Polymers – New data

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Take home messages

- *Field data from 2007, as well as modelling data, has shown that there is an optimum time to remove the polymer film before it gets too hot under the film resulting in a reduction in yield.*
- *A low cost structure is required to make polymer film economically viable, however there seems to be good initial results when using polymers to establish native tree species. There is potential that polymer film may have a future with perennial species (salt bush establishment etc) more so than with annual species due to the high cost of laying the film each year with annual crops.*

Methods

Three polymer trials were undertaken in 2007.

Trial 1 – Assess Integrated Packaging polymer film (Envirocare) and the time of removal on wheat and canola growth at Birchip.

Sow/lay film:	26/6/2007
Crop variety:	Wheat – Yitpi
	Canola – Bravo
Polymer removal:	Three different treatments: 7/8/2007 GS15; 21/8/2007 GS15 + 2 wks; 26/9/2007 GS15 + 4wks
Replications:	Four

Trial 2 – Assess the performance over wheat and lentils of three novel polymer films at Birchip.

Sow/lay film:	26/6/2007
Crop variety:	Wheat – Yitpi Lentils – Nugget
Replications:	Demonstration only

Trial 3 – Assess the effect of polymer film on the germination and establishment of direct-drilled native tree seeds.

Sow/lay film:	16/7/2007
Variety:	A mix of 20 or more native Mallee species

Results

Trial 1

Table 1. Dry matter cuts of wheat and canola at maturity in Trial 1.

	Dry matter at maturity t/ha	
	Wheat	**Canola**
No polymer	4.4	1.6
Polymer removal on 7/8/08	4.6	2.0
Polymer removal on 21/8/08	4.1	4.4
Polymer removal on 29/9/08	2.5	0.0
Significant difference	**S**	**S**
LSD	**1.8**	**1.3**
CV%	**2.8**	**27.8**

Table 1 indicates that there is an optimum time to remove the polymer before dry matter starts to decline. The optimum time for the polymer to remain on the crop in 2007 seemed to be around 1-2 months from sowing depending on crop choice. If the polymer remained on the crop for three months, the yield started to decline. One reason for the significant decline in dry matter production for both wheat and canola around the three-month period is the extreme heat under the polymer. Monitoring under the plastic suggests that daytime air temperatures during the spring can be up to 20°C greater under the polymer compared to the outside temperatures. Likewise, soil temperatures during the day (top six cm of soil) can be up to 15°C greater under the polymer in the spring. These are significant increases and sensitive crops such as canola can not withstand such extremes.

Further results on yield response to temperatures, using modelling techniques, can be seen in Figure 1.

Table 2 and 3 displays the soil moisture at each time of polymer removal for wheat and canola. Soil moisture levels in the profile had significantly decreased by the time the polymer was removed at the third timing (29/9/2007), indicating that the plants had run out of moisture. In a perfect environment, moisture should not be lost from the system. By the time the polymer was removed at the third timing there were breakages starting to appear in the polymer which may have been caused by wind damage and other environmental factors, and these gaps may have resulted in moisture evaporating from the system.

Table 2. Total soil moisture in the profile under wheat at the time of each polymer removal.

	0-10cm	10-40cm	40-70cm	70-100cm	Total moisture in profile (mm)
No polymer*	16.8	25.8	22.9	20.3	86
Polymer removal on 7/8/08	17.1	29.3	30.8	29.3	107
Polymer removal on 21/8/08	13.8	20.0	18.8	18.7	71
Polymer removal on 29/9/08	1.1	0.8	0.6	0.6	3

** The treatment 'No polymer' was sampled at the second time of removal in late August as a comparison.*

Table 3. Total soil moisture in the profile under canola at the time of each polymer removal.

	0-10cm	10-40cm	40-70cm	70-100cm	Total moisture in profile (mm)
No polymer*	20.7	31.4	28.6	26.3	107
Polymer removal on 7/8/08	20.4	26.4	27.3	26.3	100
Polymer removal on 21/8/08	20.9	29.3	25.8	25.2	101
Polymer removal on 29/9/08	1.2	0.5	0.5	0.5	3

** The treatment 'No polymer' was sampled at the second time of removal in late August as a comparison.*

Trial 2

The lentils under the novel film performed poorly due to the heat and humidity generated under the film. No dry matter or yield data was generated from the lentil trial due to death of plants early in the trial. Observations showed that the lentils plants were yellow and diseased soon after emergence due to leaf area constantly touching the moist, hot film surface.

