How a new decision support tool helps farmers in mixed farming make pasture sowing decisions about cover cropping

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Abstract: *Four farmer participatory field experiments were conducted to determine the effect of cover cropping on pasture establishment and subsequent pasture production in 2009 and 2010 at Ariah Park and Brocklesby, New South Wales. In a drier year, cover cropping reduced plant density even when the cover crop was reduced to 10 kg/ha, but dry matter production by lucerne was not reduced in the following year compared with phalaris which had reduced production. In a wetter year, plant density was maintained, but dry matter production was reduced in the following year due to cover cropping. A decision support tool was used to determine which pasture establishment method was the most profitable for each experiment. In drier years, pasture should be established directly due to low grain yield. In a wetter year, under-sown pasture was satisfactory and profitable due to high grain yields from cover cropping, leading to high income which livestock production during the pasture phase could not compensate.*

Key words: undersown, gross margin, mixed farming system

Introduction

Pasture establishment in the cropping zone has commonly occurred by sowing the pasture species under a cover crop. Research and extension information on cover-cropping is available from the last 80 years with many recommending that cover cropping should not be used to establish pastures due to a higher rate of failure and less productive pastures (Moodie 1936; Smith and Argyle 1964; Peart and Scott 1969; Cregan 1985; Dear 1986). Considering this, recent survey results have revealed that within the uniform rainfall cropping zone of southern New South Wales (NSW) that 83% of farmers regularly establish pasture under a cover crop (Li *et al.* 2010). Generally farmers use cover cropping because the grain yield covers the cost of sowing the pasture. Most research has focused on pasture density and biomass production of the different establishment methods, but has not sought to demonstrate the increased livestock productivity needed to offset any income from grain production. This decision support tool (DST) seeks to bring the costs and incomes for the pasture phase to help producers to make decision on pasture establishment.

Methods

Field experiments

Four farmer participatory field experiments were conducted at Ariah Park and Brocklesby in 2009 and 2010. Further details on sites and measurements for 2009 experiments were reported by Peoples *et al.* (2010). Experimental methods and sites were similar for 2010. All experiments were sown by the co-operating farmer in a paddock that was to be sown to pasture. Treatments were imposed as a strip of the farmer's seeder with cover crop rate changed. Across sites and seasons treatments included different cover crops (wheat or barley), cover crop rates (0, 10 and 20 kg/ha) and pasture species (lucerne, phalaris, sub clover and snail medic) (Table 1). Sites were assessed in the establishment year and the following year to determine plant density and pasture production. Results in this paper focus primarily on the perennial component in the pasture mix. Rainfall at Ariah Park and Brocklesby was below

Table 1. Experiment treatment details for Ariah Park and Brocklesby sites in 2009 and 2010.

Site	Year	Cover crop	Cover crop rates (kg/ha)	Pasture species and rates	Rainfall (mm)
Ariah Park	2009	Wheat	0, 10 and 20 kg/ha	Lucerne (2 kg/ha), Phalaris (0.45 kg/ha), Sub clover (1 kg/ha) and Snail medic (1 kg/ha)	404
Ariah Park	2010	Wheat	0, 10 and 20 kg/ha	Pasture mix 1: Lucerne (2 kg/ha), Phalaris (0.5 kg/ha) and Chicory (0.5 kg/ha). Pasture mix 2: Lucerne (4 kg/ha), Phalaris (1 kg/ha) and Chicory (1 kg/ha)	685
Brocklesby	2009	Barley	0 and 60 kg/ha	Lucerne (4 kg/ha) and Sub clover (4 kg/ha)	409
Brocklesby	2010	Barley	0, 22.5 and 45 kg/ha	Lucerne (4 kg/ha), Sub clover (2 kg/ha), Arrowleaf clover (2 kg/ha) and Chicory (0.5 kg/ha)	855

the long-term average in 2009 and above average in 2010.

Using the decision support tool

The results obtained from the field experiment were analysed with the DST to determine if cover cropping was the optimal method for pasture establishment. The DST was created in an MS Excel file with a user-friendly display where users can input their own data and choose sensitivity graphs as desired. Inputs in the DST included expected grain yield, grain price, stocking rate and stock earnings, establishment costs, the length of the pasture phase and relative effect that cover cropping has on pasture production.

