A summary of research into the use of low rates of glyphosate as a pasture management tool

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Abstract

Investigations into the use of low rates of glyphosate as a pasture management tool in New Zealand are summarised. Rates of 250 ml/ha Roundup (360 g/l a.i. glyphosate) increased white clover and decreased dead material contents on sites throughout New Zealand. Results were variable depending on site, weather and application conditions. Variable responses in perennial ryegrass content were noted, with repeated annual applications helping to improve ryegrass content. Lamb growth rates increased by an average of 30 g/d or 20%. Californian thistle numbers were reduced by annual application of low rates of glyphosate. Thistles that were not killed remained vegetative and small. The use of low rates of glyphosate to control late-spring growth improved pasture nutritional characteristics. Pastures must have enough time to recover before the onset of drought to avoid grass death and weed invasion. Careful use of this technique can aid in the management of pastures in late spring to increase pasture quality in summer. More research is needed to define rate-by-environment interactions, effects on pasture growth and feed quality through small well-designed experiments.

Keywords: botanical composition, Californian thistles, dead material, drought, glyphosate, lamb growth, pasture management, ryegrass, white clover

Introduction

Pastoral farmers have a problem controlling the rapid pasture growth in late spring using the stock available. The very rapid change from vegetative to reproductive growth can result in seedhead that is hard to graze off and summer pasture quality suffers. Keeping pastures short and leafy at this time ensures better animal growth. Management options farmers use include dry stock, cattle or mechanical topping, as well as silage making and cultivation (Lambert *et al.* 2000). Often many of these options are not available to hill country farmers.

Chemical topping as a method of controlling pasture growth has been tried using a variety of chemicals in the past, including paraquat (Williams & Palmer 1969) and plant growth regulators such as mefluidide (Leonard *et al.* 1985). However, farmers resisted using this method because of the nature of the chemicals and their cost. Use of low rates of glyphosate in Australia to control the growth of annual grasses, and to maintain palatability as seeding approaches, developed into a technique known as 'Pasture Topping' (Dowling & Nicol 1993; Hill *et al.* 1996). At the same time, it was also noted that New Zealand direct drilling programmes using the double spray technique with glyphosate, improved white clover content (P. Desborough pers. comm.). This led to a number of trials investigating the practical application of glyphosate for controlling seeding, improving pasture quality and preventing pasture reversion in New Zealand pastoral situations. Few of these have been formally reported.

The purpose of these trials was to investigate whether chemical topping would provide high-quality summer pasture by controlling rapid late-spring growth. The second objective was to find out whether repeated treatments would reduce the need for pasture renovation. The final aim of the trials was to find out if improved pasture quality resulted in increases in lamb growth.

Methods

1: National on-farm paddock trial

Farms were selected in eight regions throughout New Zealand (Table 1) as part of a nationwide study funded by Meat New Zealand. Pastures on each farm were chosen on the basis of having some ryegrass, a reasonable base of clover, and high levels of other grasses such as browntop, Yorkshire fog and sweet vernal. Chemical topping was applied to one half of a paddock at a recommended rate of 250 ml/ha Roundup^{TM} (360 g/kg a.i. glyphosate). Some farmers chose higher rates of 300–500 ml Roundup from experience of chemical topping on their property. The number of farms and paddocks treated varied from region to region and year to year, and are documented in Table 1. Pastures were sprayed in late spring with application dates varying from mid October (mainly dry regions), to mid November and mid December.

Pasture botanical composition measurements were taken before spraying and again in autumn in 1998 and 1999. Sampling dates are documented in Table 1.

2: The effects of chemical topping in the Kuriwao district, South Otago

Trial sites were selected on farms in the Kuriwao district, between Clinton and Gore, as part of a Technology New Zealand funded project, to assess the use of chemical topping for pasture renovation and thistle control. Glyphosate was applied in December to the same pastures each year for 3 years at the rate of 250–300 ml Roundup/ha. Pasture botanical composition was determined in spring and autumn each year (Table 2). Thistle populations were measured in spring and autumn by counting all thistles in a 1 m x 50 m transect on treated and untreated pastures at three sites. Visual assessments of the health of thistle populations were made.

