Giant buttercup – modelling the financial benefits of control on a Golden Bay dairy farm

GRAEME BOURDÔT[1], WARREN KING[2] and GRANT RENNIE[2]
[1]*AgResearch, Lincoln, Private bag 4749, Christchurch 8140, New Zealand*
[2] *AgResearch, Ruakura Research Centre, PB 3123, Hamilton 3240, New Zealand*
graeme.bourdot@agresearch.co.nz

Abstract

Giant buttercup (*Ranunculus acris* L. subsp. *acris*), a weed of European origin with a potential distribution embracing all of New Zealand, currently infests pastures in six of 17 dairying regions. It reduces the quantity of pasture consumed by deterring grazing, but its impact on whole-farm profitability is not well understood. To redress this, the effect of the weed and the impact of herbicides varying in efficacy were modelled with Farmax Dairy Pro®. On a dairy farm "typical" of the Golden Bay area, with the ground cover of giant buttercup peaking at 12% in November (the average per paddock cover measured on an infested farm), profit was reduced by $1040/ha ($1830 *vs*. $2870). Synthetic herbicides applied at label rates increased profitability, but only where the control was better than *ca.* 30% with MCPA or *ca.* 60% with flumetsulam. By contrast, a hypothetical biological herbicide giving 50% control had a break-even cost of $485/ha. The models show that giant buttercup reduces the profitability of a typical Golden Bay dairy farm by 36% and that its effective control can bring large financial gains.

Keywords: dairy pasture, economics, Farmax Dairy Pro®, model, profitability, weed control

Introduction

Giant buttercup (*Ranunculus acris* L. subsp. *acris*), a weed of European origin (Harper & Sagar 1953), occurs in dairy pastures in the South Auckland, Hawke's Bay and Taranaki regions, and in South Wairarapa, Horowhenua and Golden Bay (Bourdôt *et al.* 2003). The weed's persistence may be explained by the evolution of resistance to the phenoxy and ALS herbicides that have been widely relied upon for its control (Bourdôt & Hurrell 1991; Bourdôt *et al.* 1990; Lusk 2012).

In the 2001/02 milking season, when the payout to dairy farmers was $5.35/kg milksolids, the weed resulted in a gross revenue loss to dairy farmers of $156 million through reduction in utilisable pasture dry matter (Bourdôt *et al.* 2003). Assuming no spread of the weed since 2001/02, it was estimated to have caused a loss in dairy farmer revenue of $155 million in the 2008/09 season across the six dairying regions infested in 2001/02 (Bourdôt & Saville 2010). If it had spread across all 17 dairying regions at that time, the additional losses could have been between $173 million and $593 million, bringing the potential gross national revenue loss to a value between $328 million and $748 million in the 2008/09 season (Bourdôt & Saville 2010). A bio-climatic niche model indicates that all 17 dairying regions are climatically highly suitable for giant buttercup and therefore vulnerable to invasion (Bourdôt *et al.* 2012).

The gross revenue losses due to giant buttercup indicate the significance of this weed to the New Zealand dairy industry (Bourdôt & Saville 2010; Bourdôt *et al.* 2003). However, these figures do not measure the effect of the weed at an individual farm scale. The objective of the current study was to explore the effect of giant buttercup infestation on farm physical and financial performance, with and without the use of herbicides, by developing a series of farm system models using the modelling package Farmax Dairy Pro® (Bryant *et al.* 2010).

Methods

The approach adopted in this analysis was to construct a "base" model of a "typical" Golden Bay dairy farm affected by giant buttercup. This model was optimised so that it was stable from year to year in stock numbers and pasture yield. From this base model, a series of models was developed to explore a range of scenarios. The models were constructed in Farmax Dairy Pro® (Bryant *et al.* 2010; Farmax 2012) using detailed information on the farm system, including pasture, forage and other supplementary inputs as well as animal enterprise information, milk production figures and the cover of giant buttercup on the farm. The models explicitly consider the costs of the inputs and outputs, enabling the profitability of a given farm system to be calculated. Following development of the base model, a range of scenarios was developed that considered the impact of giant buttercup and its control using different herbicide treatments, including a hypothetical bioherbicide.

