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Assessing gel control lines for controlling grassfires

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Introduction

Wet control lines can potentially provide a quick and safe means for stopping or slowing fire progression or protecting assets in the path of fires. While they can be used when suppression resources are scarce, their effectiveness is temporary as it is dependent on the moisture level. Chemicals, such as gels, can be added to water to slow drying rates thereby extending the period of effectiveness.

The use of gel suppressants have been investigated in a number of previous studies mostly focussed on its use for the protection of flammable structures. There has been very little previous research investigating the use of gels for stopping or slowing fire progression and no research that has specifically investigated the longevity of this effect.

This paper presents results from field experiments that were used to investigate the effectiveness of gel control lines to stop and slow the progression of grassfires. The main objective of the experiments was to determine the effective time period that gel control lines could stop the progression of head and flank fires in grassy fuels.

Methods

Gel control lines were prepared in experimental grassland plots in a flat grassy paddock in Clarkefield, Victoria (-37.5039°, 144.8284°) prior to their ignition in March 2017. The site had a continuous cover of mixed grass species that was well cured (87%) and in a natural (4.2 t/ha) state.

A single gel product was used, with control line applications applied at a 1.1% concentration as recommended by the gel manufacturer (1.0-1.5% for fire breaks). Gel and water control lines with coverage levels of 2.1 l/m^2 were prepared using a monitor mounted to the side of the tanker. The tanker travelled at consistent speed (2.8 ±0.04 (S.E.) km/h, pump at a constant setting (500 kPa) and nozzle set to deliver a line two metres wide. Delivery flow rates were measured and a dye was used in all applications to allow the treated footprint area to be defined and the average coverage level of each treatment to be determined.

A detailed experimental schedule was used to maximise the amount of testing that could be undertaken in similar weather conditions. This required plots with differed age control line treatments being burnt in quick succession during the peak of the afternoon when fire danger conditions were at their peak.

The plots used for control line testing were 20 x 20 m (0.04 ha) which was large enough to generate a representative fire and small enough to allow for quick experiments and maximise the number of plots at the site. The plot layout was designed so that control lines would be impacted by head and flank fires within each plot (Figure 1).

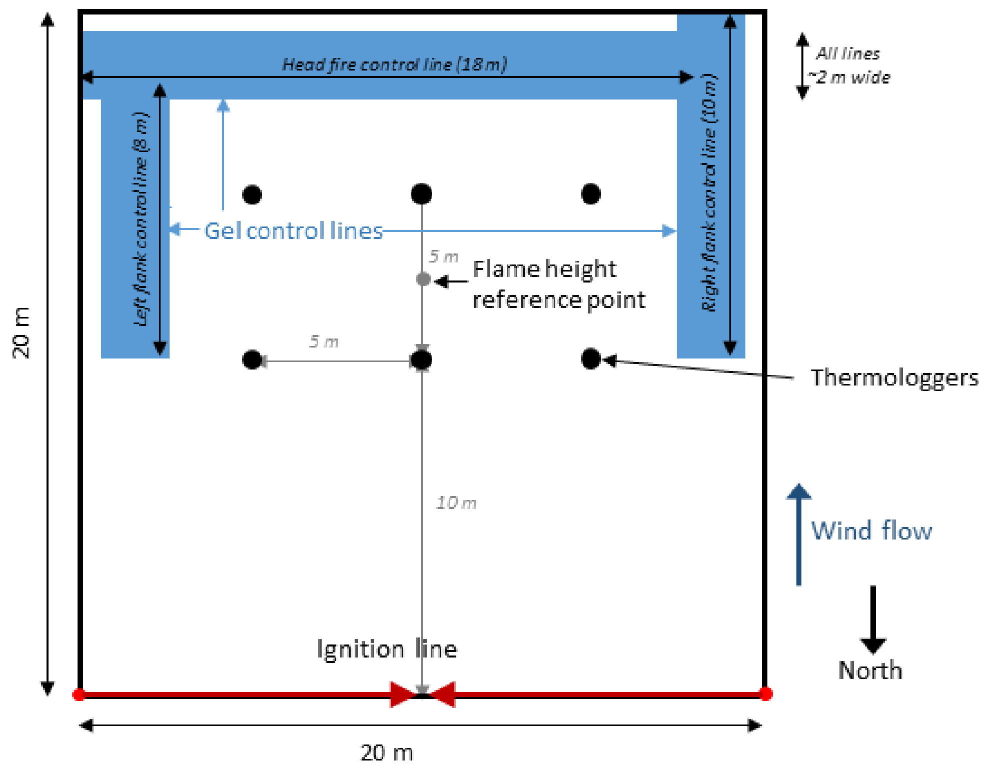

Figure 1 Internal layout of control line plots

A 20 metre ignition line was established on the upwind side of each plot in so that a running head fire would be established quickly (within 10 seconds). The ignition line was lit by two drip torch igniters starting at the corners of the plot and meeting in the centre as in previous grassfire experiments (Cruz *et al.* 2015; Cruz *et al.* 2018). The fires were allowed to burn unsuppressed within the plot area.

