Winter cover crops can increase infiltration, soil water and yields of irrigated cotton—Yelarbon

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Research Questions: *Can cover crops increase infiltration and net water accumulation in pivot-irrigated cotton systems with low (<30%) ground cover?*

- *What is the net water cost to grow winter cover crops?*
- *What is the net water gain to subsequent cotton crops?*
- *What is the impact on the yield of the subsequent cotton crops?*

Key findings

1. Winter cover crops can improve ground cover, increase plant available water and improve subsequent cotton yields in pivot-irrigated systems.
2. The early spray-out treatment was the best cover crop for storing water over the short fallow in this study where cover did not have to last very long. However, the extra cover in the mid-terminated cover treatment continued to boost infiltration in the cotton's early growth stages.
3. All cover crop treatments improved the yields of cotton by approximately 3 bales/ha; well in excess of any gains expected from the increased fallow soil water storage.

Background

Approximately 60% of rainfall in northern farming systems is lost to evaporation, with transpiration through plants typically only 20-40%. Cover crops are good for protecting the soil from erosion, building soil organic matter and maintaining soil biological activity. However, not being harvested for grain or fibre, they are considered 'wasteful' of rainfall; widely seen to be our most limited resource in dryland farming systems.

Recent research now suggests that cover crops may provide these benefits with little or no loss of plant available water. Therefore, there is renewed interest in cover cropping to use some of this 'lost' water and help develop systems that are more productive, profitable and sustainable.

For example, we know that cotton crops can leave the soil dry and unprotected with low ground cover after picking. This reduces infiltration and makes it difficult to rebuild soil water levels for the next crop. Consequently, dryland growers plant winter cereals post-cotton to get cover back on the ground and protect the soil; the crops may be harvested in good seasons, or be sprayed-out after 6-10 weeks just to provide the necessary ground cover to maintain infiltration.

However, efficient water use is also important for irrigated cotton growers; especially overhead irrigators who are interested in cover to maximise infiltration when they are watering-up and during the early growth stages of the cotton when they may have trouble getting enough water into the soil to keep up with the later crop demand. Any additional cereal stubble will also protect the young cotton plants from hot summer winds after planting.

Our project has intensively monitored crop experiments from Goondiwindi (Qld) to Yanco (NSW) to quantify the impact of cover crops on fallow water storage and crop growth. That is, how much water is required to grow cover crops with sufficient stubble, how these stubble loads affect accumulation of rainfall, the net water gain/loss for following crops and the subsequent impacts on crop growth and yield. This paper reports on an irrigated cotton paddock between Yelarbon and Goondiwindi.

What was done

The Yelarbon experiment was on a pivot-irrigated paddock that grew cotton in 2016/17. The crop was picked and root cut in May 2017, before offset discs were used on 12 June 2017 to pupae-bust and to level wheel tracks of the pivot irrigator. Nine cover treatments (Table 1) with five replicates were planted on the same day using barley (100 plants/m²), barley and vetch mixtures (30 plants/m² each) and tillage radish (30 plants/m²). Rain that night aided establishment, with the surrounding paddock planted to wheat for stubble cover two weeks later as per the grower's normal practice. The grower normally takes this wheat crop through to harvest and so we included a 'grain harvest' treatment.

Table 1. Cover treatments applied at the Yelarbon site included barley, vetch and tillage radish.

Cover crop treatment	Terminated	Peak biomass (kg/ha)
Control (bare fallow)		
Cereal (barley)	Early	1166
Cereal (barley)	Mid	4200
Cereal (barley)	Late	5104
Cereal (barley)	Mid + Roll	4200
Cereal (wheat)	Grain harvest	8175
Cereal + legume (vetch)	Mid	4928
Cereal + legume (vetch)	Late	4149
Tillage radish	Mid	4692

Three termination times matched key growth stages of the main cereal treatments:

- Early-termination at first node (Z31) when stem development began;
- Mid-termination at flag leaf emergence (Z41) when the reproductive phase began; and
- Late-termination at anthesis (Z65) for peak biomass production.