3: Lamb growth rate summaries

Lamb growth rates were measured on-farm in three regions, Southland, Otago and in the Canterbury foothills, over seven comparisons of treated and untreated pastures. Comparisons were made in several years, from 1993–1999. Mob size ranged from 10 to 183 lambs and was adjusted to suit feed supply. Trial length varied from 3–7 weeks. Pastures were treated in mid December in Otago and Southland studies and in mid November in Canterbury foothill studies with 250–500 ml/ha Roundup. Lambs were weighed after a 24-hour fast before the start of the trial, then grazed from mid January, and weighed at the end of the grazing period.

Results

Pasture composition

Pasture botanical composition measurements made in the national Meat NZ trials (Tables 2–5) show the range of responses in the autumns of 1998 and 1999. Ryegrass content (Table 2) in autumn 1998 varied from 10% DM yield in the control treatments in the Manawatu to 51% DM yield in the chemically topped treatments in Mid Canterbury. Ryegrass content in autumn 1999 ranged from 7% to 59% in the control King Country and chemically topped Otago sites, respectively. The overall ryegrass content in 1998 was 22 +/- 3.0% (SE) and 29 +/- 3.6% in the control and topped treatments respectively. In 1999, the ryegrass content was 41 +/- 4.1% and 42 +/- 4.5% in the control and topped treatments respectively.

Average white clover content (Table 3) in 1998 in all regions for the controls was 8 +/- 1.2 and in 1999 was 12 +/- 1.5% DM while the chemically topped treatments were 12 +/- 1.8 and 19 +/- 2.6% DM in

Table 1 Number of paddocks and sampling dates for each region and each year of the National on-farm paddock trial.

	Year 1 (1997/98)			Year 2 (1998/99)		
	Number of paddocks	Spring sampling date	Autumn sampling date	Number of paddocks	Spring sampling date	Autumn sampling date
Southland	8	13/11	6/3	7	5/11	25/1
Otago	10	13/11	6/3	8	4/11	6/3
Mid Canterbury	5	5/11	21/5	4	20/11	15/2
Nth Canterbury	3	23/11	21/5	-	-	-
Marlborough	3	6/10	24/4	-	-	-
Manawatu	3	10/11	22/4	2	20/11	7/5
Hawke's Bay	-	-	-	4	5/11	30/3
King Country	3	14/11	24/3	2	9/11	9/3

Table 2 Ryegrass content (% of total DM) in eight regions around New Zealand, in autumn 1998 and 1999 after late spring chemical topping in the previous year.

	Autumn 1998					Autumn 1999				
		Control		Chemical topped			Control		Chemical topped	
	n	mean	SE	mean	SE	n	mean	SE	mean	SE
Southland	8	18	5.3	28	8.6	7	40	4.8	33	8.2
Otago	10	32	5.8	33	4.3	8	52	7.8	59	6.2
Mid Canterbury	5	28	10.3	51	10.0	4	43	11.6	44	10.2
Nth Canterbury	3	22	3.4	24	2.6	-	-	-	-	-
Marlborough	3	24	18.0	29	15.5	-	-	-	-	-
Manawatu	3	10	4.1	22	7.2	2	12.4	3.1	33.2	18.0
Hawke's Bay	-	-	-	-	-	4	34	6.5	39	6.4
King Country	3	12	2.2	7	2.9	2	7	2.4	8	1.3
All Regions	35	22	3.0	29	3.6	25	41	4.1	42	4.5

the same years. The mean autumn clover content in 1998 was low in dry environments (range 1–6% control; 0–10% sprayed) and higher in moister regions (range 11–12% control; 15–17% sprayed). In 1999, the white clover content was higher for both dry environments (range 6–9% control; 8–10% sprayed) and moister regions (range 12–18% control; 19–33% sprayed).

Other grasses and weed species (Table 4) were high in all regions and both treatments, except Otago in 1999, ranging from 27 to 65% DM. The variability of the results was generally high, as shown by the standard errors.

The average dead material content from all regions (Table 5) was lower in the sprayed treatments than the controls in both years.

