Role of stubble management on the severity and duration of frost and its impact on grain yield

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AIM
To quantify the impact of stubble on the extent, severity and duration of frost and determine its effect on canopy temperature and grain yield.

TRIAL DETAILS

Property:	Wyoming Downs
Plot size & replication:	PA Scale blocks 200m x 30m replicated three times
Soil type:	Loamy Sand
Crop Variety:	Magenta
Application Date:	10 frosts from the 23rd August to 14th October
Sowing Date:	14/05/2014
Seeding Rate:	65kg/ha
Fertiliser (kg/ha):	35kg/ha MAP, 70L/ha UAN, 125kg/ha Sulphate of Ammonia, 1L/ha CuMo cereal mix
Paddock rotation:	Wheat

BACKGROUND
With a decrease in number of livestock on properties, and subsequent increase in in cropping areas, frost is now a significant risk to broadacre grain production. An estimate of economic cost of frost in barley and wheat is $63M annually (Fellowes 2006).

Previous agronomic work has shown that management practices can change the ability of the soil to maximise storage of heat during the day or maximise the head released from the soil at night. This may include practices such as delving to increase the amount of water and heat holding capacity of non-wetting sands or reducing crop canopy through low seeding rates or reduced nutrition which may also maximise heat entering the soil. These techniques can reduce severity and duration of frost and its associated damage.

Between 5 and 10 years ago we were unable to measure the effect of stubble levels on frost damage; however there was evidence of a decrease in frost severity when stubble was removed (Rebbeck & Knell). Trials conducted in 2012 at Wickepin and York and in 2013 at York, Wickepin and Nyabing demonstrated that high stubble biomass can increase the severity and duration of frost events (Jenkinson & Biddulph 2014).

This research is a continuation of this work to quantify the impact of stubble further and investigate whether cultivation plays a role in frost incidence and severity.

METHODOLOGY
A Precision Agriculture (PA) large scale field trial was conducted in a wheat paddock at Wickepin during 2014. A paddock with a known history of frost damage was identified prior to seeding. The trial was sown using farmers' broad acre seeding PA equipment, using farmers' standard cultivar, rotation and agronomic management. Stubble treatment plot

lengths were laid down along the paddocks natural slope for 200m, with a width of 30m and replicated three times (Figure 1).

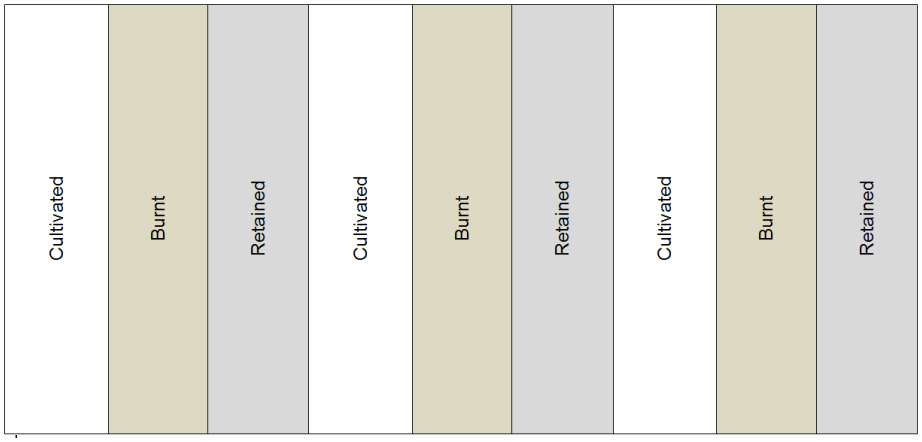

Figure 1: Trial layout Wickepin

This site was sown on the 14th May with Magenta wheat at 65kg/ha into stubble residue from a 4.5t/ha wheat crop with a falling slope of 3m in 100m (Google Maps). Stubble density at sowing was approximately 3.5t/ha (ranging from 2.9t/ha low in the landscape to 3.7t.ha high in the landscape). Three replications of standing stubble, removed stubble and cultivated soil treatments were applied down the slope.

The site was soil sampled prior to sowing to a depth of 10 cm. Data loggers were installed along the slope in each plot to measure canopy temperature at a height of 600mm every 15 minutes from July until harvest using unshielded Ting Tag Temperature loggers (TGP-4017). Plant counts were conducted six weeks after sowing at three randomly selected locations in each plot to assess crop emergence. From Zadok's (Z) 40 (flag leaf sheath extending) onwards plots were assessed weekly for crop developmental stage At Z 87 (hard dough) biomass cuts (3 x 1m) were taken from 3 randomly selected areas of the plot for frost induced sterility assessment, harvest index, 100 grain weight and screenings. At crop maturity harvest cuts were taken using a small plot research header. A total of six cuts per plot (harvest cut area approx. 26m^2) were taken along the slope.

RESULTS & DISCUSSION

Crop establishment and development

There was no visible effect of stubble treatment on crop emergence or plant biomass measured at maturity. Cultivated treatments showed some advanced maturity over the standing and burnt stubble treatments during head emergence, however all treatments flowered around the same time. Yields taken from small plot header cuts indicated an average paddock yield of 3.08t/ha with no variation between treatments or location in the landscape.