The subsequent cotton crop was planted on 15 November 2017. Importantly, the grower's 'grain harvest' treatment was used to determine the irrigation schedule for the wider paddock and our experimental plots.

Above-ground biomass was monitored across the growth of the cover crops until termination and through the subsequent fallow. Establishment counts were taken on each plot and hand cuts used to estimate cotton yields.

Soil water was estimated using soil cores to measure gravimetric soil water at key times across the fallow and the subsequent cotton, along with regular neutron moisture meter (NMM) and EM38 readings in each plot. These NMM and EM38 readings and the percentage ground cover were recorded every 2–4 weeks while the cover crops were growing, and every four weeks once all cover crops were terminated through to canopy closure of the following cotton. Final EM38 and NMM water measurements were done at cotton defoliation.

Results

Biomass and ground cover

Biomass of the barley cover crops ranged from 1166 kg DM/ha for the early-termination, up to 5104 kg DM/ha for the late-termination and 8175 kg DM/ha for the grain harvest treatment (Table 1). The cereal/legume mix and the tillage radish produced less dry matter than the cereals. Only the early-terminated cereal (barley) fell to below 1000 kg DM/ha, with ground cover down to 35% by the time the cotton was planted with the short fallow at this site (Figure 1).

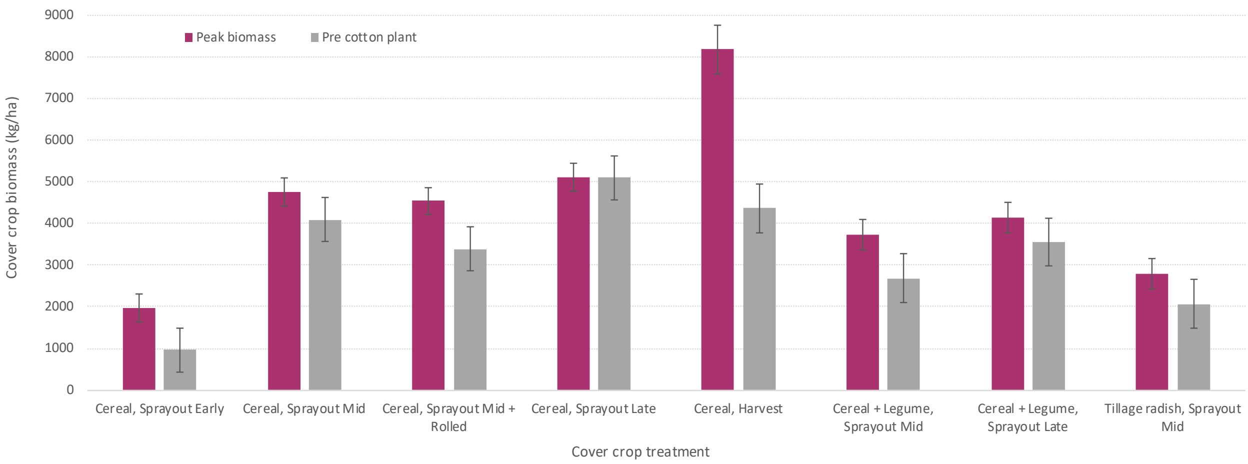

Figure 1. Above-ground biomass accumulation for each cover crop treatment (excluding old cotton stubble) showed small reductions by the end of the short fallow.

Ground cover in the tillage radish fell dramatically to ~20% ground cover, which would be of little value for infiltration in the early stages of the crop (Figure 2). Rolling had no effect on the breakdown of biomass during this short fallow.

Soil water

The 'water cost' of growing the barley cover crops, relative to the Control treatment in the early stages of the fallow was ~40 mm for the early-termination, ~70 mm for the mid-termination and ~120 mm for the late-termination treatment (Figure 3).

However by the end of the fallow, and a subsequent 170 mm of rainfall/irrigation in eight events from mid-termination to cotton plant, the mid-termination treatment caught up to the control, and the early-termination had accumulated an additional 14 mm of water. Not surprisingly, this early-termination proved to be the best cover crop treatment on the short fallow to cotton planting; it did its job and maintained over 30% ground cover until planting. However, the mid-terminated cereal maintained over 50% cover, which presumably led to it accumulating more moisture throughout the early stages of the following cotton.

