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

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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 40m replicated three times
Soil type:	Sandy Loam
Crop Variety:	Wheat Mace
Application Date:	9 frosts from 14th August – 22nd October
Sowing Date:	31st May 2013
Seeding Rate:	65kg/ha
Fertiliser (kg/ha):	35kg/ha MAP + 30L/ha Flexi-N
Paddock rotation:	Wheat

BACKGROUND

There is currently limited information available to growers surrounding present and emerging farming practices with regards to the impact and severity of frost events.
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 demonstrated that high stubble biomass can increase the severity and duration of frost events.

METHODOLOGY

A Precision Agriculture (PA) large scale field trial was conducted in a wheat paddock at Wickepin during 2013. 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 40m and replicated three times (Figure 1).

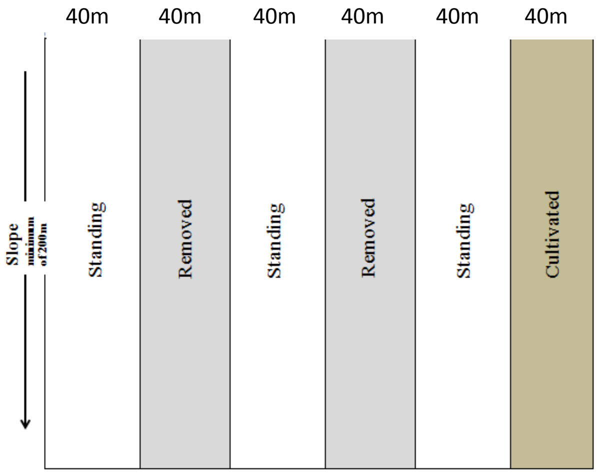

Figure 1: *Trial layout at Wickepin*

This site was sown on the 31st May with Mace wheat at 65kg/ha into stubble residue from a 1.0-1.5t/ha wheat crop with a falling slope of 1.7m in 100m (Google Maps). Stubble density at sowing was approximately 4t/ha. Three replications of standing stubble, two replications of removed stubble and one plot of cultivated land 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 3 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 and Normalised Difference Vegetative Index (NDVI). At Z 65 (anthesis) biomass cuts (3 x 1m) were taken from 3 randomly selected areas of the plot to determine plant biomass. Additional biomass cuts were taken at Z 89 (hard dough) 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

There were 4 frost events (hourly canopy temperature below 0°C) in August/September prior to flowering, and then a further 5 frost events during grain development in October.

Low in the landscape, the cultivated treatment decreased the severity of the frost (Table 1) and was on average 0.7 and 0.9°C warmer than the burnt and standing treatments respectively. Low in the landscape also increased the duration of hours the canopy temperature was below 0°C (Table 2). The cultivated treatment decreased the duration of the frost event. By comparison, no differences in the severity or duration of frost events were evident with burnt or stubble treatments low in the landscape.

Results from Wickepin show that 8 of the 9 frost events that occurred low in the landscape show significant differences in frost severity. Throughout the trial the cultivated treatment remained warmer than the removed or standing stubble treatments. The standing stubble treatment provided the coldest temperature on 6 of the 9 frost events (Figure 2). On average, across the 9 frost events, standing stubble was the coldest at -0.7°C, followed by removed (burnt) stubble at -0.5°C and the cultivated treatment remained the warmest at 0.2°C. These results suggest that if this paddock had been cultivated at the beginning of the season there would have only been four occasions low in the landscape were canopy temperature fell below 0°C.

Table 1: *Minimum canopy temperature for frost events between August and October 2013 in Wickepin, recorded on Tiny Tag at 600mm height*

