Evaporative protection in wheat

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Abstract
In semi-arid cropping regions where rainfall is variable, stored soil water is important for reducing the impact of dry periods. Water lost, in-season due to evaporation represents a lost opportunity for building yield potential. We tested the value of protecting a wheat crop from inter-row evaporation on growth and water use efficiency. Protecting the inter-row area using PVC cover significantly increased yield by up to 50%. This demonstrates the benefit of water conservation and/or concentration of water shed to the crop row in a decile 2 year. The alternative inter-row cover options of a spray-on polymer or 5 t/ha of stubble as a mat did not provide the same benefit as using PVC cover, where yields were equivalent to when there was no cover. Given the promising results for the PVC cover, testing other inter-row control measures including alternative polymer formulations, stubble load and arrangement or canopy designs to limit evaporative losses of soil water, in-season is of value.

Key Words
crop, water use, profitability

Introduction
In dryland cropping regions, where rainfall during the growing season is low and unreliable, water storage and conservation within the soil for crop use is vital for buffering dry periods (O'Leary and Connor 1997). Long fallowing as a management options, accrues soil water for use in the subsequent season, thus drought proofing crops, although this practice can affect overall farm profitability. Summer fallow can also provide significant benefit to autumn sown crops (Hunt and Kirkegaard 2011). For in-season water conservation for crop use, canopy closure and stubble cover also provide benefits. Consequently, management options which are optimized to limit evaporative water losses, in-season, could improve yield and yield stability of crops. If an economic method of using polymers or other cover material for protecting against evaporative losses within crops could be applied, this would increase the proportion of water used by the crop compared with evaporative losses (Ekebafe et al 2011). Such interventions could increase crop water use and provide the industry with tools to increase yield within semi-arid cropping environments. To determine the impact of inter-row evaporative water loss on crop growth and yield, we tested the concept of protecting the inter-row region of wheat crops from evaporative loss using the options of either polyvinyl chloride (PVC) covers, an alginate based spray-on polymer or a 5 t/ha stubble mat.

Methods
Trial design
A field trial was sown at Longerenong, Victoria as a randomised block design to assess the effect of a range of inter-row evaporative protection methods, timing of protection and growing season water on wheat growth. Wheat (*cv*. Scepter) was sown at 89 kg/ha on the 19 June 2018 using knife points and press wheels at 30 cm and cross sown (perpendicular) into a 1.1 t/ha standing wheat stubble. Total mineral N within the soil profile (0-120 cm) at sowing was 73 kg/ha. Sowing fertiliser was Granulock® Z at 60 kg/ha (with flutriafol at 200 ml/100 kg). The imposed treatments, in-season were a combination of i) protection method (nil; PVC - 225 mm half pipe cover; spray-on polymer (alginate based) (Figure 1) and stubble mat at 5t/ha), ii) protection timing (mid-tillering to heading; mid-tillering to maturity and heading to maturity) and iii) growing season water (low water (LW), rainfed; high water (HW), rainfed + 20 mm irrigation at mid-tillering). All treatments were replicated five times. In-season rainfall was 122 mm. Crop biomass at anthesis (20 October) was measured for the treatment comparisons, LW/HW across nil and PVC protection methods. Crops were quadrat (1.2 m^2) harvested on the 4 December, processed with a stationary thrasher and yield components (grain number, kernel size and yield) determined.

Gravimetric soil water content to 120 cm was measured at sowing and harvest for the treatment comparisons, LW/HW across nil and PVC protection methods and was used to calculate water use (WU) and crop water use efficiency (WUE). Water use was calculated as the sum of in-season rainfall, irrigation and difference between soil profile water between crop sowing and maturity. Time Domain Reflectometry (TDR) was also used to assess temporal water dynamics of the topsoil/shallow subsoil (0 to 20 cm). A Tektronix 1502B metallic time-domain reflectometer with stainless steel probes (20 cm) inserted vertically into the soil profile was used to measure soil dielectric constant and was converted to soil volumetric water content using a calibration equation (Topp et al 1980). TDR measurements were taken on the subset of treatments, LW/HW treatments and nil and PVC protection methods.