The 'cover' crop that continued through to grain harvest was ~145 mm behind by the end of the fallow. Again, this treatment mirrored the wider paddock that set the pivot irrigation schedule.

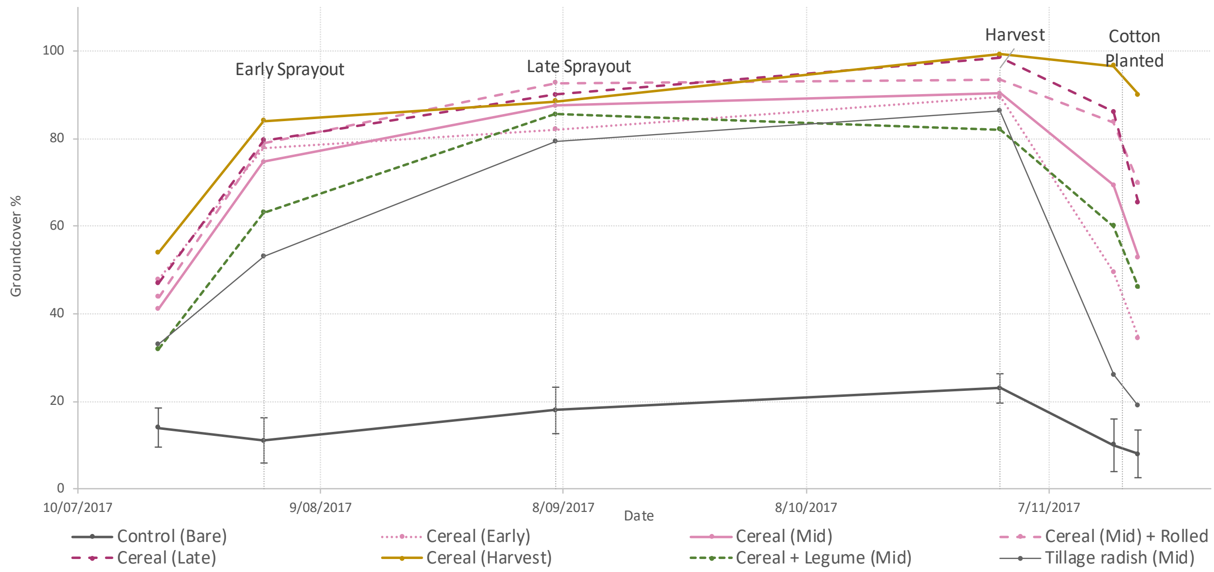

Figure 2. Ground cover assessments showed the largest decline under the tillage radish treatment.