The underlying calculation for the DST is the net income from cover cropped (CC) pasture establishment method minus the net income from straight sowing (SS) the pasture for the length of the pasture phase.

(Grain income + CC stock income – CC variable cost) – (SS stock income – SS variable cost)

where,

Grain income = grain yield × grain price

CC stock income = stocking rate × $/(dry sheep equivalent (DSE) × (pasture years – 1) × CC relative effect

SS stock income = stocking rate × $/DSE × (pasture years – 1)

CC variable cost = cost of establishing grain crop and pasture under a cover crop

SS variable cost = cost of establishing straight sown pasture

The value for $/DSE was determined from NSW DPI farm budgets and is the net income from livestock including costs for stock and pasture management. The years are for the length of the intended pasture phase minus the establishment year, where grazing is limited. The DST does not calculate pasture production *per se,* but rather calculates the differences of stocking rates which presumably is related to pasture production.

The DST provides a single number to estimate which method of pasture establishment is more profitable. If the returned value is positive then greater profitability is obtained from cover cropping. In comparison, if the value is negative, directly sowing the pasture would be more profitable. A series of sensitivity analysis were built in DST to provide paired comparison between factors that the user is interested in.

Rules of thumb for cover-cropping

A simulation study using the DST was conducted to determine whether any ‘rules of thumb’ could be established. The parameters used in the DST are presented in Table 2. Sensitivity analysis was conducted for a range of parameters, including grain yield, length of pasture phase, CC relative value and stock income.

Results

Cover cropping at Ariah Park in 2009 reduced the plant density of pasture regardless of cover crop rate in May, 2010. This difference in plant density did not reduce annual dry matter production of the lucerne established under the 10 kg/ha cover crop rate. At the 20 kg/ha cover crop rate the annual dry matter production of lucerne was reduced. Lucerne and phalaris behaved differently under cover cropping, with dry matter production of the phalaris reduced under any cover crop rate. In the third autumn (March 2011), it was noted that weeds comprised 9% of the direct sown pasture sward, with the 10 and 20 kg/ha cover cropping rates increasing the weed component to 29 and 59%, respectively for the Ariah Park 2009 experiment. In the wetter establishment year of 2010 at Ariah Park, cover cropping did not reduce lucerne density, whereas phalaris density was reduced (Table 3). Increasing pasture seed rate generally led to higher plant densities of both lucerne and chicory in the following year. At Brocklesby in 2009, no difference in plant density was found when the pasture was established by cover-cropping, although cover cropping reduced biomass production in the following wet year (2010) (Table 3). In 2010, at Brockelsby, cover cropping did not reduce plant density of lucerne or chicory, but in the following year dry matter for the lucerne was reduced at both cover cropping rates (Table 3).

Data derived from the field experiments were analysed using the DST to determine the most profitable method of establishing pasture (Table 4). Low grain yields at Ariah Park in 2009 resulted in direct sown pastures achieving a greater total gross margin over the four year pasture phase. The proportional difference of the sown perennial pasture species between the direct sown pasture and the cover crop pasture at the lowest cover crop rate was 0.69. At the higher cover crop rate this was reduced to 0.26. The three other experiments demonstrated that the high grain yields from the cover crop resulted in cover cropping achieving higher total gross margins.

The DST enabled the user to look at the sensitivity of each of the parameters and develop some 'rules of thumb' in regards to cover cropping. Using the basic parameters from the simulation study, cover-cropping was more profitable when grain yields exceeded 2.5 t/ha (Figure 1a). If the pasture phase was longer than four years, directly sowing the pasture would be more profitable (Figure 1b). Cover cropping was more profitable when the CC relative value was greater than 0.6 (Figure 1c). Direct sowing pasture was more profitable when stock incomes exceeded $25/DSE (Figure 1d).

Discussion

The plant density established under a cover cropping scenario was dependent on seasonal conditions. Drier environments will result in reduced plant number surviving until the following season. Under wetter conditions plant numbers can be similar between cover-cropping and direct sowing pasture establishment methods. Surprisingly, the effect of cover-cropping can still be seen in environments where there was high dry matter production potential despite plant density being similar, as seen at Brocklesby. Alternatively, different plant densities in drier environments can lead

Table 2. Input data for the DST for the Ariah Park and Brocklesby experiments and 'rules of thumb' for cover cropping.