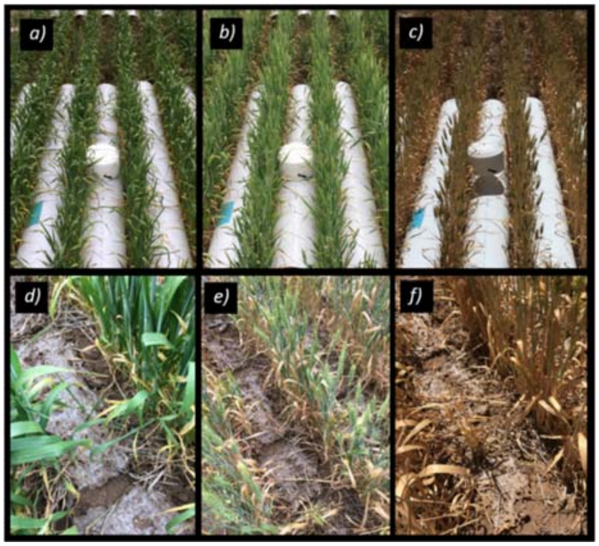

Figure 1. Inter-row evaporative protection methods, PVC (*a, b & c*) and spray-on polymer (*d, e & f*), for wheat (*cv.* Scepter) at mid-tillering, (*a & d*); heading, (*b & e*) and maturity (*c & f*).

Results and Discussion

Where inter-row PVC cover was imposed at mid-tillering for LW crops, anthesis biomass was equivalent to where crops had an additional 20 mm of irrigation applied at mid-tillering and were uncovered (Figure 2). Moreover, for crops with inter-row cover, growth was equivalent across water treatments (4.3 t/ha), whereas for those crops with no cover, irrigation increased anthesis biomass by 26%. Evidently, greatest relative benefit of inter-row cover on crop growth occurred under drier conditions.

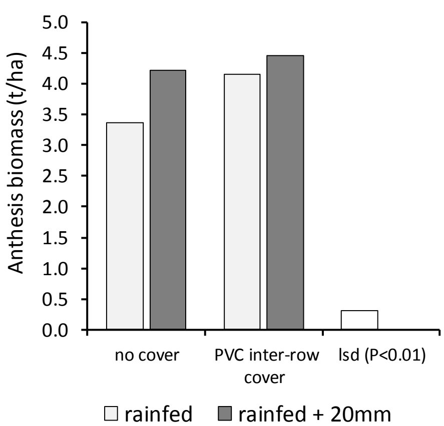

Figure 2. Comparison of wheat (*cv.* Scepter) biomass (t/ha) at anthesis for crops where a factorial combination of inter-row cover (no cover and PVC) and external water supply (rainfed and rainfed + 20mm at mid tillering) were tested. lsd is for the interaction effect of method of cover and irrigation.

Applying PVC inter-row cover from mid-tillering to both heading and maturity significantly increased grain yield by 42 and 50% respectively compared with where there was no inter-row cover (Table 1). This increase in yield was linked with a 50 and 53% increase in grains set respectively. The effect of removing the PVC inter-row cover at heading (mid-tillering to heading treatment) was a significant reduction in kernel size compared with all other treatments, suggesting that the absence of post-flowering protection increased late water stress and limited grain-filling. When PVC inter-row cover was restricted to the heading to maturity growth window, there was no significant increase in yield compared with the uncovered control. This indicates that most gain in yield was made by protecting water against early evaporation for building yield potential, rather than increasing kernel size, through late water conservation, alone.

Table 1. Comparison of wheat (*cv*. Scepter) yield components for a range of inter-row cover (protection) methods applied across three different windows during the growing season. Protection windows were mid-tillering to maturity (Mt to Mat), heading to maturity (Hd to Mat) and mid-tillering to heading (Mt to Hd). lsd is for the interaction of these two treatments.

Protection method		Protection window		
	No cover	Mt to Mat	Hd to Mat	Mt to Hd
		Grain number (grains per m²)		
	2755			
PVC		4208	2926	4140
Spray on polymer		2727	2537	
Stubble mat		2870		
lsd (P<0.001)		415		
		Kernel size (mg)		
	40.7			
PVC		40.0	41.0	38.7
Spray on polymer		40.4	40.6	
Stubble mat		40.3		
lsd (P<0.001)		1.0		
		Grain yield (t/ha)		
	1.13			
PVC		1.69	1.21	1.61
Spray on polymer		1.11	1.03	
Stubble mat		1.15		
lsd (P<0.001)		0.18		

The pattern of response for inter-row cover effects remained the same across the LW and HW treatments. The main effect of an additional 20 mm of irrigation applied at mid-tillering was to increase yield from 1.1 to 1.4 t/ha (pooled across protection method and window treatments). For the spray on polymer, applied at both mid-tillering and heading, there was no yield (or yield component) advantage compared with crops where there was no inter-row cover (Table 1). The difference in the response between PVC and the spray-on polymer may be due to the formulation being semi-permeable to water and/or the limited longevity of cover before breakdown (Figure 1 d - f), which did not adequately protect against surface evaporation of soil water. For the stubble mat imposed at mid-tillering (straw horizontal and aligned), at 5 t/ha within the inter-row, this provided no yield benefit compared with the control and may indicate that the load was insufficient to limit evaporative losses.