The farm chosen for constructing the optimised "base" model was considered to be representative of the many dairy farms in the Golden Bay area that are affected by giant buttercup (Bourdôt *et al.* 2003). This farm was 110 ha in area stocked at 2.8 cows/ha with a milk production in the 2010/11 season of 930 kg milk solids/ha. This farm would be classed "System 3" (DairyNZ 2012) with approximately 82% of the feed being home-grown pasture. The percentage ground cover of giant buttercup in each paddock was estimated visually in November 2010. The weed was present in nearly every paddock and its cover varied from 0 to 40% with a mean of 12% on recently-grazed paddocks and 9% on soon-to-be-grazed paddocks (Table 1). The base model assumed a maximum groundcover value for giant buttercup of 12% (in November). This was the average of the values visually estimated across the recently-grazed paddocks on the Study Farm (Table 1) and was considered to provide a better estimate of cover (and hence production loss) than the soon-to-be-grazed pastures where the weed was partially obscured by tall grasses and other pasture plant species.

The farmer was interviewed to determine monthly values for forage supply, milk production and cow numbers. These values were used to build the base model and are available from the authors upon request. The default Farmax operating expenses and the 2010/2011 Fonterra milk schedule were used in the modelling (Farmax 2012).

Incorporating the effects of giant buttercup into the model

The base farm model does not explicitly include the effect of giant buttercup on pasture supply. The approach adopted to include the effect of giant buttercup in subsequent models consisted of two steps. Firstly, the model's pasture utilisation parameter was reduced according to the seasonal ground cover pattern for giant buttercup described in Bourdôt *et al.* (2003). In the month of peak cover (November) pasture utilisation was reduced by 12%, the mean cover of giant buttercup measured in November on recently-grazed paddocks on the base farm (Table 1). This 12% was multiplied by 1.25 to incorporate the grazing aversion associated with giant buttercup as determined by Bourdôt *et al.* (2003), which is 25% greater than that expected from the percentage ground cover of the buttercup alone. This peak reduction in utilisation was scaled back in the other months according to the seasonal growth pattern of the weed's cover (Bourdôt *et al.* 2003) (Table 2). Secondly, pasture growth was increased to compensate for the reduced utilisation and match the milk production in the base model.

Table 1. Details of the infestation of giant buttercup (*Ranunculus acris*) as measured on 18–20 November 2010 on the study farm in Golden Bay used as the basis for the Farmax Dairy Pro® models (Table 4).

Statistics	Recently grazed	Soon-to-be-grazed	Silage
Number of paddocks	31	42	24
% of paddocks with *R. acris*	94	95	96
Mean % ground cover of *R. acris*	12	9	5
Range of % ground cover of *R. acris*	0–40	0–30	0–30

There were five additional paddocks in maize – none had giant buttercup present.

Table 2. The four seasonal patterns in pasture utilisation (%) used in Farmax Dairy Pro® (Table 4) to reflect the impact of different levels of giant buttercup ground cover. Values are relative to the default pasture utilisation values in Farmax Dairy Pro®

	Pasture utilisation pattern			
	A	B	C	D
January	100	91	92	95
February	100	92	92	96
March	100	92	93	96
April	100	92	93	96
May	95	89	90	92
June	90	85	86	88
July	90	87	88	89
August	90	85	85	87
September	95	86	87	90
October	100	87	89	94
November	100	85	87	93
December	100	88	89	94
Peak % ground cover of giant buttercup in November	No giant buttercup	12	10.8	6

Incorporating the effects of herbicides into the model

The effects of MCPA and flumetsulam at label-recommended rates were modelled by including the product and application costs. A range of efficacy from 10 to 100% control was used incorporate the effect of herbicide resistance. These herbicides have no effect on the grass component of the sward. The effect of the herbicides on clover was modelled by reducing the metabolisable energy (ME) of the pasture. MCPA caused a reduction in ME while flumetsulam resulted in no reduction as its effect on clover is negligible (Table 3). With a likely reduction in nitrogen fixed due to the MCPA-induced loss of clover, the cost of additional applications of nitrogen (N) fertiliser was included. This was estimated at 50 kg N over two applications for the MCPA scenarios and 10 kg N in one application for the flumetsulam scenario. The putative bioherbicide was assumed to have no effect on clover so that only the cost of its application was included. This resulted in a total effective herbicide cost of $156/ha for MCPA ($40 product + $40 application + $76 fertiliser), $132/ha for flumetsulam ($77 product + $40 application + $15 N fertiliser), and $40/ha for the bioherbicide (application only).