The study of repeated chemical topping at Kuriwao (Table 6) showed trends of improved ryegrass and white clover content with chemical topping. The increase in dead material, and the variability of dead material content during summer, were lower in chemically topped pastures.

The effect of glyphosate on Californian thistles was both immediate and ongoing (Table 7) in the Kuriwao study. Repeated applications produced thistle

Table 3 White clover content (% of total DM) in eight regions around New Zealand, in autumn 1998 and 1999 after late-spring chemical topping in the previous year.

	Autumn 1998					Autumn 1999				
		Control		Chemical topped			Control		Chemical topped	
	n	mean	SE	mean	SE	n	mean	SE	mean	SE
Southland	8	11	3.4	15	4.2	7	18	3.1	33	4.6
Otago	10	12	1.5	17	3.6	8	12	2.4	19	4.0
Mid Canterbury	5	6	1.7	10	2.5	4	9	1.7	10	1.7
Nth Canterbury	3	1	0.2	1	0.5	-	-	-	-	-
Marlborough	3	1	0.3	0	0	-	-	-	-	-
Manawatu	3	4	3.5	8	4.0	2	7	3.4	23	5.7
Hawke's Bay	-	-	-	-	-	4	6	1.3	9	1.7
King Country	3	4	1.2	16	8.1	2	6	3.0	8	3.8
All Regions	35	8	1.2	12	1.8	25	12	1.5	19	2.6

Table 4 Other grasses and weed species content (% of total DM) in eight regions around New Zealand, in autumn 1998 and 1999 after late spring chemical topping in the previous year.

	Autumn 1998					Autumn 1999				
		Control		Chemical topped			Control		Chemical topped	
	n	mean	SE	mean	SE	n	mean	SE	mean	SE
Southland	8	50	5.6	43	7.2	7	37	5.5	33	9.2
Otago	10	45	5.5	38	3.2	8	14	4.2	13	3.3
Mid Canterbury	5	42	11.9	28	8.1	4	33	10.2	35	11.5
Nth Canterbury	3	59	1.8	65	3.7	-	-	-	-	-
Marlborough	3	32	23.0	21	13.1	-	-	-	-	-
Manawatu	3	33	11.8	38	2.4	2	63	6.8	27	12.3
Hawke's Bay	-	-	-	-	-	4	27	7.2	28	6.6
King Country	3	44	6.7	43	4.4	2	45	2.0	46	7.3
All Regions	35	42	3.2	38	2.9	25	28	3.4	27	3.9

Table 5 Dead material content (% of total DM) in eight regions around New Zealand, in autumn 1998 and 1999 after late spring chemical topping in the previous year.

	Autumn 1998					Autumn 1999				
		Control		Chemical topped			Control		Chemical topped	
	n	mean	SE	mean	SE	n	mean	SE	mean	SE
Southland	8	17	5.0	13	6.1	7	5	1.6	2	0.9
Otago	10	11	2.7	12	3.2	8	22	7.0	10	3.4
Mid Canterbury	5	24	5.2	10	1.1	4	15	2.5	11	2.0
Nth Canterbury	3	17	5.3	9	2.1	-	-	-	-	-
Marlborough	3	44	20.6	50	17.3	-	-	-	-	-
Manawatu	3	51	21.1	32	10.9	2	18	11.0	7	1.1
Hawke's Bay	-	-	-	-	-	4	34	6.0	24	3.5
King Country	3	40	8.3	34	9.8	2	40	8.3	35	10.7
All Regions	35	24	3.5	19	3.1	25	19	3.4	12	2.5

numbers of 1.8/m^2, while untreated pastures had populations of 4.3/m^2 and were relatively unchanged with time. Thistle numbers were also measured in the national trials but were not consistent across sites and paddocks. There was a trend towards less in the pastures that were sprayed. The observations in both trials were that sprayed thistles stayed small and green without flowering, reducing their detrimental effects on the pastures and animals.

Lamb growth

A description of the results of various farm trials (funded by Monsanto and Meat NZ, Table 8) measuring lamb growth showed that lamb performance increased by an average of 30 g/day, a 20% in improvement in lamb growth, on sprayed pastures.

