On-farm participatory research investigating the use of covercropping for the establishment of perennial pastures in mixed farming enterprises

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Abstract

Workshops and surveys conducted with farmers and agribusiness in the mixed farming zone of southern New South Wales (NSW) identified concerns about the cost of establishment and poor survival of perennials, and uncertainties about their impact on farm profit and risk as constraints to the wider integration of perennial pastures into cropping systems. Subsequent consultation with farmers and consultants led to the development of several on-farm participatory trials in 2008-09. One such series of studies investigated issues surrounding pasture establishment. Cover-cropping (sowing pasture species under a grain crop) is the dominant method of pasture establishment but although this technique has been used for many years, farmers are now reporting a higher frequency of failure. This paper reports the findings from 4 trials undertaken in direct collaboration with farmers using farming machinery at Brocklesby and Ariah Park in southern NSW which aimed to compare the influence of sowing rate and the presence and absence of a cereal cover-crop on the establishment and persistence of the perennials lucerne, phalaris, cocksfoot, and chicory sown in different mixes and rates. There was little or no effect of the presence of a cover-crop on initial establishment of any of the perennials, but both growth and survival of some species during the drier than average spring and over the 2009 summer were severely impacted by cover-crop sowing rates as low as 10 kg barley/ha and 12 kg wheat/ha. The results are compared to outcomes of cover-cropping studies undertaken in the same region between 1996 and 2000.

Introduction

A recent survey of 95 farmers undertaken in the mixed pasture-cropping zone of southern NSW indicated that farmers recognise the benefits of including perennial pasture species in the rotation. Lucerne (*Medicago sativa*) and chicory (*Cichorium intybus*), or grasses such as phalaris (*Phalaris aquatica*) or cocksfoot (*Dactylis glomerata*) are included in pastures for livestock production and natural resource management, and, in the case of lucerne, the improvement in the nitrogen fertility of the soil for following crops via biological nitrogen fixation (Dear *et al.* 2010). However, farmers also reported experiencing difficulties in the establishment and survival of perennials (Dear *et al.* 2010). Consultative workshops held with groups of farmers and leading local agribusiness consultants in 2009 identified a need to resolve issues associated with the reliability of pasture establishment as being a key priority to improve farmer confidence in adopting perennial pastures. A strong trend has become evident across the target zone of NSW where annual average rainfall has declined by 15-30 mm per decade over the past 50 years (BOM 2010) and pasture establishment has become even more challenging under the drier seasonal conditions.

Cover-cropping, whereby seed of a mixture of pasture species is undersown with the final grain crop in a cropping phase, has been a popular method of establishing new pastures in southern NSW for several decades (Koetz and Norton 1998). Indeed, over 80% of farmers surveyed in the region in 2009 indicated that they used cover-cropping at some time. Interestingly, cover-cropping appears to be the dominant establishment technique in the drier, western zone where 69% of farmers report that they either mostly, or almost always used cover-cropping to sow perennial pastures (Dear *et al.* 2010). Farmers use cover-crops so that they can offset the costs of pasture establishment against the income gained from the proceeds of the grain harvest. Some farmers also believe that an additional benefit of cover-cropping is that the crop stubble helps protect both the soil and pasture seedlings during early pasture establishment. The on-farm studies described here aimed to quantify the impact of cover-cropping on the establishment, survival and persistence of several different perennial pasture species over a 12 month period following sowing.

Materials and Methods

Description of the region

An on-farm trial was undertaken on each of three farms at Ariah Park in the northern part of the mixed farming zone of southern NSW on Red Kandosols (red earths) and on one farm at Brocklesby to the south on a Red Chromosols (red brown earths). Annual rainfall varies from a uniform distribution pattern at Ariah Park to slightly winter-dominant at Brocklesby. Rainfall over the past decade has been considerably below the long-term average and much of the region has been drought declared. Total rainfall at the 3 trial sites at Ariah Park in 2009 ranged from 398-418 mm compared to the long-term average (1970-2009) of 488 mm, and was 466 mm in 2009 at Brocklesby, compared to a long-term average (1975-2009) of 540 mm. The patterns of rainfall experienced over the duration of the experiment are presented in Table 1.