Observations from Trial 2 in wheat showed that the three novel films broke down at different times depending on the make-up of the polymer. This data will be used in the future to develop a film that breakdowns naturally in sunlight at the optimum time for maximum yield, approximately between 1-2 months after the polymer film has been laid or 1.1-1.2 times the air temperature (see modelling data below).

Trial 3

In July 2007, 20+ native tree species were direct-drilled at the BCG Farming Systems site and immediately covered with a polymer. A sowing length of tress was left uncovered as a comparison.

Plant establishment was monitored three times during the year (5/9/2007, 18/9/2007 and 30/9/2007). On all three dates, eight species of native trees had emerged and survived under the polymer compared to zero emergence without the polymer. Some of the native species that had emerged included: *Dodonaea viscosa* (Sticky saltbush), *Enchylaena tomentosa* (Ruby Saltbush), Chenadod family, plus Eucalyptus and Acacia species.

Due to the limited but interesting results gathered from this trial, Greening Australia would like to conduct further investigations by manipulating sowing times and experimenting with directing drilling using polymers across different soil types.

Modelling exercise in polymers

In 2007, Shaun Lisson from CSIRO Sustainable Ecosystems has been working on the response of polymers using modelling techniques. He has produced some very interesting results including soil moisture differences, yield responses to seasonal climatic variability, and an economic response to polymers.

The modelling techniques Shaun used assumed the following:

Variety:	Yitpi Wheat
Sowing date:	15 April
Starting soil nitrogen:	50kg N/ha
Topdressing nitrogen:	25kg N/ha
Rainfall:	Collected from long-term Bureau of Meteorological weather station from 1889-2006

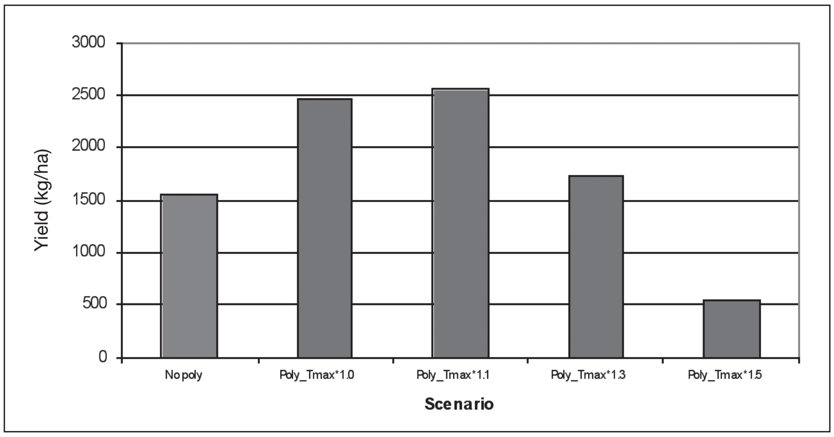

Figure 1. Yield response (13-year average) to temperature for the first three months after sowing/laying polymer.

The temperatures in Figure 1 are: a control (no polymer), Polymer (air temp x 1), Polymer (air temp x 1.1), Polymer (air temp x 1.2), Polymer (air temp x 1.3), Polymer (air temp x 1.4) and Polymer (air temp x 1.5).

Figure 1 is the predicted wheat yield response to increases in subsurface temperature under the film. The model has been based on a 13-year average of wheat responses to climatic conditions. This is the predicted final yield for wheat following three months under plastic from 15 April. An assumption is that runoff from the top of the film is fully captured, and that evapotranspiration from under the film is negligible.

The model shows that there is an optimum temperature under the polymer before it gets too hot and yield start to decrease. Clearly the optimum temperature increase is around 1.1 to 1.2 times the air temperature according to the model.