Table 3. Pasture metabolisable energy (ME) (MJ ME/kg DM) content changes from Farmax Dairy Pro® default used to model the loss of clover due to herbicide use (Table 4).

	Farmax Default	With application of MCPA	With application of Flumetsulam
January	11.4	11.2	11.4
February	11.2	11.0	11.2
March	11.5	11.5	11.5
April	11.7	11.7	11.7
May	11.8	11.8	11.8
June	12.0	12.0	12.0
July	12.1	12.1	12.1

Table 4. The 11 Farmax Dairy Pro® models developed for evaluating the effect of giant buttercup on a dairy farm in Golden Bay and the profitability of its control.

Model	Description	Reduction in buttercup (%)	Modelled buttercup control method	Cows	Annual pasture prod. (t DM/ha)	Pasture utilisation pattern (Table 2)	Profit ($/ha/y)
1	[1]Base farm	-	-	310	13.2	A	1,830
2	[2]Buttercup effect explicit	0	-	310	15.1	B	1,829
3	[3]Buttercup absent	100	-	310	15.1	A	2,870
4	" "	100	-	326	15.1	A	2,609
5	" "	100	-	341	15.1	A	2,131
6	[4]Buttercup cover reduced with herbicides	100	MCPA	310	15.1	A	2,521
7	" "	50	MCPA	310	15.1	D	2,017
8	" "	10	MCPA	310	15.1	C	1,620
9	" "	100	Flumetsulam	310	15.1	A	2,685
10	" "	50	Flumetsulam	310	15.1	D	1,647
11	" "	50	Bioherbicide	310	15.1	D	2,315

[1]This model estimates the amount of pasture required to produce the milk production measured on the Golden Bay base farm.
[2]This model estimates the additional pasture production required to offset the effect of the giant buttercup cover on the Golden Bay base farm.
[3]These three models calculate the increased profit generated if the giant buttercup was absent. Scenario 3 uses the same stocking rate as Scenarios 1 and 2 but increases the amount fed to each cow. Scenarios 4 and 5 increase the stocking rate progressively with Scenario 5 having the same per cow production as Scenarios 1 and 2.
[4]These six models calculate the profit generated with the partial or complete removal of the giant buttercup using herbicides.

Results and Discussion

Effect of giant buttercup on farm profitability

Conceptualisation of the effect of giant buttercup on whole-farm profitability began with a generalised version of the study farm – the optimised "base" model (Scenario 1 in Table 4). The impact of giant buttercup is implicit in this model. Scenario 2 makes this explicit by reducing pasture utilisation to account for giant buttercup abundance and then increasing pasture production to compensate. This identified an effective loss of pasture of 1.9 t DM/ha year (15.1 minus 13.2, Scenarios 2 and 1 in Table 4). The removal of giant buttercup in Scenario 3, 4 and 5 revealed an "opportunity cost" of up to $1040/ha/year depending on stocking rate (Table 1).

These figures are likely to be broadly representative of Golden Bay dairy farms. The most affected paddock on the study farm had a cover of giant buttercup of 40% in November (Table1) and previous work has shown comparative cover values on 10 other farms in the area (Bourdôt & Hurrell 1990; Bourdôt *et al.* 2003).

Effect of controlling giant buttercup on farm profitability

The reality of herbicidal control of giant buttercup includes variable control of the weed and collateral clover damage. Use of both MCPA and flumetsulam improve profitability if the control is 100% (Scenarios 6 and 9 respectively in Table 4). At 50% control however, MCPA still improves profitability but the use of flumetsulam is not supported (Scenarios 7 and 10 respectively in Table 4). Using 10% control of giant buttercup with MCPA to represent the development of herbicide resistance (Scenario 8; (Bourdôt *et al.* 1990)) resulted in the least profitable scenario – nearly $200/ha less than the base scenario (Table 4). The "break-even" points for these herbicides, with respect to their efficacy, were *ca*. 30% for MCPA and *ca.* 60% for flumetsulam.

