EverCrop: Improving establishment of perennial pastures

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Take home messages

- Cover-crops in general increase the risk of pasture establishment failure, but can provide useful additional income from the sale of grain.
- If a cover-crop is used, reduce the wheat/barley sowing rate to ¼ normal rate, and maintain full pasture sowing rates.
- Do not attempt to undersow pasture species other than lucerne.
- Avoid sowing pre-coated pasture seed.

Background

EverCrop is a national research, development and extension project investigating the role of perennial species in cropping systems. In mixed farming environments of eastern Australia, perennial species such as lucerne have long been a critical component of cropping and grazing enterprises. The focus of EverCrop in this region was to increase the productivity and performance of pastures by improving establishment. The emphasis of the initial research in the eastern region was to evaluate the practice of cover-cropping given that many farmers sow pastures under the final winter crop of their rotation. In this context cover-cropping is defined as the simultaneous planting of pasture and winter crop (usually wheat or barley) seed, with a view to harvesting grain from the crop at the end of the establishment year, and allowing the pasture species to recover before using the paddock for grazing in subsequent years.

Assessing the costs and benefits of perennials in a mixed farming enterprise is not simple due to the multiple impacts on cropping and livestock enterprises and due to the variable nature and overriding influence of costs, prices and seasonal conditions on farm decision making. The EverCrop project conducted a number of field experiments at a range of locations over contrasting seasons, and undertook a financial risk analysis to determine the impact of cover-cropping on the farm cash balance. This paper summarises key findings of the EverCrop research to date and provides recommendations to farmers of principles they can apply immediately to improve pasture performance and financial outcomes. The research remains ongoing.

Methodology

A series of field experiments were established from 2008 in a range of locations from Burrumbuttock to Condobolin to evaluate the impact of cover-crops on grain yield and pasture performance. Results from the earlier experiments have been reported in detail and are available upon request (Li *et al.* 2014; Swan *et al.* 2014). Field experiments monitored pasture growth and crop yield in the establishment year, as well as pasture productivity for 1-2 years following the harvest of grain in year 1.

Field data from all experiments were combined to model financial risk using a sequential multivariate approach (Hutchings and Nordblom 2011). This analysis uses established relationships between rainfall and crop/pasture yield to simulate probable outcomes in sequences of years that are randomised many times, based on historical rainfall records. Using weekly percentiles in commodity prices over the last decade and recent estimates of farm costs, the range of simulations are used to establish probability curves of the likely residual farm cash balance after 10 years.

Results and discussion

1. Seasonal conditions

Predictably, crop and pasture yields were highly impacted by climatic conditions of the particular year. For example, Yerong Creek received only 400 mm rainfall in 2008, and undersown lucerne-based pasture produced 0.1 t/ha under a wheat crop that yielded 1.5 t/ha. By contrast, the same site in 2010 received 830 mm of rainfall, and undersown lucerne-based pasture produced >16 t/ha of biomass under a wheat crop that yielded 2 t/ha grain. The latter grain yield might have been increased further but for the incidence of rust on the wheat in that particular year.

2. Species choice

The range of perennial pasture species which are productive and persistent in environments across the central west of NSW is limited. Previous evaluations of perennial species across southern Australia demonstrated there to be very few viable alternatives to lucerne across many mixed farming environments. A summary of results for the mixed farming zone of southern NSW is provided in Hayes *et al*. (2012) and would be relevant to most environments in the central west. In general, there are almost no viable alternative perennial legume species to lucerne, other than for in specific niches such as frequently waterlogged soils. The use of tropical grass species is highly constrained by the inability to establish them reliably on a commercial scale in southern environments where soil temperature and moisture requirements rarely align. The range of temperate perennial grasses suited to lower rainfall environments is largely limited to a very small handful of phalaris and cocksfoot varieties. Chicory, a summer growing perennial herb, is also broadly adapted although its use is limited to higher rainfall environments. The EverCrop research focussed on lucerne, phalaris, chicory and to a lesser extent, cocksfoot.

Compared to phalaris and chicory, lucerne was the pasture species shown to be most resilient under a cover-crop across sites and seasons. This most likely reflects the fact that lucerne is inherently drought tolerant, is summer active and can fix its own nitrogen. As a comparison, subterranean clover has little capacity to escape competition from the cover crop due to its annual growth habit; by the time the cereal crop has matured the subclover has senesced. Lucerne, being a summer growing species, has the capacity to recover following grain harvest in response to summer storms.

