White clover: loss in drought and subsequent recovery

I.M. KNOWLES¹, T.J. FRASER¹, M.J. DALY²

¹AgResearch, PO Box 60, Lincoln, New Zealand

²146 Halswell Rd, Christchurch 8003

ian.knowles@agresearch.co.nz

Abstract

There are limitations to the production and persistence of white clover in drought prone regions. We report on the population dynamics of white clover during the summer/autumn drought of 2000. Seventeen paddocks were selected from Marlborough, Mid Canterbury, South Canterbury and North Otago on the east coast of the South Island, and Wairarapa in the North Island. The pastures were sown in 1998/99 and are comprised of ryegrass, tall fescue, cocksfoot or combinations of these as the grass base, with white clover included in the mix. White clover populations were monitored pre- and post-drought using tiller cores. The percentage of each region's long-term mean rainfall received during the 6-month "drought period" had the largest influence on the presence of white clover in these pastures. Marlborough, with only 73 mm of rainfall during November 2000–April 2001 (23% of its expected rainfall) suffered a 95% reduction in white clover. Mid Canterbury, South Canterbury and North Otago, at 53–61% of expected rainfall had a 40–78% loss. In contrast, Wairarapa, with 303 mm of rainfall, lost only 8%. The rate of recovery was closely related to the magnitude of white clover loss during drought. In regions where large losses occurred, further sampling after 18 months showed little increase in white clover presence.

Key words: drought, persistence, populations, seedling, *Trifolium repens*, white clover

Introduction

White clover is the dominant legume grown in New Zealand pastures and is often described as the key competitive edge New Zealand has over other pastoral farming countries. The benefits include

nitrogen fixation and high quality forage leading to increased animal performance (Caradus *et al.* 1996). However, some of the weaknesses include difficulties in establishment, maintenance and persistence in pastures (Brock & Caradus 1996). A pasture persistence programme has been monitoring the same 260 paddocks annually throughout NZ to examine species composition within pastures that were all established in 1998/99. Large areas of the South Island (mainly east coast) and some regions in the North Island (Wairarapa) were subject to a prolonged dry period during the summer of 2001. Approximately 30% of monitored paddocks were in the regions worst affected by drought. Many farmers reported concerns about how well their pastures would persist during drought. This programme provided a framework to monitor white clover loss during, and recovery after, drought.

Method

The pasture persistence programme involves annual paddock sampling using tiller cores each spring (October to December) from paddocks established in 1998 and early 1999, throughout New Zealand. The regions targeted for the drought monitoring, which is the focus of this paper, were in North Otago, South

Figure 1 Regional white clover presence (means of 100 cores) from several properties within each region. Percentage of long term rainfall received during the 6-month 'drought' is overlaid in the shaded zone. Regions are North Otago (◆), South Canterbury (■), Mid Canterbury (●), Marlborough (x), Wairarapa (□).

Canterbury, Mid Canterbury, Marlborough and Wairarapa. From 260 paddocks, a sample of 17 paddocks, 2-5 in each of the 5 regions, were identified for monitoring. The original pasture seed mixes contained ryegrass, tall fescue or cocksfoot, and all included white clover (2-5 kg/ha). The paddocks selected for drought monitoring had adequate white clover presence (53-67% of cores) before the drought as shown by the October 2000 sampling (Figure 1).

Regional rainfall records were taken from the closest National Institute of Water & Atmospheric Research (NIWA) metrological station to the selected monitor paddocks. The NIWA stations used were, Oamaru (North Otago), Waitawa (South Canterbury), Winchmore (Mid Canterbury), Blenheim (Marlborough) and East Taratahi (Wairarapa).

The drought, indicated by low rainfall compared to the long-term mean, began in early November 2000

identification), then scored for presence of sown grass, white clover or weed species. During post-drought identification (May, June, August and October 2001), all cores were scored for the same species presence as for annual sampling, in addition, grass, clover and weed seedlings were identified.

Regional rainfall means for the 6 months of the drought (November 2000 to April 2001) are presented in Table 1, and compared with the regional long-term means to demonstrate the severity of the water deficit. Marlborough had the largest deficit during the drought period, receiving only 73 mm of rain (23% of the long-term regional mean). The other regions received variable rainfall: Mid Canterbury 199 mm (53% L-T mean), South Canterbury 163 mm (50% L-T mean), and North Otago 165 mm (61% L-T mean). Wairarapa received 303 mm (80% L-T mean) and did not appear to have a drought.

Table 1 Monthly rainfall (mm) during the drought period compared with long-term rainfall means (in parentheses).