In the Otago and Southland trials, improved lamb growth rates were the result of an increase in the white clover content of the pasture. Morton (1998) measured 8% and 32% while Stevens & Baxter (1995) measured 15 and 20% white clover in the control and sprayed pastures respectively, while changes in dead material content were variable. Canterbury lamb growth rates were unrelated to measured changes in botanical composition, possibly related to the time of measurement.

Variation in responses occurred owing to both farmer management skills and weather patterns. Roundup topping provided an overall benefit in lamb growth in both moist and dry summers, though stocking rates were reduced more in dry summers.

Discussion

These results are highly variable both within and between regions and years. It is difficult to make direct statistical comparisons from the results owing to the inherent variation in pasture type, environment, farmer management practices, aspect and chemical

Table 6 Changes in pasture botanical composition with three seasons of chemical topping in the Kuriwao district, South Otago.

	---- Control ----			- Chemical topped -		
	n	Mean	SE	n	Mean	SE
Ryegrass						
Jan-97	6	10	3.4	3	19	6.7
Apr-97	6	6	3.0	7	10	3.9
Jan-98	6	5	1.7	8	18	7.3
Mar-98	6	9	2.8	8	18	3.6
Dec-98	5	11	3.1	3	17	3.5
Apr-99	5	36	16.4	6	43	10.7
White clover						
Jan-97	6	15	4.3	3	19	7.2
Apr-97	6	11	2.4	7	17	3.4
Jan-98	6	15	5.7	8	17	2.8
Mar-98	6	15	3.2	8	20	4.9
Dec-98	5	8	1.8	3	10	1.9
Apr-99	5	10	4.3	6	19	4.6
Other grasses/weeds						
Jan-97	6	67	4.8	3	55	9.3
Apr-97	6	62	4.3	7	62	2.9
Jan-98	6	73	5.1	8	61	8.0
Mar-98	6	56	5.7	8	54	5.4
Dec-98	5	73	2.5	3	71	5.9
Apr-99	5	41	13.9	6	29	10.4
Dead material						
Jan-97	6	8	4.2	3	8	5.6
Apr-97	6	22	7.0	7	12	1.1
Jan-98	6	6	4.5	8	4	1.0
Mar-98	6	20	4.7	8	7	1.9
Dec-98	5	7	2.1	3	3	0.7
Apr-99	5	13	4.0	6	9	4.2

Table 7 The changes in Californian thistle number with the use of glyphosate topping in the Kuriwao district, South Otago.

	---- Control ----		- Chemical Topped -	
	Mean[1]	SE	Mean[1]	SE
Summer 1997	3.5	0.43	3.74	1.28
Autumn 1997	3.8	0.59	0.6	0.13
Summer 1999	8.1	2.02	2.1	1.55
Autumn 1999	4.3	1.98	1.8	1.37

[1] Mean of the three sites

Table 8 The influence of chemical topping on lamb growth rates and stocking rates.

Study[1]	Trial length (weeks)	---------------- Control ---------------- Stocking rate (lambs/ha)	Gain (g/d)	SE (lambs/ha)	------------- Sprayed ------------- Stocking rate (g/d)	Gain	SE
Southland (Stevens & Baxter 1995)	6	29	118	-	28	151	-
Southland (Stevens & Baxter 1995)	6	47	155	-	40	140	-
Otago (Stevens & Baxter 1995)	6	37	114	-	35	148	-
Otago (Morton 1998)	5	25	119	19	25	142	8
Southland (Morton 1998)	7	19	172	10	19	190	13
Canterbury (Harmer 1997)[2]	3	59	189	-	54	263	-
Canterbury (Casey 1998)[2]	4	nr[3]	185	-	nr	233	-
Average		36	150		33.5	181	

[1] (Researcher and year of study)
[2] Unpublished data
[3] not recorded

application methods in paddock-scale trials. For example, the 2 years of the Meat New Zealand trials were strongly affected by the La Niña weather pattern. This restricted spraying in some regions and influenced recovery from spraying in others. However, the repeatability shown in such a variable data set indicates that the measured effects were real.