The behaviour of each experimental fire and its interactions with the control line were closely monitored using aerial and ground based videography, a thermologger grid and fire behaviour observers. Aerial video imagery was captured using an unmanned autonomous aircraft. Thermologgers were located at each grid point (Figure 1) and were used to log flame temperatures and determine rate of spread. Fire arrival was defined as the time that a temperature of 300° C was first reached, while flame residence time was the time period above 300° C (Wotton *et al.* 2012). Control lines were monitored during fires and the times of impacts and breaches were recorded.

Results

Fourteen plots had been prepared for experiments to provide a range of pre-ignition treatment times from one to 6.5 hours. Three of these had been prepared using water to provide a comparison to the gel applications. Eight control line experiments were undertaken, with three of these involving a secondary application of either water or gel at a higher concentration. Only one plot (the first to be ignited) was burned according to the pre-planned schedule. This plot was intended to have most recent application (2 hours). The fire in this plot burned through the control lines with little slowing effect. Following this result the experimental design was changed to concentrate testing on more recent gel treatments.

There was some variation in fire behaviour between plots mainly as a result of the variability in wind speed and direction, however most fires spread relatively fast (> 1 km/h), had high intensities (≥ 2000 kW/m) and tall flames (≥ 1.5 m) (Table 1). Some fires spotted up to four metres ahead of the main fire, but no spotfires breached the control lines.

All head fires burnt through the control line treatments showing no effect in reducing the rate of spread (Table 1). In these situations the head fire leaned across the top of the grass layer igniting the highest parts of the grass, and continuing onto the other side. In many cases there were residual unburned or lightly burned fuels underneath those that have been burned (Figure 2).

Table 1 Summary of fire behaviour and control line fires breaches

Treatment [plot]	Grassland fire danger index	Rate of spread (m/h)	Intensity (kW/m)	Mean flame height (m)	Application Age (h:mm)	Time between impact and breach (s)		
						left flank	head	Right flank
Gel (1.1 %) [2]	8.9	1385	2868	1.8	2:03	7	3	4
Gel (1.1 %) [5]	9.0	1636	3084	1.7	0:59	13	3	87
Water [8]	20.2	1500	3055	2.7	1:25	9	2	10
Gel (1.1 %) [15]	5.8	1385	3015	2.0	4:16	2	3	11
Gel (1.1 %) [22]	7.4	2571	5796	1.7	1:32	4	3	6
Gel at 1.7% [4]	26.4	900	1944	3.0	0:32	34	4	48
Rehydration [1]	8.4	1500	3126	1.3	0:36	6	2	Held
Rehydration [6]	15.7	2571	5383	1.9	0:42	Held	8	14

