Effect of 10 years of organic dairy farming on weed populations

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Summary To determine whether converting to organic farming increases weed problems, a trial at Massey University in New Zealand split a dairy farm in half, with one half farmed conventionally for 10 years and the other half farmed using organic principles. Weed populations in selected paddocks of each farmlet were studied for 8 years to determine how these populations would differ between the two systems. After 10 years, weed problems differed little between the two farmlets. Both still had broad-leaved dock (*Rumex obtusifolius* L.) and hairy buttercup (*Ranunculus sardous* Crantz) as their main weed species. Weeds were most noticeable in pastures in the year following regrassing activities for either farmlet, but being unable to use glyphosate during seed-bed preparation or use selective herbicides after sowing of new swards, meant weeds were sometimes worse in organic pastures after resowing than in conventional pastures. These weed problems were dealt with over the first few years after resowing by good grazing management, and ensuring pastures were dense once the annual species hairy buttercup had flowered and died, thus minimising any further establishment. Results from the trial suggest that weeds need not be an impediment to organic dairying.

Keywords Organic farms, dairy pastures, *Rumex obtusifolius, Ranunculus sardous*.

INTRODUCTION

Dairy farmers within New Zealand have been converting to organic farming systems over the past few decades for a variety of reasons, but partly to earn the higher premiums being paid for organically produced milk (Kelly *et al*. 2008). A trial was set up at Massey University in August 2001 in which a dairy farm was split in two, with one half run conventionally and the other half organically, to study how much production is affected by converting to organic methods (Shadbolt *et al*. 2009).

Within this trial, many aspects of production were studied, including effects of organic farming on weed populations. Initial results from measurements of weed populations were presented by Harrington *et al*. (2008) after 4 years. Within this trial, measurements were also made of the relative levels of minerals and the overall feed value of weeds within the organic farmlet compared with pasture species (Harrington *et al*. 2006).

The trial ended in June 2011. This paper presents data on how the weed composition of the pastures changed during the 10 years since half of the farm was converted to organic production systems.

MATERIALS AND METHODS

The trial was conducted at the Dairy Cattle Research Unit of Massey University on a Tokomaru silt loam soil beside the university campus at Palmerston North, New Zealand, where the annual rainfall is 960 mm. The organic unit was 20.1 ha, compared with 21.7 ha for the conventional unit, both with pastures based on perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.). Initially both farmlets had 44 cows, but this was modified annually depending on the seasons and pasture available. In later seasons, there were about 53 cows on the conventional unit and 45 cows on the organic unit. Each herd was milked separately.

Organic farming methods were used on the 20.1 ha block from 1 August 2001, and AgriQuality organic certification was granted on 1 August 2003. Fertiliser was applied annually based on soil test results, with the conventional unit receiving traditional types of fertilisers such as potassic superphosphate, with urea to boost pasture production at times of feed shortage, while the organic unit received materials such as reactive rock phosphate, vermicast and composted chicken manure.

Ten paddocks were randomly selected from each of the units (from totals of 24 for each of the conventional and organic farmlets) for detailed monitoring, and a fixed transect was established in each paddock on November 2003. The weed composition in each paddock was estimated by a skilled assessor within ten fixed quadrats, each 1 m^2 in size and spaced at 5 m intervals along the transect. This process was repeated every 6 months by the same assessor until May 2011. The transects were located each time using a tape measure extended between fixed posts located at the edges of each paddock, and each quadrat was positioned at predetermined points along this transect.

As weed populations changed most substantially whenever a pasture was renewed, data will be presented below illustrating changes in weed composition for three organic pastures and three conventional pastures following regrassing.