Phalaris enters a state of dormancy in summer so also has little capacity to recover and respond to summer rain in most years. Similar with chicory, phalaris cannot fix nitrogen and must compete with the crop for nitrogen as well as for water, light and other nutrients during the establishment year. The N-fixing characteristics of legumes such as lucerne reduce the severity of competition between it and cereal cover-crops. For these reasons, sowing species other than lucerne under cover crops will increase the risk of pasture establishment failure.

3. Plant size and density

In a dry year at Ariah Park, increasing the density of the cover-crop reduced the number and size of establishing perennial pasture plants even though there was no significant difference in final grain yield between the two crop sowing rates (Table 1). The probability of individual perennial plants surviving over summer decreases as plant size reduces, but can be heavily influenced by chance rainfall events in late spring or early summer.

Table 1. Impact of increasing cover-crop density on seedling size and number of lucerne, phalaris and chicory, sampled at the end of November (from Swan *et al.* 2014). Values in columns followed by the same letter are not significantly different at *P*=0.05; ns – not significant.

Pasture species	**Wheat sowing rate (kg/ha)**	**Perennial plant density (plants/m^2)**	**Perennial plant size (g/plant)**
Lucerne	0	19a	0.57a
	12	13b	0.14b
	24	5c	0.07c
Phalaris	0	5a	1.49a
	12	1b	0.32b
	24	0b	0.11b
Chicory	0	9a	0.52a
	12	5ab	0.20b
	24	2b	0.03c

4. Weed invasion

Table 2. Difference in cumulative biomass production of perennial species (t/ha) in the year following sowing between swards sown with or without a cover-crop, and the reduction (%) in perennial species biomass in year 2 due to the presence of a cover-crop at sowing.

Site/establishment year	**Species**	**Nil cover-crop (t/ha)**	**Cover-crop (t/ha)**	**% Reduction**
Yerong Creek 2008	Lucerne	4.5	1.5	67
	Phalaris	2.0	0.6	70
	Chicory	1.2	0.1	92
Yerong Creek 2009	Lucerne	20.9	14.4	31
	Phalaris	8.3	2.6	69
	Chicory	13.8	7.0	49
Yerong Creek 2010	Lucerne	9.2	2.7	71
	Phalaris	4.8	2.6	46

	Chicory	12.3	7.7	37
Ariah Park 2009	Lucerne	7.5	4.3	43
	Phalaris	5.4	0.7	87
Ariah Park 2010	Lucerne	2.9	2.9	0

There was often no significant difference in total pasture biomass in year 2 in swards established either with or without a cover-crop the previous year. This was largely due to weed species opportunistically filling gaps in the less dense perennial swards established under a cover-crop. However, the contribution of the perennial species to total biomass was almost always reduced by the presence of a cover-crop, and lucerne almost always performed significantly better than either phalaris or chicory. Averaged across all species and sites, establishment of pastures under a cover-crop reduced the biomass of sown perennial species in year 2 by 55% compared to swards established without a cover-crop (Table 2). Total legume biomass was also reduced by the presence of a cover-crop at most sites. Averaged across 9 experiments, total legume biomass was reduced 6-fold in year 1 and by 22% in year 2 due to the presence of a cover-crop in the establishment year (Li *et al.* 2014; Swan *et al.* 2014).

5. Sowing rate

Doubling the lucerne sowing rate increased initial lucerne density in year 1 and basal frequency following the first summer, leading to an increased proportion of lucerne in the pasture sward and decreased weed biomass (Swan *et al.* 2014), but had no effect on crop density or yield (Table 3). Halving the cover-crop sowing rate from the standard farmer rate of 20 kg/ha had no effect on lucerne performance nor on initial wheat density or final wheat yield. This result was observed at Ariah Park in 2010 where annual rainfall was 733 mm, well above the long term average of 501 mm for that location (Swan *et al.* 2014).

Table 3. Initial seedling density (plants/m^2), wheat grain yield (t/ha) and lucerne basal frequency in year 2 (%) following sowing in 2010 at Ariah Park (from Swan *et al.* 2014). Values in columns followed by the same letter are not significantly different at P=0.05; ns – not significant.

Wheat sowing rate (kg/ha)	Lucerne* sowing rate (kg/ha)	Wheat density (plants/m^2)	Initial lucerne density (plants/m^2)	Wheat grain yield year 1 (t/ha)	Lucerne year 2 basal frequency (%)
0	2	0a	27a	-	20.8a
0	4	0a	48b		33.5b
10	2	27b	26a	3.05ns	19.7a
10	4	27b	44b		32.1b
20	2	48c	26a	3.40ns	22.2a
20	4	46c	39b		31.0b

* Sowing rate refers to pre-coated lucerne seed

The 20 kg/ha wheat sowing rate described in Table 3 was the rate used by the farmer at Ariah Park and was approximately half his normal wheat sowing rate. Halving the cereal sowing rate is currently a common practice for farmers establishing pastures under a cover crop. However, by reducing the cereal rate further to approximately one quarter of the normal sowing rate, we found little reduction in crop yield and little difference on lucerne establishment in this wetter than average year. However, in a drier year such as in 2009 at Ariah Park (398 mm), reducing the crop sowing rate to approximately ¼ the normal rate increased lucerne DM production by up to 73%, again with little difference in grain yield (Swan *et al.* 2014). Reducing crop sowing rates to one quarter of normal sowing rates would seem to be a sound strategy for mitigating the risk of pasture establishment failure under a cover-crop.