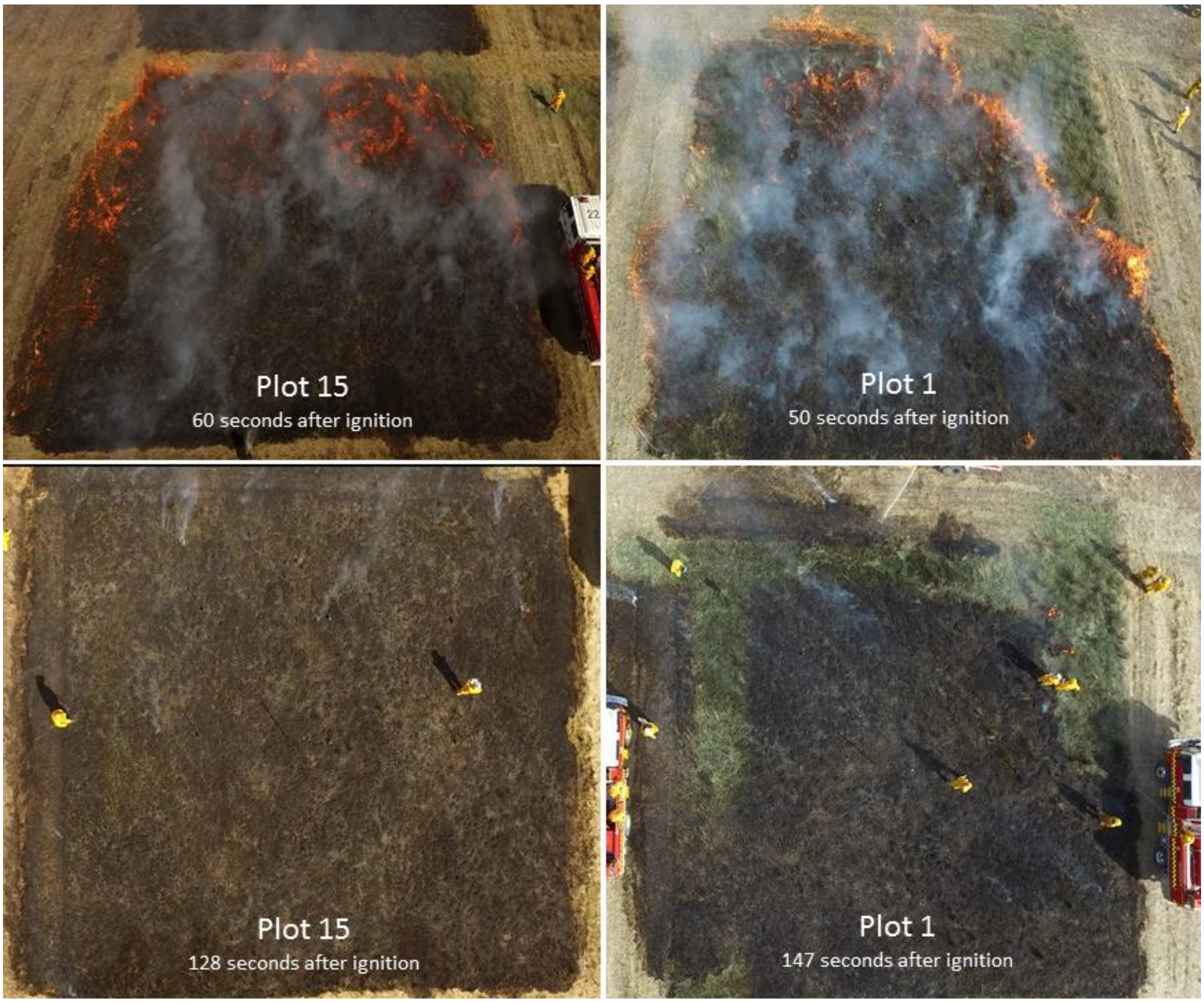

Figure 2 Aerial view of fires reaching the control line and the remaining fuel in the plots with the longest (plot 15, 4 h 16 min) and shortest (plot 1, 36 minutes) time since application.

Discussion

The results consistently showed that gel control lines do not stop grassfire spread. This is because of the rapid drying of gel on the exposed tops of the fuel profile which sustain combustion when flames reach them. Brief changes in wind direction (~1 to 2 seconds) changed flanking fire to head fire with flames leaning over the flank control lines and breaching them. Gel control lines are likely to dry more slowly in calmer and cooler conditions and may even stop fires in lighter winds, however as grassfires typically occur in windier and drier conditions gel control lines could not be expected to stop grassfire spread.

The lower parts of the fuel profile remain moist for much longer, as evidenced by residual unburnt fuels in some plots (e.g. Plot 1 as shown in Figure 2). While moist fuels lower in the profile did not stop fire spread, fire intensity within these treatments was lower as less fuel was consumed (see Equation 1).

The effectiveness of gel control lines in other fuel types, such as forests with litter layers, are likely to be different due to their microclimates. Previous studies of drying rates in litter layers have shown that gel treated fuels can dry much more slowly than those treated with water or foam suppressants (Taylor *et al.* 2005; Plucinski *et al.* 2014). Control lines in forest fuel types are likely to be more vulnerable to being breached by spotting.

The weather conditions experienced during the control line fires were representative of low to very high grassland fire danger ratings. The results are likely to be consistent during more extreme fire danger conditions as the drying rates would be faster than those reported here.

Conclusion

The testing also showed that gel is not suitable for control line operations in grasslands with all but two of the 21 gel control lines tested being breached easily by fires. The two control lines that held had been recently rehydrated (36 – 42 minutes) and were impacted by lower intensity flank fires.

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