Region (NIWA station)	Nth Otago (Oamaru)		Sth Cant (Waitawa)		Mid Canty (Winchmore)		Marlborough (Blenheim)		Wairarapa (East Taratahi)	
Nov 00	50	(45)	53	(53)	81	(62)	18	(70)	49	(84)
Dec 00	56	(55)	42	(60)	30	(65)	15	(48)	99	(59)
Jan 01	44	(50)	33	(55)	58	(60)	5	(51)	41	(57)
Feb 01	6	(33)	13	(54)	11	(54)	3	(55)	40	(55)
Mar 01	2	(58)	1	(56)	4	(68)	8	(47)	45	(70)
Apr 01	7	(31)	21	(51)	15	(64)	24	(53)	29	(52)
May 01	30	(32)	46	(44)	44	(62)	28	(53)	81	(74)
Total Nov-Apr	165	(272)	163	(329)	199	(373)	73	(324)	303	(377)
% LT Nov-Apr	61		50		53		23		80	

in Marlborough, and in February 2001 in North Otago, South Canterbury and Mid Canterbury. The drought lasted until May 2001 at which time substantial rainfall, comparable with that expected from the long-term mean, occurred in all regions. Post-drought sampling began at the end of May and was repeated in June, August and October 2001.

From each paddock, 100 tiller core (50 mm diameter) samples were taken along a transect line each spring. The cores were grown on (spray watered under shade cloth) for around two weeks after sampling to restore plant health (thus improving ease of species

Soil fertility was measured from each monitor paddock using ~30 soil cores (75 mm depth) during October in 2000 and 2001, representing pre- and post-drought conditions. Soil cores were analysed by Celentis Analytical for pH, phosphorous, elemental and organic sulphur and potassium (Table 2).

Fertility levels indicated adequate levels of nutrients pre-drought (Table 2), with Olsen P levels considered above average (25-35). The exceptions were two paddocks, (Olsen P 12) both in South Canterbury, which were below the average of Olsen P 26. Post-drought fertility levels were also adequate (average

Table 2 Soil fertility, pH, Olsen P, sulphur (S), organic sulphur (OS), potassium (K).

Region	Pre-drought					Post-drought				
	pH	P	S	OS	K	pH	P	S	OS	K
Nth Otago	6.2	34	16	7	8	6.1	22	10	3	6
Sth Cant	6.0	19	18	6	7	5.9	20	14	4	7
Mid Cant	5.9	25	10	5	9	5.5	32	20	6	9
Marlb	5.9	25	20	3	8	5.7	28	15	6	11
Wairarapa	6.0	27	18	6	6	-	-	-	-	-

Olsen P of 26) and did not appear to have affected plant recovery, with the exception of the same two South Canterbury paddocks with P levels of 10 and 16.

Statistical analysis

The tiller core data from each monitor paddock were grouped into regions; this allowed calculation of regional means. Data presented are mean $\pm$ standard error of mean.

Results

The percentage of cores containing white clover showed large variation over the four years of sampling with large changes identified between samplings within a region and between regions. Figure 1 summarises the regional changes in white clover presence between pre- and post-drought samplings. Marlborough had the largest change, decreasing by 95%, representing a 92-100% loss of white clover from the 2 paddocks monitored. Other major reductions were in Mid Canterbury at 75%, North Otago at 56% and South Canterbury at 40%. In contrast, Wairarapa maintained a high presence of white clover throughout.

The recovery of white clover was closely related to the extent of the damage during the drought. Regions that had moderate white clover loss (North Otago, South Canterbury) showed complete recovery by 2002. In contrast, regions that suffered high losses during the drought showed a much lower rate of recovery. For example in Marlborough, there was an 80% reduction in white clover and only a 20% recovery over the following 18 months.

In terms of seedlings, the percentage presence was less than 15% during all samplings, especially in May and June (Table 3). Seedling presence increased during August and October with North Otago having the highest recorded seedling numbers in August 2001. Wairarapa had the lowest seedling presence overall.

Discussion

White clover presence in the monitored paddocks varied considerably between sampling date and between regions. Rainfall appeared to be the major factor affecting presence, with regions that experienced the most severe drought exhibiting the greatest depression in white clover presence. This

Table 3 Mean white clover seedling presence (% of cores with seedling), for 2-5 farms sampled after a severe drought in 2000/01 ($\pm$ SEM).