Input	Ariah Park	Brocklesby	'rules of thumb'
Grain price ($/t)	150	150	150
Grain yield (t/ha)			2.5
Stocking rate (DSE/ha)	7.5	12	10
$/DSE	25	25	25
Pasture establishment cost ($/ha)			
Cover-cropping (CC)	200	200	200
Straight sowing (SS)	120	120	120
Years for pasture phase	4	4	4
Cover-cropping relative effect (0–1)	Reduced pasture production due to covercropping		0.6

Table 3. Plant density (plants/m²) and total dry matter (DM, kg/ha) for the year following pasture establishment.

Ariah Park 2009		**Cover crop rate**		**Significance**
	0 kg/ha	**10kg/ha**	**20kg/ha**	
Plants/m² (May 2010)				
Lucerne	15a	11a	3b	
Phalaris	5a	1b	0b	
Dry matter kg/ha in 2010				
Lucerne	4090a	4120a	1760b	$P < 0.05$
Phalaris	4460a	1770b	500c	$P < 0.05$
Ariah Park 2010		Cover crop rate		
	0 kg/ha	10kg/ha	20kg/ha	
Plants/m² (March 2011)				
Lucerne 2 kg/ha	20a	18a	20a	$P < 0.05$
Lucerne 4 kg/ha	33b	31b	31b	
Phalaris 0.5 kg/ha	19b	20b	7d	$P < 0.05$
Phalaris 1 kg/ha	32a	20b	15c	
Dry matter (kg/ha) in 2011				
Lucerne	2907	2943	2909	ns
Phalaris	2137a	1082b	812b	$P < 0.05$
Total DM	5734	5129	4896	ns
Brocklesby 2009		Cover crop rate		
	0 kg/ha	60 kg/ha		
Plants/m²				
Lucerne	27	21		ns
Dry matter (kg/ha) in 2010				
Lucerne	20195a	15066b		$P < 0.05$
Total DM	23529a	18034b		$P < 0.05$
Brocklesby 2010		Cover crop rate		
	0 kg/ha	22.5 kg/ha	45 kg/ha	
Plants/m² (Dec 2010)				
Lucerne	34	31	32	ns
Chicory	7	9	7	ns
Dry matter (kg/ha) in 2011				
Lucerne	4647a	2252b	3053a,b	$P < 0.05$
Chicory	3965a	4256a	3354b	$P < 0.05$
Total DM	10266a	9250b	8885b	$P < 0.05$

Table 4. Decision support tool (DST) analysis of the field experiments at Ariah Park and Brocklesby in 2009 and 2010.

Site	**Year**	**Grain yield (t/ha)**	**CC relative effect**	**Total gross margin**
Ariah Park	2009	0.8	0.69	-$134
	2010	3.3	0.80	$303
Brocklesby	2009	4.0	0.77	$313
	2010	3.8	0.90	$400