Table 1 Seasonal patterns of rainfall at trial locations in southern NSW

Trial location	Seasonal rainfall (mm)			
	Winter 2009	Spring 2009	Summer 2009	Autumn 2010
Brocklesby	203.9	141.1	105.9	194.8
Ariah Park	127.4	78.0	151.2	182.2

Treatments

All trial sites represented paddocks that farmers had already decided to return to pasture in 2009. The farmers were selected from the groups that participated in the workshops and survey referred to earlier. Experimental treatments were developed in consultation with collaborating farmers and represented variations to the individual farmer’s standard cover-cropping practices. All pastures were sown in late May 2009. Each of the three replicates for each treatment was imposed as a strip the width of the farmer’s seeding equipment (11-14 m) for the length of the paddock (200-750 m). Treatments at Brocklesby represented a simple comparison of sowing a pasture with or without a cover-crop, while at the trial sites on three different farms near Ariah Park (‘Cypress Vale’, ‘Allambie’ and ‘Shannonvale’) an additional treatment equivalent to half the farmer’s standard cover-crop sowing rate was included (Table 2). All pastures included perennials mixed with annual species such as subterranean clover (*Trifolium subterreaneum*) and snail medic (*Medicago scutellata*), but only details and data for the perennial species listed in Table 2 are presented. Two different mixes of perennial species were evaluated at two of the trial sites at Ariah Park (Table 2).

Table 2 Experimental treatments imposed as part of on-farm participatory trials in southern NSW in 2009

Trial location	Perennial pasture species and sowing rate	Cover crop and sowing rate
Brocklesby	Lucerne (4 kg/ha)	Barley@ 0 or 60 kg/ha
Ariah Park		
‘Cypress Vale’	Lucerne (4 kg/ha)+Cocksfoot (1.5 kg/ha)	Barley@ 0, 10 or 20 kg/ha
	Lucerne (3.5 kg/ha)+Chicory (1 kg/ha)	Barley@ 0, 10 or 20 kg/ha
‘Allambie’	Lucerne (2 kg/ha)+Phalaris (0.45 kg/ha)	Wheat@ 0, 12 or 24 kg/ha
	Lucerne (2 kg/ha)+Phalaris (0.45 kg/ha)+Chicory (3kg/ha)	Wheat@ 0, 12 or 24 kg/ha
‘Shannonvale’	Lucerne (2 kg/ha)+Chicory (0.25 kg/ha)	Wheat@ 0, 15 or 30 kg/ha

The trial results from 2009/10 were compared to data collated from similar cover-cropping trials undertaken at Ardlethan and Barellan in southern NSW more than a decade ago (Norton and Koetz 1998; Norton, unpublished), which compared lucerne survival and productivity where it had either been sown without a cover-crop, or at half (10-20 kg/ha) or full cover-cropping rates (20-39 kg/ha).

Measurements

A ‘fixed-quad’ location was randomly selected within each treatment replicate, marked with two permanent pegs. A 1 m^2 quadrat with 10 x 10 cm grids was placed over the top of these permanent pegs to quantify changes in densities of the various perennial species over time at exactly the same location in each treatment. Observations from the fixed-quadrats were complemented with additional assessments of pasture botanical composition collected over larger areas within each treatment using the visual rating system ‘Botanal’. However, these Botanal data are not presented here because of space restrictions. The fixed-quadrats were first used in late July 2009 to ascertain the number of each perennial species that had successfully established after sowing. Thereafter, plant population counts were determined from the fixed quadrats at the end of the 2009 summer and autumn in 2010. Pasture dry matter (DM) production measurements were determined at the end of spring with 2 ? 0.4m^2 quadrants collected from each treatment replicate in the immediate vicinity of the fixed-quadrats, and above-ground biomass was separated on the basis of plant species. This was done to avoid influencing the survival of the sown species within the fixed-quadrat areas through the physical process of hand harvesting biomass at ground level. Plant counts at the end of spring were also undertaken in the areas harvested for DM so that species biomass could be calculated on a per plant basis. Final DM production data for individual species at the end of autumn 2010 were collected from the fixed-quadrat locations. Data were analysed by ANOVA using the Genstat statistical program.