The three organic pastures were Paddocks 24, 26 and 7 of the Dairy Cattle Research Unit. Paddock 24 was regrassed on 24 March 2005, Paddock 26 on 4 April 2007 and Paddock 7 on 25 March 2008. Paddock 24 was mouldboard ploughed, fallowed and put straight back into grass, whereas both Paddocks 26 and 7 were ploughed in the previous spring, a crop of turnips grown then planted into grass in autumn following further cultivation. Narrow-leaved plantain (*Plantago lanceolata* L. cv Tonic) was planted at 2 kg ha^{-1} with the perennial ryegrass and white clover seed for Paddocks 24 and 7, whereas only a ryegrass/clover mix was planted in Paddock 26 and plantain was oversown a year later into the sward. Ryegrass sowing rates are listed in Table 1, but were kept low for Paddock 24 to facilitate plantain establishment.

The three conventional pastures being studied in more detail are Paddocks 16, 10 and 15, which were sown into perennial ryegrass and white clover swards on 2 April 2005, 21 April 2007 and 25 March 2008, respectively. Paddock 16 was sprayed with a glyphosate/tribenuron mix 3 weeks before sowing, then was ploughed, power-harrowed and planted. Paddock 10 was sprayed with glyphosate and then direct-drilled several weeks later. Paddock 15 was sprayed with glyphosate in the previous spring, cultivated and sown into turnips over summer, then sprayed again with glyphosate in autumn, cultivated and sown into pasture. Only Paddock 16 received any selective post-emergence herbicides, with MCPB applied 7 weeks after sowing.

T-tests were used to determine whether populations differed between organic and conventional farmlets at each assessment time, and also whether populations within paddocks changed significantly over time compared with densities prior to sowing.

RESULTS

Total weed densities remained fairly low in permanent pastures on both the organic and conventional farmlets over the 10 years of the trial, often averaging less than 5% of the sward (Table 1). However, weed densities often increased markedly within new pastures. The data presented in Table 1 are from those pastures which were not renewed for the entire period of the trial to prevent increased weed densities in new pastures raising the average and thus hiding overall trends in weed densities. Only three of the monitored organic pastures were renewed over the 10 year trial period compared with six of the conventional ones.

The two main components of the weed populations were usually buttercup and dock. There were two buttercup species, the main one being hairy buttercup but there was also some creeping buttercup (*Ranunculus repens* L.), which were bulked for assessments due to being difficult to tell apart vegetatively. The main dock species was broad-leaved dock, though some

Table 1. The estimated percentage ground cover of buttercup, dock and total weeds in seven organic (org) and four conventional (con) dairy pastures assessed every 6 months from November 2003 (11/03) until May 2011 (5/11), including overall averages (avg) across all times of assessment.

	Buttercup		Dock		Total	
Date	**Org**	Con	**Org**	Con	**Org**	Con
11/03	**0.37**	0.20	**0.82**	0.84	**2.20**	2.14
5/04	**0.55**	0.65	**0.76**	1.71	**2.64**	3.73
11/04	**2.66**	1.97	**1.54**	1.69	**5.94**	4.18
5/05	**2.19**	0.66	**0.82**	1.15	**3.49**	2.15
11/05	**1.48**	0.89	**0.77**	1.99	**3.22**	3.13
5/06	**3.94**	0.80	**0.82**	1.15	**5.68**	2.17
11/06	**4.64**	1.72	**1.01**	1.23	**6.80**	3.55
5/07	**1.38**	1.00	**0.62**	0.87	**3.11**	2.58
11/07	**0.69**	0.76	**0.49**	1.66	**3.03**	4.09
5/08	**0.31**	0.21	**0.68**	1.06	**2.29**	2.13
11/08	**0.48**	0.94	**1.00**	1.95	**4.06**	4.99
5/09	**0.74**	0.57	**1.11**	1.32	**3.86**	4.74
11/09	**1.81**	1.77	**1.52**	1.47	**5.55**	6.15
5/10	**1.11**	1.36	**0.70**	1.28	**3.41**	3.93
11/10	**4.07**	1.66	**1.87**	1.18	**7.32**	4.07
5/11	**5.68**	3.33	**2.37**	1.85	**9.43**	6.58
Avg	**2.01**	1.16	**1.06**	1.40	**4.50**	3.77

clustered dock (*Rumex conglomeratus* Murray) and fiddle dock (*Rumex pulcher* L.) were also present and bulked together for assessments.