6. Pre-coated pasture seed

Commercial pasture seed similar to that used in many of our experiments is increasingly sold pre-coated. There are several risks associated with sowing pre-coated pasture seed:

i. Farmers are commonly unaware of how much seed coat they are purchasing with their seed making it very difficult to determine actual pasture sowing rates, or adjust sowing rates accurately to account for the seed coating.

ii. The survival of N-fixing bacteria on pre-coated seed is variable and often poor (Hartley *et al.* 2012), reducing the N-fixation potential of legumes.

iii. The very short shelf-life of seed coats limits the capacity to sow unused pasture seed at a later date, potentially adding to wastage costs.

iv. Independent surveys show a significant percentage of coated legume seed that is within the advised shelf-life still fails to meet quality standards for inoculant

v. A lack of information about the other components of seed coats, such as insecticides and fungicides, makes it difficult for a grower to assess whether the seed coat offers additional advantages in a particular situation and whether other approaches, such as ground application of insecticides post-sowing, would be a more cost-effective approach to improving pasture seedling growth.

It is very likely that in many situations, coating on pasture seed serves to reduce the effective sowing rate of pastures. The 2 kg/ha lucerne sowing rate in Table 3 was chosen by the farmer and is a common sowing rate used in that region for several decades. However, to get the equivalent of 2 kg/ha of seed into the ground using pre-coated seed, a farmer may need to double or triple sowing rates. Table 3 shows the benefit to lucerne performance of doubling the sowing rate of coated lucerne seed. This serves to increase the unit cost of pasture seed which is yet to be demonstrated to represent a sound value-proposition in most broadacre situations. There may be instances where a coating on seed is justified, for example, to improve the flow of tropical grass seed through a seeder or where local data exists quantifying the production gains due to seed coats. Otherwise, in general we recommend that farmers avoid the use of pre-coated seed due to the significant risks associated with it. Where possible, the traditional approach of sourcing bare legume seed and freshly inoculating prior to sowing should be used. If coated seed is used, farmers should ensure that every seed lot they purchase complies with the industry code of practice and is labelled to specify the content of seed coat on coated seed. Further information is available on the Australian Seed Federation website: http://www.asf.asn.au/

7. Whole farm economic analysis

A whole farm economic analysis was conducted using results from the series of experiments conducted in the EverCrop project. Despite the increased density of sown species in swards sown without a cover-crop, the economic analysis was unable to find any difference in the probable farm cash balance at the end of a decade between pasture establishment with or without a cover-crop (Fig 1). This result suggests that a farmer may be financially justified either way, whether pastures are established with or without a cover crop. This is likely due to the relatively small differences in total pasture biomass between establishment methods, as well as the over-riding influence of factors such as seasonal conditions, farm costs, commodity prices and farm debt:equity ratios which dwarf agronomy practices such as cover-cropping in the finances of a mixed farming operation.