Results

2009 trials - Grain yield of the cereal cover-crops were around 1 t/ha at Ariah Park (no significant difference between half and full sowing rate) and 4 t/ha at Brocklesby (only one cover-cropping rate used, Table 2), reflecting lower rainfall at Ariah Park over winter and spring (205.4 mm) than Brocklesby (345 mm; Table 1). Perennial plant populations established during the winter of 2009 were not significantly affected (*P*<0.05) by the presence or absence of cover-crops and were deemed to be acceptable for each species at all locations (Table 3). By the end of spring the shoot biomass of individual lucerne, cocksfoot, phalaris and chicory plants under the farmers' standard cover-cropping technique represented only 8-16% of the DM where pastures had been sown alone (calculated from data presented in Table 3). Plant populations of cocksfoot, phalaris and chicory declined at the all three sites at Ariah Park over the 2009 summer so that by the end of autumn 2010 cover-cropped pastures contained <50% of the plants of these species that had originally established 12 months before. Even at Brocklesby where rainfall was more favourable (Table 1), only 65% of the lucerne plants had survived where lucerne had been cover-cropped (Table 3). Measurements collected at both the end of summer and the following autumn indicated significantly lower (P<0.05) plant populations and/or herbage production wherever pastures had been sown under a cover-crop (Table 3).

Table 3 Trends in plant population (plants/m^2) and dry matter (kg/ha) accumulated by individual perennial pasture species over a 12 month period after being sown under various cover-cropping treatments in May 2009

Location	Cover crop	Plant density (plants/m^2)				Pasture DM (kg/ha)		
and species	sowing rate	Winter[a]	Spring[b]	Summer	Autumn	Spring[b]	Summer	Autumn
Brocklesby								
Lucerne	Nil crop	27	nd[c]	nd	27	3016	2043	519
	60 kg/ha	29	nd	nd	19	nd	750	203
Ariah Park - Cypress Vale								
Lucerne [d]	Nil crop	43	61	28	25	456	nd	nd
	10 kg/ha	41	35	6	5	42	nd	nd
	20 kg/ha	42	24	4	3	23	nd	nd
Cocksfoot	Nil crop	54	51	2.3	0	452	nd	nd
	10 kg/ha	35	55	0.1	0	119	nd	nd
	20 kg/ha	46	49	0	0	70	nd	nd
Chicory	Nil crop	7	7	0	0	80	nd	nd
	10 kg/ha	6	0	0.3	0	0	nd	nd
	20 kg/ha	7	0	0.3	0	0	nd	nd
Ariah Park - Allambie								

Lucerne [d]	Nil crop	20	25	19	15	146	nd	500
	12 kg/ha	22	13	13	11	19	nd	310
	24 kg/ha	26	7	5	3	4	nd	140
Phalaris [d]	Nil crop	13	14	5	5	204	nd	410
	12 kg/ha	13	11	1	1	38	nd	80
	24 kg/ha	11	7	0	0	8	nd	30
Chicory	Nil crop	50	48	9	11	239	nd	395
	12 kg/ha	75	18	5	4	33	nd	230
	24 kg/ha	59	6	2	2	4	nd	150
Ariah Park - Shannonvale								
Lucerne	Nil crop	23	nd	nd	22	339	708	nd
	15 kg/ha	17	nd	nd	15	nd	275	nd
	30 kg/ha	15	nd	nd	16	nd	271	nd
Chicory	Nil crop	6	nd	nd	1	54	18	nd
	15 kg/ha	4	nd	nd	2	nd	54	nd
	30 kg/ha	4	nd	nd	1	nd	34	nd

[a] Indicates the number of perennial plants that successfully established after sowing. [b] Data derived from random quadrats rather than the fixed quadrats, the rationale for which is described in the materials and methods. [c] nd = no data available. Note: it was not possible to collect meaningful DM data in summer or autumn at some locations because the newly established pastures had been too heavily grazed. [d] There were no significant differences ($P<0.05$) in plant population counts or DM for the two pasture mixes examined so data were combined for ease of presentation.