Region	Post-drought							
	May		June		Aug		Oct	
	2001		2001		2001		2001	
Nth Otago	0.3	($\pm$ 0.3)	1.3	($\pm$ 1.3)	13.0	($\pm$ 10.1)	9.0	($\pm$ 3.1)
Sth Cant	0.8	($\pm$ 0.5)	0.0	($\pm$ 0.0)	1.3	($\pm$ 0.6)	3.8	($\pm$ 2.6)
Mid Cant	0.4	($\pm$ 0.4)	1.6	($\pm$ 1.2)	3.4	($\pm$ 3.2)	6.0	($\pm$ 3.2)
Marlb	0.6	($\pm$ 1.5)	1.0	($\pm$ 1.5)	3.3	($\pm$ 5.5)	6.7	($\pm$ 10.0)
Wairarapa	0.0	($\pm$ 0.0)	0.0	($\pm$ 0.0)	1.7	($\pm$ 0.9)	2.0	($\pm$ 0.8)

was most evident in the extreme case of Marlborough, which received 73 mm (23% L-T mean) rainfall during the six months from November 2000 to April 2001, corresponding to a 95% reduction in white clover presence. In contrast, Wairarapa received 303 mm (80% L-T mean) rainfall and showed no change in clover presence.

Research has shown that the timing of the drought period appears to be critical to the survival of white clover. Brock (1988) showed that spring droughts may have a stronger effect on plant mortality during white clover population fragmentation, whereas in autumn plant losses due to drought are reduced. This probably compounded the loss in Marlborough where the drought began in November and carried through to May 2001. In the other regions the drought period began in February.

The high white clover loss observed could also be attributed to the period in the life cycle when the drought occurred. The prolonged dry period may have coincided with the phase in the life cycle when the tap root dies around years 1-2, and the parent plant fragments, to be replaced by smaller clonal daughter plants with less tap root and more stolon development (Brock & Hay, 2001). This notion is supported by previous research (e.g. Frame & Newbould 1986), which showed a decline in white clover performance after 2-3 years, even when initial establishment was successful. Figure 1 shows that all regions had high levels (53-67%) of white clover presence during the October 2000 sampling. With the exception of Wairarapa, the other four regions had large losses (21-95%) corresponding to the drought period.

Post-drought recovery of white clover over the six months (May, June, August, October 2001) after rainfall in May 2001 was poor. Sampling during October 2002 showed a 42% increase in white clover presence in North Otago. This was the only region where a major increase in clover presence occurred after the drought, also the only region with substantial seedling presence. Those regions showing the greatest loss of white clover during the drought tended to be the slowest to recover.

Seedling numbers were low (0-13%) in the winter/spring period of 2001. North Otago had the highest seedling presence, which suggests that the increase in presence of white clover could be attributed to both an increase in plant numbers through seedling recruitment and increased size of resident plants.

There were a range of white clover cultivars sown in the monitored paddocks, and the variation seen in white clover presence suggests that some selection for survival in drought conditions may be achievable. Brock & Caradus (1996) showed that a range of cultivars (small- to large-leaved) were equally affected by drought, and recovery over 3 years was slow across all leaf sizes. However, Brock (1988) showed different recovery rates of white clover cultivars due to leaf size and corresponding stolon density. Therefore as other researchers (e.g. Woodfield and Caradus 1996) have suggested, while the suitability of current white clover cultivars under drought conditions can be questioned, there is selection potential for cultivars that persist under drought conditions and demonstrate improved recovery rates following rain.

Grazing management appears to be an important factor in the effect of drought on white clover populations. Brock & Hay (1996) suggest that rapid rotational grazing or set stocking during spring/ early summer creates pastures with high growing point density. The higher density increases shading to protect stolons from solar radiation damage; this reduces stolon loss during drought and improves plant recovery following rains.

White clover recovery from seedlings does appear to be a factor post-drought. This was particularly evident in the rapidly recovering North Otago region. Vartha & Hoglund (1983) suggest that if summer drought occurs pastures become highly sensitive to grazing of regrowth, with pasture damage likely. As a result, regrowth should be treated as a newly established pasture.

Conclusions

These results show that white clover is generally not tolerant of drought conditions; the presence is greatly reduced during drought, with poor post-drought recovery. The severity of the drought is also important. Regions with very low rainfall during November to April showed the largest loss in white clover presence.

These results correspond with other research, suggesting that the timing of the drought period in the white clover life cycle may also be a factor in its persistence and recovery. The 2000/01 drought period occurred around year two after pasture establishment; thus, white clover parent plants may have fragmented during spring and may have been at a disadvantage

when coping with drought, contributing to the high losses seen.

ACKNOWLEDGEMENTS

The support of the farmers involved in the Pasture Persistence monitoring, and research funding from Meat New Zealand and New Zealand Wool Board is appreciated.

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