The change in topsoil (0-20 cm) water content (WC) across time, varied with position and PVC inter-row cover. For LW (non-irrigated) crops where the inter-row was uncovered, the row and inter-row WC followed the same pattern, although the crop row was generally drier (Figure 3). For wheat where PVC inter-row cover was imposed, the WC of the crop row spiked after rainfall events, whereas there was no recharge in the inter-row, due to the PVC being impervious and concentrating run-off to the crop row. For crops under the HW (20 mm of irrigation at mid tillering) treatment, the row and inter-row WC also followed the same pattern, although the crop row was generally wetter, a likely artefact of the high intensity 20 mm irrigation event at mid tillering where there was preferential infiltration in the crop row. Moreover, for wheat where PVC inter-row cover was imposed, the WC of the crop row spiked after rainfall events whereas there was no recharge in the inter-row, again a result of the PVC affecting the recharge pattern.

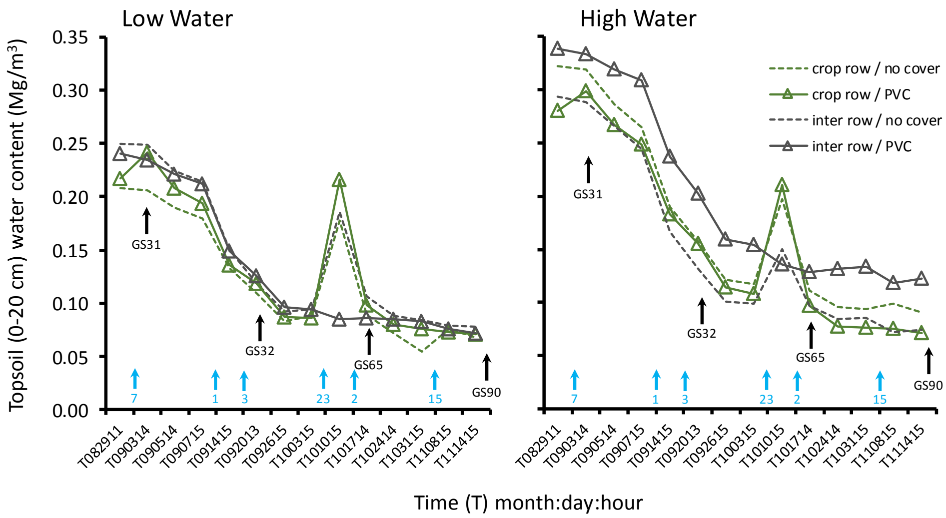

Figure 3. Topsoil (0 – 20 cm) volumetric water content within the crop row and inter-row area, over time for wheat (*cv.* Scepter) grown where a factorial combination of inter-row cover (no cover and PVC) and external water supply (rainfed and rainfed + 20mm at mid tillering) were tested. GS is growth stage of wheat and blue arrows/values are rainfall distribution and amount (mm).

The WU for where PVC inter-row cover was applied from mid-tillering to maturity was lower (P = 0.05) compared with unprotected crops (171 vs 189 mm). Conversely, for grain production, the WUE was significantly higher where PVC (mid-tillering to maturity) was applied compared with uncovered controls (10 vs 6 kg/ha/mm).

Conclusion

Overall, inter-row protection using PVC demonstrated the benefits of water conservation and/or concentration of water shed to the crop row region on yield (up to 50% increase), applied in a decile 2 growing season. For the alternative protection approaches tested, we could not demonstrate a yield benefit from the spray-on polymer formulation used or the 5 t/ha stubble mat. Next steps include testing other polymer formulations, stubble presentation methods/amounts or canopy designs. If successful, this may offer industry a management option to limit evaporative losses of soil water, in-season, and increase crop yield similar to that observed when using the PVC cover.

Acknowledgments

This work was funded by the ‘Improving practices and adoption through strengthening D&E capability and delivery in the southern region’, Regional Research Agronomists program (DAV00143) as part of the Grains Research and Development Corporation (GRDC) and Agriculture Victoria - Department of Jobs, Precincts and Regions (DJPR), Bilateral Research Agreement. The authors also wish to acknowledge the assistance of Birchip Cropping Group in delivery of the experimental program.

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