There were ten frost events (hourly canopy temperature below 0°C) August to October, all falling outside the flowering window of the crop. Low in the landscape had colder and longer frosts (ie lower minimum temperature and longer duration of temperatures below zero (Table 1 and 2).

Low in the landscape the standing stubble treatment (3 t/ha) increased the severity (minimum temperature) of the frost (Table 1) on one occasion (6th October) and was 0.27°C colder than the cultivated or removed stubble treatments. Standing stubble also increased the duration of frost events below 0 and -1°C by several hours, low in the landscape. By comparison, no differences in duration of frost events were evident with stubble treatments

higher in the landscape. Temperature data from Wickepin demonstrated that 3t/ha of stubble increased the severity of the frost in 1 of the 10 frosts in contrast to the cultivated and removed stubble treatments, however the duration of the frost events was increased throughout the August- October period. .

Assessment of harvest index and grain quality correlated with yield and demonstrated no significant differences in any treatment, highlighting the low incidence of frost during the 2014 growing season (Table 3).

Table 1: Minimum canopy temperature for frost events between August and October 2014 in Wickepin, recorded on Tiny Tag at 600mm height.

	Low			Med			High			
	Burnt	Cultivated	Retained	Burnt	Cultivated	Retained	Burnt	Cultivated	Retained	$LSD_{0.05}$
23/08/2014	-1.3	-1.4	-1.6	-0.9	-0.7	-0.9	-0.2	-0.3	-0.5	0.53
24/08/2014	-0.1	-0.3	-0.4	0.0	0.1	0.1	0.7	0.7	0.6	0.55
25/08/2014	0.2	0.2	-0.0	0.3	0.3	0.4	0.5	0.5	0.5	0.57
1/09/2014	-1.3	-1.4	-1.5	-1.2	-1.1	-1.0	-0.8	-0.8	-1.1	0.43
4/09/2014	0.1	-0.1	-0.2	0.3	0.3	0.5	1.1	1.0	1.0	0.43
14/09/2014	-1.2	-1.3	-1.5	-0.7	-0.8	-0.6	0.2	0.3	0.0	0.48
23/09/2014	-0.1	-0.2	-0.3	0.1	0.0	0.3	0.0	-0.1	-0.1	0.4
6/10/2014	0.0a	0.0a	-0.2b	0.2a	-0.1a	0.1a	-0.0a	-0.0a	-0.2b	0.41
7/10/2014	-1.5	-1.7	-1.9	-1.2	-1.3	-1.4	-0.8	-1.0	-1.0	0.38
14/10/2014	-0.9	-1.3	-1.2	1.1	1.1	1.3	2.1	1.7	1.9	0.88

Table 2: Number of hours below different temperature thresholds for frost events between August and October 2014 in Wickepin, recorded on Tiny Tag at 600mm height. Within each temperature threshold, different letters represent significant differences ($p<0.05$).

Number of hours below different thresholds during frost events (with letters abcd)*												
Temp. threshold below	Low				Medium				High			
	Burnt	Cultivated	Retained	$LSD_{0.05}$	Burnt	Cultivated	Retained	$LSD_{0.05}$	Burnt	Cultivated	Retained	$LSD_{0.05}$
0°C	15.5a	17.3ab	19.7b	2.67	11.0a	11.1a	10.3a	5.1	6.2a	7.0a	8.4a	3.6
-1°C	3.9a	4.7a	7.3b	1.7	1.3a	1.1a	1.4a	2.1	0.1a	0.2a	0.9a	1.2
-2°C	0.0	0.0	0.2	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	NA

*a,b comparisons conducted within slope levels and between treatments.

Table 3: Yield and quality data for Magenta wheat at Wickepin 2014.

Yield and quality data (observed means)												
Position	Low				Medium				High			
Stubble	Burnt	Cultivated	Retained	$LSD_{0.05}$	Burnt	Cultivated	Retained	$LSD_{0.05}$	Burnt	Cultivated	Retained	$LSD_{0.05}$
Yield (t/ha)*	3.0	3.	2.9	0.5	3.1	2.9	2.8	0.4	3.4	3.4	3.2	0.6
Stubble biomass (LSD=0.79)	NA	NA	2.92	NA	NA	NA	2.77	NA	NA	NA	3.72	NA
Heads/ m^2	1945	218	217	28	213	210	199	30	214.	217	212	42
Hectolitre	78.4	81.2	80.4	4.77	80.0	80.3	80.6	3.9	80.1	80.4	80.2	5.5
HI	0.42	0.41	0.41	0.01	0.43	0.42	0.42	0.02	0.41	0.40	0.42	0.04
100GW (mg)	38.6	35.6	36.5	2.8	38.2	35.8	36.8	2.6	39.4	39.8	39.2	2.1
Screenings† (%) <2mm	1.2	1.5	1.4	0.5	0.9	1.4	1.1	0.4	0.8	0.8	0.8	0.2

*Yield estimated from small plot harvester cuts with 2 replicates per plot

† Means of the square root of the proportion of screenings <2mm

CONCLUSION

Insufficient frost events occurred at Wickepin during the susceptible windows in 2014 to cause significant frost damage. Temperature results demonstrated that low in the landscape retained stubble increased the severity of the frost in one of the 10 frost events, but also increased the duration of frost events. Results from 2014 were not conclusive at Wickepin to demonstrate whether retaining stubble increases the incidence or severity of frost.

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