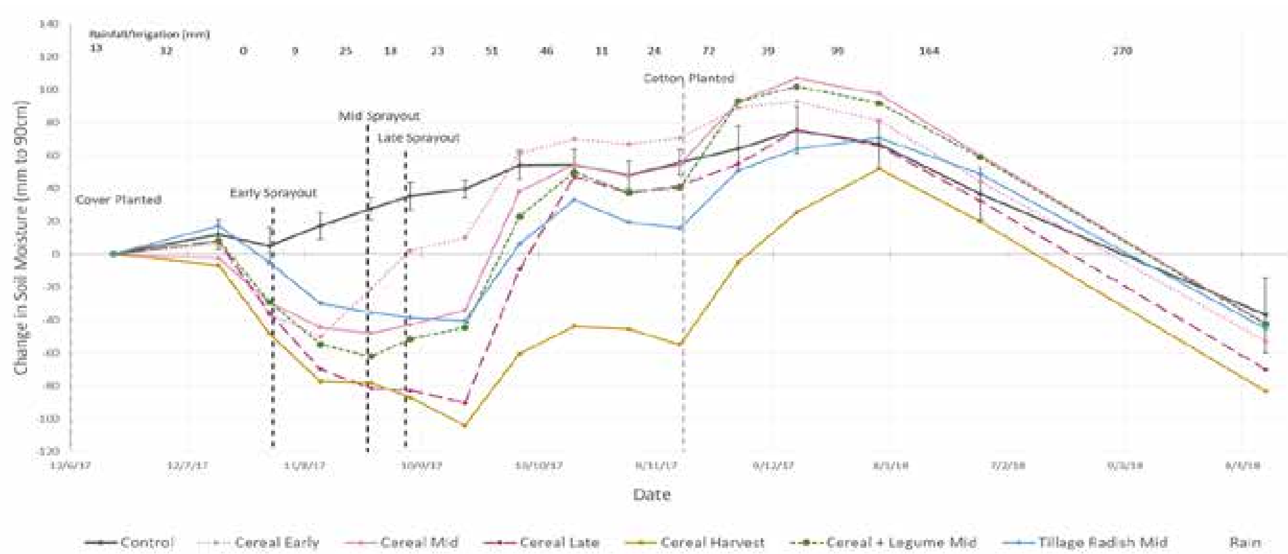

Figure 3. There were large changes in soil water (mm to 90 cm) from planting of the winter cover crop treatments and defoliation of the subsequent cotton crop at Yelarbon.

Crop performance

Matching the irrigation schedule to the harvested crop appears to have provided more than adequate water across the cover crop treatments; yields for all cover crop treatments were similar. However, the Control with limited ground cover was the poorest performer with at least 2.6 bales/ha lower yield, lower infiltration in early growth stages, and less water extracted late in the crop than treatments with cover crops.

The costs to plant the cover crops (~$50/ha) and to spray them out (~$20/ha) almost matched the savings from three less weed sprays during the fallow (~$60). Consequently, the measured cotton yield responses were very profitable, and appear to have been due to more than water alone.

For people who also grow grain, the 14 mm of extra stored water from this early-termination cover crop would typically produce ~200 kg grain (assuming 15 kg grain/mm water). This is worth ~$50/ha (at $270/t) for a net return of ~$40/ha.

Table 2. Net change in water storage over the life of the fallow (relative to the Control) and final cotton yield for each cover crop treatment at Yelarbon ranged from -111 mm to +14 mm.

Cover crop treatment	Terminated	Water gain (cf control)	Cotton yield (bales/ha)
Control (bare fallow) Starting water ~100 mm PAW		56 mm (fallow gain)	9.3
Cereal	Early	+14 mm	12.9
Cereal	Mid	-1 mm	12.7
Cereal	Late	-14 mm	11.9
Cereal	Mid + Roll	-2 mm	12.6
Cereal	Harvest	-111 mm	14.1
Cereal + legume	Mid	-16 mm	11.9
Cereal + legume	Late	-7 mm	13.9
Tillage radish	Mid	-40 mm	14.4

Implications for growers and agronomists

The project results show that cover crops can indeed help increase net water storage across fallows that have limited ground cover. How often these soil water results will occur across different seasons will be explored with further experiments and simulation modelling.

The yield results for the subsequent cotton crop (and the wheat crop at Bungunya, page 63) are dramatic. These very large responses represent big improvements in returns; far beyond what could be expected from the increases in net soil water storage across the fallows. There also appears to have been greater water extraction in some cover crop treatments in this Yelarbon experiment.

While wheat establishment was dramatically better after cover crops at Bungunya, the trial planter configuration and the alignment of plots in the paddock at Yelarbon led to the cotton rows crossing over rows of cover crop stubble, making establishment hard to assess. The grower ensures his cover crop planter bar and row alignment is configured so that the cotton is planted between the rows of stubble to ensure good establishment. How much of the final responses can be attributed to these factors, how often such results are likely, and the contributions of other factors to these gains remains to be explored.

Acknowledgements

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Trial details

Location:	Yelarbon
Crop:	Cover crops, cotton
Soil type:	Brigalow, Grey Vertosol
In-crop rainfall and irrigation:	895 mm (253 mm Cover/Fallow and 642 mm in cotton)