The use of a putative bioherbicide was also investigated. The bioherbicide fungus *Sclerotinia sclerotiorum* has been shown to give a 50% reduction of giant buttercup in dairy pastures in Golden Bay (Bourdôt *et al.* 2007). Modelling of this bioherbicide (Scenario 11) indicated an increase in profitability of $485/ha from the base scenario. Given that the cost of the bioherbicide itself was not included in the model (only the cost of application), this suggests that the use of such a bioherbicide would be profitable provided that the cost of such a product (applied) is less than $485/ha.

Summary

Giant buttercup has a significant impact upon the profitability of affected dairy farms in Golden Bay. Given its propensity to develop herbicide resistant populations and the potential for it to become more widespread, giant buttercup deserves closer attention. Development of herbicide resistance management strategies, effective control options, and mechanisms for monitoring and preventing spread should be regarded as a priority. Development of a bioherbicide may provide a new and cost-effective tool for the management of this serious weed.

ACKNOWLEDGEMENTS

We thank DairyNZ for funding this work under the On-Farm Innovation Fund scheme and the members of the Giant Buttercup Management Group for frank and helpful discussion. Special thanks to the study farm owner who was a gracious host under persistent questioning. We thank also, Geoff Hurrell and Carolyn Lusk, AgResearch, Lincoln, for technical assistance and the referees for helpful comments on the manuscript.

REFERENCES

Bourdôt, G.W.; Hurrell, G.A. 1990. Effects of annual treatments of MCPA and MCPB on giant buttercup (*Ranunculus acris* L.) in dairy pastures. pp. 233-236. *In*: Proceedings of the 43rd New Zealand Weed and Pest Control Conference.

Bourdôt, G.W.; Hurrell, G.A. 1991. Evidence for the heritability of MCPA-resistance in giant buttercup (*Ranunculus acris*). pp. 270-274. *In*: Proceedings of the 44th New Zealand Weed and Pest Control Conference.

Bourdôt, G.W.; Saville, D.J. 2010. Giant buttercup – a threat to sustainable dairy farming in New Zealand. pp. 355-359. *In*: Australasian Dairy Science Symposium 2010 - Meeting the Challenges for Pasture-Based Dairying.

Bourdôt, G.W.; Hurrell, G.A.; Saville, D.J. 1990. Variation in MCPA-resistance in *Ranunculus acris* L. subsp. *acris* and its correlation with historical exposure to MCPA. *Weed Research 30*: 449-457.

Bourdôt, G.W.; Saville, D.J.; Crone, D. 2003. Dairy production revenue losses in New Zealand due to giant buttercup (*Ranunculus acris*). *New Zealand Journal of Agricultural Research 46*: 295-303.

Bourdôt, G.W.; Hurrell, G.A.; Saville, D.J. 2007. Variation in the efficacy of a mycoherbicide and two synthetic herbicide alternatives. pp. 507-511. *In*: XIIth International Symposium on Biological Control of Weeds.

Bourdôt, G.W.; Lamoureaux, S.L.; Watt, M.S.; Kriticos, D.J. 2012. The potential global distribution of tall buttercup (*Ranunculus acris* subsp. *acris*); Opposing effects of irrigation and climate change. *Weed Science (In Press) doi: http://dx.doi.org/10.1614/WS-D-12-00106.1*

Bryant, J.; Ogle, G.; Marshall, P.R.; Glassey, C.B.; Lancaster, J.A.S.; Garcia, S.C.; Holmes, C.W. 2010. Description and evaluation of the Farmax Dairy Pro decision support model. *New Zealand Journal of Agricultural Research 53*: 13-28.

DairyNZ 2012. Accessed: 7 September 2012.

http://www.dairynz.co.nz/page/pageid/2145861231/The_5_Production_Systems

Farmax 2012. FARMAX DAIRY PRO. Accessed: 16 Feb 2012. http://www.farmax.co.nz/Farmax-for-Dairy.aspx

Harper, J.L.; Sagar, G.R. 1953. Buttercups, some aspects of the ecology of buttercups in permanent grassland. pp. 256-263. *In*: 1st British Weed Control Conference.

Lusk, C.S. 2012. Variation in the susceptibility of giant buttercup (*Ranunculus acris*) populations to herbicides. Thesis for Master of Agricultural Science. Massey University, Palmerston North.