differences in FS between years with an average FS of 21.1% in 2014 compared with 6.0% in 2015.

Grain yield

In 2014, the Removed treatment (2.2 t/ha) was higher yielding than the Retained treatment (2.0 t/ha). The Reduced treatment (2.1 t/ha) was not statistically different from either the Removed or Retained treatment.

In 2015, the Removed (3.4 t/ha) and Reduced (3.3 t/ha) treatments were both higher yielding than the Retained treatment (3.0 t/ha).

Conclusion

Stubble retention consistently reduced canopy temperature during frost events when compared with stubble removal by burning. This did not affect the level of floret sterility at maturity, but did affect the final grain yield, with burnt stubble out-yielding retained standing stubble in both seasons of this experiment.

The colder minimum canopy temperatures from stubble retention are believed to be the result of two factors:

1. Stubble shades the soil during the day so it heats up less than bare soil.
2. When the air temperature drops at night, there is less heat available in the soil to radiate out and warm the canopy.

Stubble retention brings benefits to the farming system, especially for improved water infiltration and reduced evaporation. Growers need to consider management strategies that avoid frost where high levels of stubble are retained at sowing. This could include selecting a more frost-tolerant species (such as barley or oats) or delaying flowering slightly (using a combination of sowing date and variety choice).

Acknowledgements

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