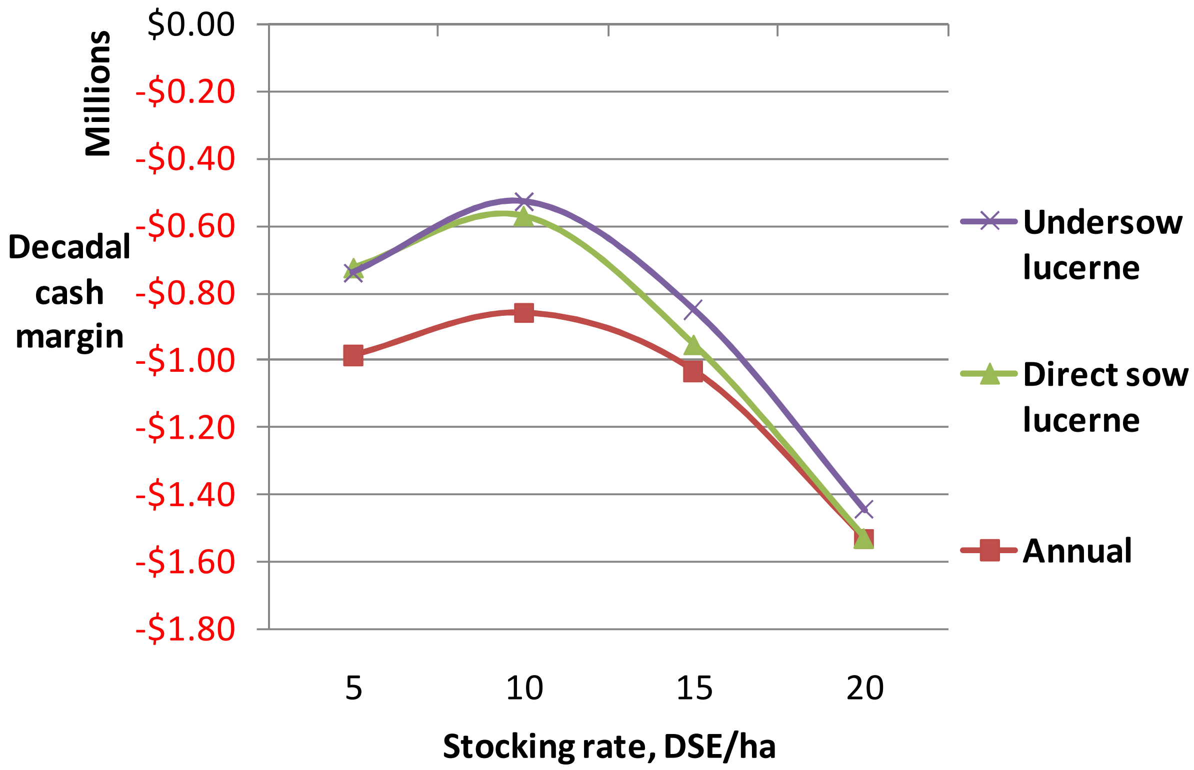

Figure 1. Predicted decadal cash margin ($) of a modelled mixed farming enterprise in the Coolamon region, NSW, at 4 different stocking rates (DSE/ha) where lucerne is sown either with (undersow) or without (direct sow) a cover crop, compared to an annual pasture control.

8. Decision support tool

To assist growers to make decisions of whether to sow a pasture with or without a cover crop in a particular paddock or year, the EverCrop project developed a simple tool designed to provoke farmers to think more deeply about their approach to pasture establishment. The tool is freely available at http://www.grazplan.csiro.au/CoverCrop/CoverCrop.html. A farmer may choose to establish pastures under a cover-crop on better soil types more favourable for pasture growth, or in years where grain prices are higher, or in an enterprise where livestock are a relatively minor component. Conversely, a farmer may elect to establish pastures without a cover-crop on poorer soil types, or where subsoil moisture is low, or where species other than lucerne are to be sown. Factors such as increased suppression of weed populations in pastures established without cover crops may not be fully costed by existing models, and may require additional consideration in certain circumstances, such as where populations of weeds resistant to selective herbicides exist.

Conclusion

Establishing pastures under a cover-crop increases the risk of pasture establishment failure in poor seasons. However, income earned by the sale of grain from a cover-crop can be an important addition to a mixed farming enterprise. Individual farmers need to consider the potential risks and rewards in the context of their own farming business, and their decision of whether to establish pastures under a cover-crop may change from paddock to paddock or year to year as circumstances change.

In the event that a farmer decides to establish a pasture under a cover-crop, the following steps can be taken to reduce the risk of pasture establishment failure. Firstly, reduce the cereal crop sowing rate to ¼ of normal sowing rates. For example, if wheat would normally be sown at 40 kg/ha in a given environment, we suggest reducing it to 10 kg/ha where it is used as a cover crop. Trial results showed that a reduced crop sowing rate had little impact on crop performance but a potentially large benefit to pasture performance, particularly in dry years. Farmers should be mindful to ensure that they achieve adequate weed control prior to sowing their pasture and cover-crop as a reduced crop sowing rate may provide reduced competition with weeds. Secondly, only consider a cover-crop when sowing a pure lucerne stand. Other pasture species such as phalaris are less resilient under a cover-crop and their inclusion increases the risk of pasture establishment failure. Thirdly, do not reduce pasture sowing rates. A convenient way to achieve this without increasing pasture seed costs is to avoid sowing pasture seed that is pre-coated. There are typically far more seeds in a kilogram of bare seed than in a kilogram of pre-coated seed, and providing the bare seed is inoculated prior to sowing, recent results have shown rhizobia numbers to be higher on fresh-inoculated bare seed compared to pre-coated legume seed.

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Further reading

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