	High landscape			Mid landscape			Low landscape		
Date	Standing	Removed	Cultivated	Standing	Removed	Cultivated	Standing	Removed	Cultivated
14th Aug	-0.3	0.0	0.0	-0.3	-0.1	0.0	-0.7	-0.6	0.0
16th Aug	0.2	0.5	0.2	-0.3	-0.3	-0.1	-0.7	-0.9	-0.5
6th Sept	-0.5	-0.1	0.4	-0.6	-0.2	0.1	-0.9	-0.8	-0.1
27th Sept	-0.7	-0.3	0.6	-0.2	-0.3	0.4	-0.6	-0.5	-0.1
1st Oct	-0.6	-0.3	-0.1	0.0	-0.5	-0.1	-0.6	-0.3	0.4
10th Oct	-0.4	0.4	0.6	0.4	0.1	0.6	-0.2	0.2	0.9
12th Oct	-1.3	-0.5	0.3	-0.3	-0.4	0.4	-0.2	-0.1	0.9
13th Oct	-1.6	-1.1	-1.0	-1.0	-0.9	-0.9	-1.6	-1.7	-0.2
22nd Oct	0.1	0.6	0.5	0.5	-0.1	0.6	-0.3	0.3	0.7
(LSD 0.32) AVE	-0.6	-0.1	0.2	-0.2	-0.3	0.1	-0.7	-0.5	0.2

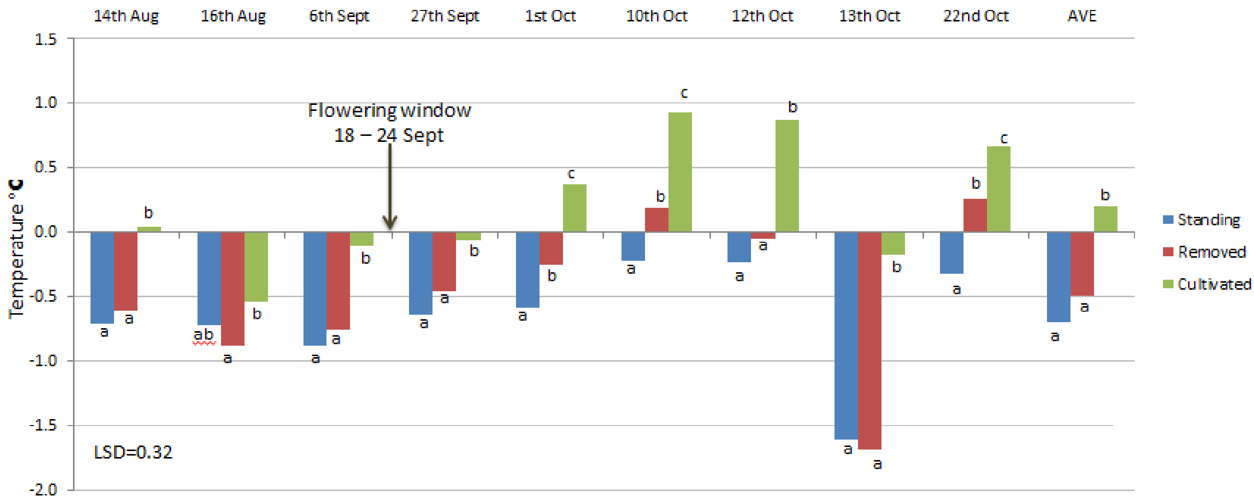

Figure 2: *Minimum canopy temperature low in the landscape for frost events between August and October 2013 in Wickepin, recorded on Tiny Tags at 600mm height*

Table 2: *Number of hours below different temperature thresholds for frost events during September and October 2013 in Wickepin, recorded on Tiny Tag (TGP-4017) at 600mm height. Within each temperature threshold, different letters represent significant difference (P<0.05).*

	High Slope			Mid Slope			Low Slope		
	Standing	Removed	Cultivated	Standing	Removed	Cultivated	Standing	Removed	Cultivated
Below 0	13 *a*	8 *a*	5 *a*	9 *a*	14 *ab*	6 *a*	19 *b*	19 *b*	6 *c*
Below -1	2 *a*	1 *a*	0 *a*	1 *a*	0 *a*	0 *a*	2 *a*	2 *a*	0 *a*

As a result of no damaging frost events falling during flowering in September and October the paddock did not experience significant frost damage. The overall paddock yield was 4t/ha, reaching its rainfed yield potential.

Effect of landscape

- Crop lower in the landscape gave higher NDVI readings, a measurement of living green vegetation, than crop high in the landscape. This is due to better soil and higher water holding capacity of the soil in this location (*Pers comms. Sarah Hyde)*.

- Crop higher in the landscape had lower yields than crop located low in the landscape. Again, this is due to the soil type variation across the site and concentration of foliar diseases higher in the landscape.