Figure 2 highlights the changes in yield to seasonal climatic variability. If you assume 80 percent light transmission and 1.1 times ambient subsoil temperature, with 100 percent evapotranspiration capture over the three months under film, then the modelling shows a situation where there is a variable response to polymers depending on the seasonal conditions, but that overall, the use of polymers gives a more reliable and higher yield outcome compared to not using polymers.

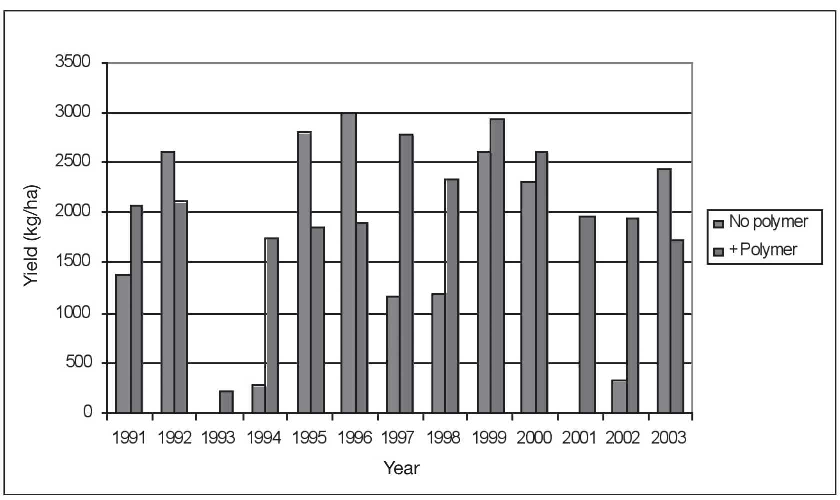

Figure 2. Polymer yield response to seasonal climate variability

However, Figure 3 shows that the economics for polymers require a low cost structure to make it worthwhile for wheat. It is highly likely that the economics would be more attractive for sorghum (Qld data). Queensland data has shown predicted outcomes to be greater with sorghum than wheat; while the input costs of the two crops are the same, the returns are much higher using polymers over sorghum.

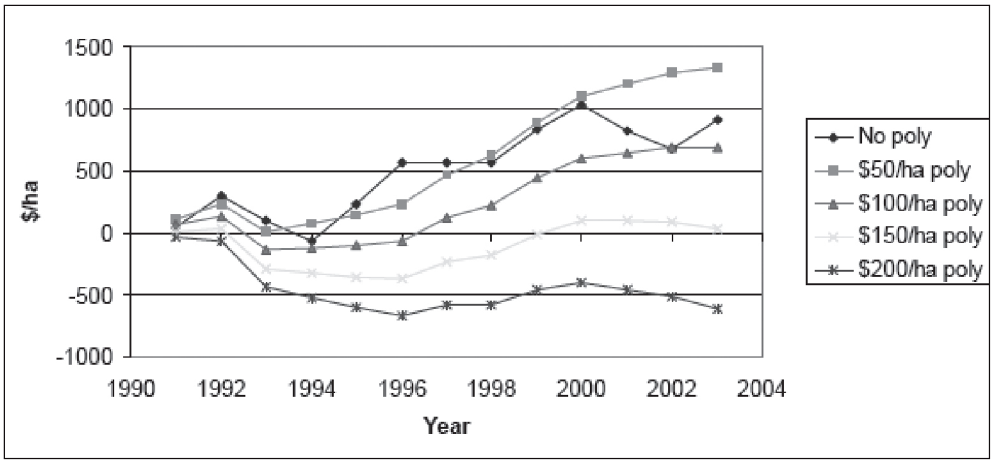

Figure 3. Accumulated cash flow response to polymers in wheat – variable cost sensitivity test.

Commercial practice

In 2008, BCG is considering the development of polymers by:

- **Extending the season using crop choice.** Planting sorghum in winter and overlying with polymers; incorporating a very early planning of wheat/canola/lentils in March to capture the autumn rains and benefit from the extra heat during winter.
- **Extend the range of crops** that could not otherwise be produced in the region, planting Sunflower, Mungbean, Cowpea, Soybean, Peanut, Lucerne, Hemp, Pigeonpea etc
- **Test the use of films** on crops such as native trees and saltbush.