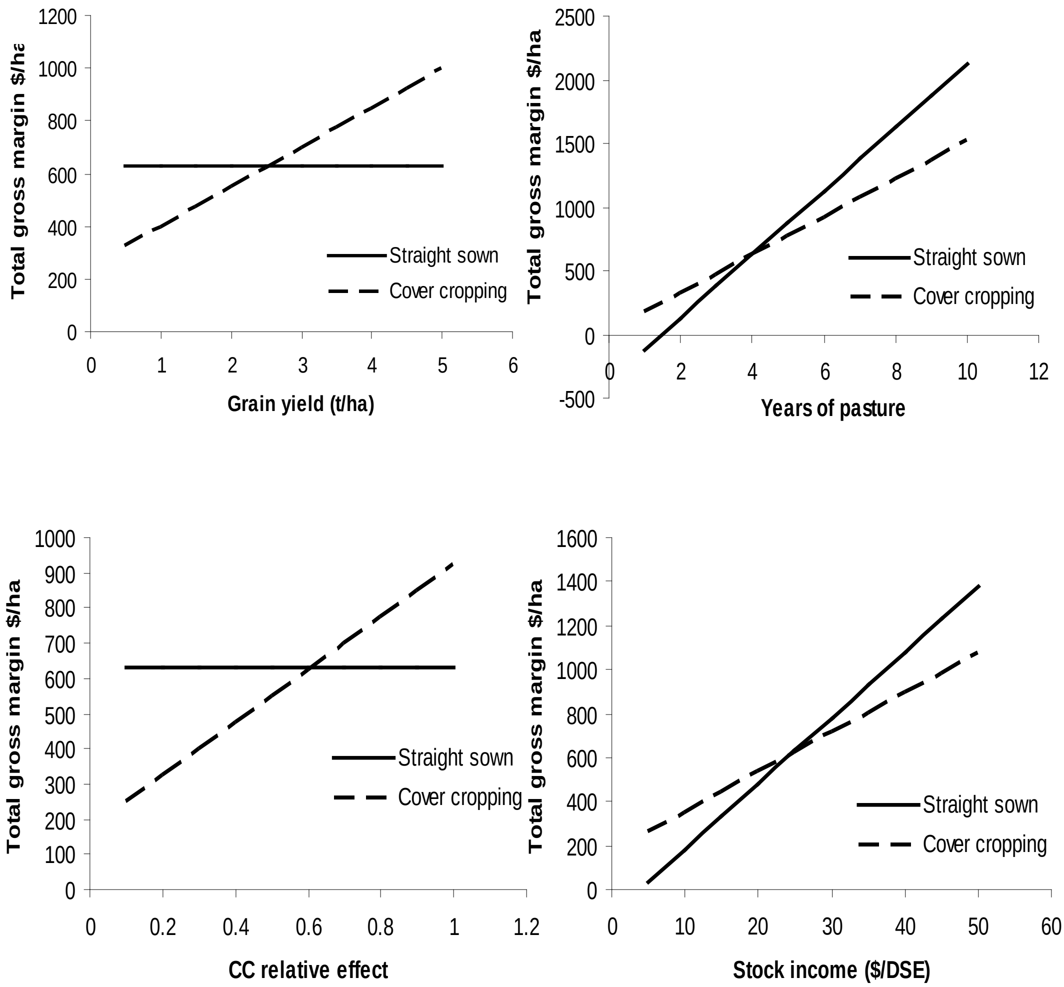

Figure 1. Sensitivity graphs for the DST simulation study for the effect on (a) grain yield, (b) length of pasture phase, (c) cover-cropping relative effect and (d) stock income.

to similar dry matter production. Plants species also differ in their ability to establish under cover-cropping with lucerne more robust than phalaris.

The primary purpose of pastures on farms is to increase long term profitability of the farming system. Although the field experiments demonstrated a loss of pasture production in more favorable seasonal conditions, the DST indicated that it was difficult for animal production systems to utilise the extra pasture to cover the cost of not producing grain in the establishment year.

One of the difficulties of the current version of the DST is that it does not predict pasture production for a certain set of parameters as it is not a biological model. This is particularly important for determining the CC relative value. Farmers will tend to believe that cover cropping does not reduce pasture growth, while agronomists believe reductions in pasture production are large. This data tends to indicate that commonly the relative difference between pasture establishment methods is 0.6–0.8. Only at Ariah Park in 2009 at the 20 kg/ha cover rate was this value reduced markedly. This can have a large influence on the DST (Figure 1c). Another difficulty regarding the model is in relation to pasture establishment failure. The model does not determine whether there has been a pasture failure. Currently there is no published data to define pasture failure quantitatively.

The DST is currently being showcased to producers to determine their interest in the model and whether it corresponds to what they observe. It will be important to simplify some inputs such as $/DSE as these are difficult for the individual farmer to quantify. Incorporating climate data into the model will enable specific sites to determine over a large number of seasonal years whether cover cropping is more profitable or not.

Conclusions

The establishment of pastures by cover cropping resulted in reduced plant density in drier seasons. Pasture production in the following year depended on species. Lucerne could compensate at lower rainfall levels, but phalaris could not. Under higher rainfall conditions, lucerne established under cover cropping had reduced dry matter production. Utilising the DST demonstrated that cover crop yields above 2.5 t/ha led to higher profitability from the cover crop. Higher stock income and longer pasture phases resulted in directly established pasture being more profitable.

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