Previous trials - The cover-cropping studies undertaken between 1996-2000 at Ardlethan and Barellan had similar winter rainfall (107-151 mm, detailed data not shown) to that experienced by Ariah Park in 2009 (Table 1), but both sites had more rain in spring (140 and 129 mm in 1996; 162 and 124 mm in 1998; 171 and 195 mm in 1999) and this was reflected in higher grain yield by the barley cover-crops

(1996: 1.2-3.8 t/ha; 1998: 2.5-3.8 t/ha; 1999: 1.7-2.3 t/ha). There was less rain in the summer-autumn period at the two trial sites in 1996/97 (191 and 110 mm) and at Ardlethan in 1998/99 (209 mm) than Brocklesby and Ariah Park in 2009/10 (300.7-333.4 mm; respectively, Table 1), but rainfall was very similar at Barellan in 1998/99 (313 mm), and at both Ardlethan and Barellan in 1999/2000 (318 and 303 mm; respectively). The trends in lucerne survival in 1996/97 were comparable to results from 2009/10 in terms of losses of the sown perennial species over summer in the cover-cropped treatments (Norton and Koetz 1998). However, even in the wetter years of 1998/99 and 1999/2000 where the numbers of lucerne plants established under cover-cropping did not differ greatly from the pure sward and there was no great loss in plant numbers over the summer-autumn period, the use of cover-cropping always resulted in lower forage production the following autumn (Table 4).

Table 4 Trends in lucerne population counts (plants/m^2) and dry matter production (kg/ha) measured in autumn 12 months after sowing for cover-cropping experimentation undertaken in southern NSW between 1996 & 2000[a]

Location and rainfall	Cover-crop	Year				
Species	sowing rate	1997	1999		2000	
		(plants/m^2)	(plants/m^2)	(kg/ha)	(plants/m^2)	(kg/ha)
Ardlethan	Nil crop	40	45	1220	62	932
	Half rate	4	31	316	51	670
	Full rate	9	42	423	57	591
Barellan	Nil crop	66	61	1462	57	1273
	Half rate	34	54	726	27	805
	Full rate	15	59	657	40	655

[a] Lucerne-barley cover-cropping experiments undertaken in southern NSW between 1996 and 2000. Note no data are provided for 1998 as none of the lucerne sown in 1997 survived regardless of the presence or absence of cover-crop.

Discussion and conclusions

The collaborating farmers at Ariah Park seemed to recognise the potential competition between pasture seedlings and the companion cereal for water and resources and they routinely sowed both wheat and barley at lower rates when cover-cropping (20-30 kg/ha) than where a cereal was sown alone elsewhere on their farm (35-50 kg/ha). However, this did not seem to be the case at Brocklesby where barley sowing rates used by the collaborating farmer were similar regardless of whether it was used as a cover-crop (60 kg/ha) or not (66 kg/ha). The data in Table 3 clearly illustrated that in a year such as 2009 even the level of competition provided by just a 10 kg/ha cover-crop resulted in poorer survival and lower forage production than where the perennial pasture species were sown without a cover-crop.

In terms of forage production by the sown perennials, the data from both 2009/10 and the earlier studies in southern NSW indicate that cover-cropping is a much less effective means of establishing a viable perennial pasture than sowing the pasture species alone (Tables 3 and 4). Given the value of perennial pasture seed of $60-80/ha, the failure to establish the sown perennial species represents a substantial cost if ultimately the pasture needs to be re-sown. With the drying trend in total annual rainfall (BOM 2010) and the apparent shift in rainfall pattern toward drier springs, the risks of failure must be considered to be high if farmers rely on cover-cropping as a technique to establish perennial pastures. An immediate impact of the participatory studies in 2009 has been that the collaborating farmers at Ariah Park sowed their perennial pastures in 2010 without a cover-crop.

References

BOM (2010) Australian climate variability and change – Trend maps. Australian Bureau of Meteorology www.bom.gov.au/cgi-bin/climate/change/trendmaps. retrieved 21 May 2010.

Dear BS, Casburn GR, Li GD, Walker J, Bowden P and Hayes RC (2010) A survey of the use of perennial pastures as part of the pasture-crop rotation in the mixed farming zone of southern New South Wales. Future Farm Industries CRC Technical Report 3, Future Farm Industries CRC, Perth WA.

Koetz E and Norton M (1998) A survey of lucerne establishment in southern NSW. *Proc. 13th Ann. Conf. Grasslands Soc. of NSW.* eds. Frank McRae and David?Michalk, pp 92-93.

Norton MR and Koetz EA (1998) Establishment of undersown lucerne in southern NSW. **In**: Agronomy - Growing a Greener Future. Proc. 9th Australian Agronomy Conference (DL Michalk and JE Pratley, Eds), Australian Society of Agronomy, Wagga Wagga, pp. 337-338.