Due to variability between the ten assessed quadrats in each paddock, t-tests comparing the mean cover of weeds in organic pastures never showed significant differences to the average cover in conventional pastures for the same assessment date, both with total weeds and also buttercup and dock covers. However, the average data bulked from the 16 assessment dates did show significantly ($p<0.05$) more buttercup overall in organic pastures than conventional pastures, a small but significant reduction in docks compared with conventional pastures, and no difference overall in total weed cover.

To investigate how resowing of pastures affected weed covers in pastures, the weed densities present within three organic pastures are shown in Table 2 for the 27 month period after resowing each pasture. The average weed densities over the 2-year period prior to resowing were compared with densities in each of the May and November assessment times for the following 2 years. Table 3 shows the equivalent data for three conventional pastures which were resown at similar times to those in Table 2.

DISCUSSION

The most significant finding was that weed densities in the permanent organic pastures seldom got very high, often below 5% of the sward, and usually no higher than in conventional pastures. There was variability across each paddock as normally happens in pastures subject to dung and urine patches, damage from treading and other such factors. Likewise, there was variability between times of assessment as affected by factors such as weather conditions and differential grazing pressure. Hairy buttercup densities varied the most between assessments, usually low in biomass in May when establishing for the year and high in November when flowering. Other weed species could be

Table 2. The estimated percentage ground cover of buttercup, dock and total weeds in three organic dairy pastures assessed every 6 months from 2 years before resowing until 27 months later. (* before mean is significantly ($p<0.05$) less than before sowing; * after mean is significantly higher.)

	Pdk 24	Pdk 26	Pdk 7
Date sown	24/3/05	4/4/07	25/3/08
Ryegrass rate (kg/ha)	14	20	23
Total weeds:			
- prev 2 yr	4.14	2.42	4.12
- after 2 mth	23.32*	5.56*	3.21
- after 9 mth	9.51*	5.32*	16.98*
- after 15 mth	2.34	3.38	5.64
- after 21 mth	6.07	8.00*	12.75*
- after 27 mth	4.01	5.83*	3.48
Buttercup:			
- prev 2 yr	1.10	0.65	3.04
- after 2 mth	14.80*	0.96	1.38
- after 9 mth	8.15*	2.90*	12.40
- after 15 mth	*0.08	*0.20	*1.11
- after 21 mth	0.76	2.18	3.60
- after 27 mth	*0.35	*0.21	*0.97
Docks:			
- prev 2 yr	0.92	0.40	0.22
- after 2 mth	6.40*	3.75*	1.17*
- after 9 mth	1.00	2.03*	1.63*
- after 15 mth	1.43	1.60*	0.70*
- after 21 mth	4.80*	1.41*	2.80*
- after 27 mth	3.07	2.53*	1.84*

Table 3. The estimated percentage ground cover of buttercup, dock and total weeds in three conventional dairy pastures assessed every 6 months from 2 years before resowing until 27 months later. (* before mean is significantly ($p<0.05$) less than before sowing; * after mean is significantly higher.)

	Pdk 16	Pdk 10	Pdk 15
Date sown	2/4/05	21/4/07	25/3/08
Ryegrass rate (kg/ha)	26	25	23
Total weeds:			
- prev 2 yr	5.43	3.65	3.13
- after 2 mth	7.85	-	3.71
- after 9 mth	*0.78	4.48	15.21*
- after 15 mth	*1.60	4.21	7.87
- after 21 mth	*1.74	8.50*	6.63*
- after 27 mth	*2.44	5.90*	4.87
Buttercup:			
- prev 2 yr	3.23	2.48	1.25
- after 2 mth	2.70	-	*0.43
- after 9 mth	*0.55	3.96	14.40*
- after 15 mth	*0.58	*0.91	*0.20
- after 21 mth	*1.26	6.80*	2.22
- after 27 mth	*0.83	2.41	*0.34
Docks:			
- prev 2 yr	1.86	0.57	0.53
- after 2 mth	*0.32	-	*0.07
- after 9 mth	*0.09	*0.07	0.58
- after 15 mth	*0.23	0.44	4.55*
- after 21 mth	*0.17	0.62	2.88*
- after 27 mth	*0.39	1.10	2.01