- There was no effect of position in the landscape on grain protein, screenings or 1000 grain weight, as there were no substantial frost events during flowering.

- There was no effect of position in the landscape on number of frosted grain in a harvest sample, again due to the lack of frosts.

- High in the landscape had significantly lower biomass at maturity than low in the landscape, this again relates to the soil type variation within the trial.

- There was more heads/m^2 lower in the landscape (242 vs 158 plants/m^2). The site received 300mm growing season rainfall in 2013, and it appears that areas low in the landscape were better able to store moisture (potentially higher clay content) than sandier soils high in the landscape (Table 3) leading to a more vigorous crop.

- Low in the landscape provided higher harvest index, due to the points mentioned above, with better soil type and higher water holding capacity leading to a more vigorous crop.

All biomass and yield results demonstrate the lack of damaging frost events at the Wickepin site in 2013. In a year with significant frost events it is expected that the opposite would be the case. As generally, areas low in the landscape experience more severe frosts.

Table 3: *Soil test results collected across the landscape before seeding occurred. Samples analysis conducted through CSBP*

Stubble Treatment	**Standing**	**Standing**	**Standing**	**Removed**	**Removed**	**Removed**
Position in Landscape	**High**	**Mid**	**Low**	**High**	**Mid**	**Low**
Soil Texture	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand
Soil Colour	Dark Brown	Dark Brown	Brown Grey	Brown	Dark Brown	Brown Grey
Gravel %	5	5	5	5	5	5
pH (CaCl2)	5.1	4.9	4.9	5.0	5.0	4.9
pH (h2O)	5.7	5.4	5.5	5.6	5.5	5.5
EC	0.13	0.13	0.17	0.15	0.17	0.19
Organic Carbon	1.20	1.62	1.56	1.81	1.80	1.36
Nitrate Nitrogen	43	48	53	53	46	52
Ammonium Nitrogen	3	7	3	3	3	6
Phosphorus	35	36	36	39	41	42
PBI	27.2	22.2	22.1	21.5	26.2	22.3
Potassium	63	76	40	94	84	45
Sulphur	12.1	14.5	18.3	11.0	17.6	23.2

Effect of stubble treatment

Stubble treatment did not influence the emergence of the crop at Wickepin. Development shifted slightly, with removed stubble plots developing one to two days faster than retained stubble plots. This may be due to moisture conservation from retaining stubble. Due to the lack of severe frosts, stubble treatments did not influence yield or yield components. The cultivated treatment demonstrated higher biomass, more heads/m^2 and higher yield than the other treatments. This may be due to nutrient availability through the process of cultivation or an increased canopy temperature leading to decreased frost severity. Further research needs to be conducted to explore this.

Table 4: *Yield and yield component data for Wickepin. Values are the predicted means, estimated using linear mixed models.*

Position	Low Landscape			Mid Landscape			High Landscape			
Stubble	Standing	Removed	Cultivated	Standing	Removed	Cultivated	Standing	Removed	Cultivated	$LSD_{0.05}$
NDVI	0.59	0.63	0.55	0.60	0.53	0.60	0.46	0.40	0.57	0.078
Days to Head	114	114	115	114	112	114	115	113	113	1.8
Yield (t/ha)	4.38	4.39	4.61	4.95	3.89	5.09	3.05	3.58	4.51	0.941
Biomass at Maturity	696	769	787	776	599	799	535	519	722	254.8
Heads/m^2	224	237	265	225	161	233	155	139	179	82.3
Harvest Index	0.38	0.36	0.39	0.36	0.34	0.36	0.29	0.29	0.38	0.043
Hectolitre Weight	79.6	81.3	82.6	80.3	81.4	83.4	81.1	83.3	82.9	2.36
FIS	11	10	10	9	9	10	12	8	6	1.9

CONCLUSION

Although the Wickepin site did not experience damaging frost events in 2013, results show that the severity (minimum temperature) and duration (hrs <0°C) of frost increased at positions lower in the landscape and was less severe under cultivation. Standing stubble treatments also showed colder temperatures than removed stubble treatments. These results also supported the two other trials conducted in Western Australia during 2013 that showed stubble can have an influence on crop canopy temperature.

ACKNOWLEDGEMENTS

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