Using botanical compositions as a simple measurement of pasture quality, the resultant increases in white clover content (Table 3) and decreases in dead material (Table 5) indicated that the use of chemical topping improved pasture quality in summer. High concentrations of glyphosate are required to significantly affect white clover compared to grass, therefore white clover has a competitive advantage over grasses after spraying. The decline in dead material was owing to reductions in other grass species, stem and seedhead. The increase in grazing pressure, owing to reduced pasture growth, may have also reduced dead-material content. Sampling pastures more frequently after spraying would have provided a more robust indicator of the changes.

The variability of the responses between regions and years showed that many factors interact to generate the final response. Important considerations were the likelihood of summer drought, application factors and the original condition of the pasture.

With summer drought, the pasture response was less because pasture recovery was restricted. Traditionally, areas of greater drought risk have higher summer white clover content than summer wet regions owing to less growth from the grasses. During the second year of the Meat New Zealand trials, and the final year of the Kuriwao study, there was a period of near drought in Southland and Otago. This was reflected in the data as a sharp increase in ryegrass content and a reduced amount of dead material.

Most farmers used low rates and this was especially important in dry environments to avoid plant death, weed invasion or a long interval before grazing. The few higher rates were used in summer-moist environments with reliable recovery growth and dense pastures. The timing of application also varied between regions. The onset of seedhead emergence varies between regions so spraying time varied. In summer-dry environments, enough time is required for the pastures to recover before the regular onset of drought. Application will be after pasture supply exceeds demand in the spring, and before high-quality pasture was required for lamb growth.

If farmers can easily increase ryegrass and clover content, and reduce other grasses in poor pastures, they may be able to reduce the need for pasture renovation. The initial increase in ryegrass content from 10 to 19%, and a final ryegrass content of 43% by year 3 (Table 6) showed that this was possible with chemical topping. Visually the response was dramatic owing to the reduction in dead material, seedhead and thistles and these farmers chose not to renovate these pastures as a result.

The effect of a dry summer on ryegrass content was also seen in these results, as the ryegrass content was high in both control and chemically topped pastures in year 3. This response was also evident in the comparison of Autumn 1998 and Autumn 1999 results in the Meat New Zealand trials. The effect of the drought was similar to chemical topping, by reducing pasture growth, increasing the grazing pressure and increasing plant death. This implies that careful use of higher rates of Roundup may be more effective in making major changes in ryegrass and clover content.

Control of Californian thistles was an unexpected bonus to this use of glyphosate. Thistles remain small and do not flower, with repeated applications depleting the population over time (Table 7). This method of control is low cost and improves the pasture composition, compared to other herbicides that often cause a decline in clover content.

The variability of the results was high, as these were on-farm, paddock-scale comparisons. The original condition of the pastures and the subsequent management also contributed to this. Overall, the improvements in pasture quality from chemical topping were translated into an increase in lamb growth. The increase in lamb growth rates was similar to that found using other chemicals (Leonard *et al.* 1985) of between 12 and 45 g/d in the Waikato and by an average of 50 g/d in the South Island. The pasture has short vegetative regrowth once chemically topped, resulting in an increase in green leaf and decrease in dead material. White clover content also increased in the chemically topped pastures. These responses were both important in improving lamb growth rate.

Conclusions

The trials were not set up to examine the cause and effect of chemical topping but to demonstrate the benefits of the technique to farmers. The response of permanent pastures to chemical topping was consistent over time but variable responses occurred in some regions and seasons. Pasture quality was improved at a critical time of year for animal growth.

Slower pasture growth owing to chemical topping will make it easier to manage the pastures on the rest of the farm. The overall effects from chemical topping of significant areas of a farm will increase the grazing pressure, and therefore improve pasture utilisation and quality over the whole farm.

Chemical topping was a useful tool to control late-spring surpluses and return pasture to a high quality for lamb growth. Results to date have not fully defined the range of environmental conditions in which chemical topping can be used.

Future research should focus on rate-by-environment interactions, and on the effects on pasture growth and feed quality through small, well-designed trials.

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