variable too, with pennyroyal (*Mentha pulegium* L.) in particular being dense in some years and absent in other years, presumably due to the wetness of the seasons.

The greater abundance of hairy buttercup in organic pastures and the lower dock abundance (Table 1) were both considered to be due to grazing pressure. On the conventional farmlet when feed was lacking, urea could be used to boost pasture production, and also supplementary feed could be supplied to cows. On the organic unit, urea could not be used, and the composted chicken manure used to provide extra nitrogen did not give the same increase in pasture growth as urea. It was also bulky and thus difficult to apply at times of the year when soil was soft. There were also only limited supplies available of approved organic supplementary feed.

Thus organic pastures were often grazed harder than conventional pastures at some times of the year. Docks were more likely to be grazed as a result, stopping them from dominating the pastures as much. Also the organic pasture cover was often quite short in autumn when hairy buttercup was germinating, so seedlings were better able to establish.

Weed densities in either farmlet only got high when new pastures were established, at which time the bare soil allowed weeds to establish alongside the pasture seedlings. Glyphosate was used for seed-bed preparation in the conventional pastures, allowing better control of perennial weeds and also more rapid resowing of swards than on the organic farmlet where more cultivation and fallowing was used to try controlling perennial weeds. Having pastures out of production for longer periods on the organic unit made regrassing less attractive. Selective post-emergence herbicides could be used on the conventional unit, yet the manager involved only did this for Paddock 16 of the three pastures featured in Table 3, after the 2 month assessment. Weed densities were noticeably lower in subsequent months for this pasture than the other five pastures featured in Tables 2 and 3.

Hairy buttercup was the main weed species to cause problems in new pastures. After it flowered and died each spring, the density of the pasture in the following autumn determined whether a new flush of buttercup established. Usually the problem only occurred for the first year. Pastures were often mown in spring when seed-heads were forming to reduce the seed rain from these plants.

Although buttercup was unsightly for the first year after sowing, weed densities were back to tolerable levels for the second year both for organic pastures and also conventional pastures where MCPB was not used, explaining why managers often do not bother with MCPB application. However, it is noticeable in Tables 2 and 3 that the dock populations often increased after resowing of pasture. Unlike the hairy buttercup, perennial weeds such as broad-leaved dock do not die after the first year so can become more of a problem as a result of resowing pastures.

Weed control in pastures for both the organic and conventional farmlets mainly involved keeping pastures dense throughout the year by not overgrazing, avoiding pugging damage in winter, applying fertiliser and regrassing those paddocks with low pasture densities. Weeds that did establish were usually dealt with by grazing pressure and occasional mowing of pastures, especially in late spring when grasses began flowering. Some spot-spraying of herbicides were used on the conventional farmlet for thistles and ragwort. On the organic unit, thistles were removed with a hoe and ragwort was pulled out as it flowered.

The main differences between the organic and conventional farmlets with respect to weed management was that glyphosate could not be used to assist with controlling perennial weeds during regrassing and boom-spraying of herbicides was not available if management mistakes resulted in high weed populations. Such mistakes included bad pugging events in winter and poor establishment of new pastures due to poor timing or poor technique.

But generally weeds were not a limiting factor to production on the dairy farm during the 10 years of the comparison trial.

ACKNOWLEDGMENTS

The authors wish to thank the many farm staff, technicians and scientists that contributed to the trial over the 10 years, and also DairyNZ for funding the work.

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