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AGMARDT GRANT No 20514

Cost benefit analysis of clover re-establishment options in the presence of clover root weevil

MILESTONE REPORT 9

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Executive Summary

In 2004 a paddock scale field trial had investigated the benefits of removing clover root pests and diseases through the use of a break crop on subsequent pasture establishment. Two years later, the resultant pastures were assessed for composition and production and the data were used in the Farmax® and Udder™ farm decision programmes to determine the long term economic benefits.

Two year old pasture following a maize or turnip crop had more clover, fewer weeds, and higher autumn production compared to pasture following grass to grass establishment. On farm scale, this equated to gains of $106-108/ha for a central North Island sheep and beef farm where pasture was renewed after a crop, and crop area was optimised to fully utilise pasture; in comparison grass to grass re-establishment resulted in more modest benefits ($53/ha). Similar outcomes were shown for a typical Waikato dairy farm with gains of $490-541/ha for pasture established after crops compared to $336/ha for grass to grass renewal.

Overall, two year old Bronsyn (diploid perennial ryegrass) pastures had more grass and less clover than Quartet (tetraploid perennial ryegrass) pastures. There were no differences in total pasture production in spring, but Bronsyn pastures had higher production than Quartet in summer and autumn. The farm decision programmes indicated it was most economically beneficial to use Bronsyn in the North Island sheep and beef farm and Quartet in the Waikato dairy farm.

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1 Project background

This AGMARDT Grant (No 20514) obtained by Dr. Han Eerens is closely tied to SFF project 05/085. The goal of the SFF project is to compare a range of pasture establishment and management regimes in order to develop scientifically-based recommendations of how to best manage pasture in the presence of clover root weevil. It includes nitrogen fertiliser strategies that will give affected farmers a breathing space until longer term control measures, such as biological controls and tolerant clover cultivars, become widely available.

The AGMARDT linkage has enabled an increased level of farmer input, additional field trials covering a wider variety of environments and, most importantly, will provide cost benefit analyses of the different management strategies.

Changes arising since previous report

None

Tasks previously reported as completed

(Numbers denote SFF contract milestones and brackets AGMARDT milestones)

1.1 Collate information on the impact and life cycle of CRW
1.2 Identify and upskill key people in the regions
2.1 Identify trial sites and collaborating farmers and establish background information on sites
2.2 Establish field trials
  2.2.1 Plot trials
  2.2.2 (AGMARDT 3) Paddock evaluations
3.2 Cost/benefit analysis of clover re-establishment option (AGMARDT 7). Quantify the economic impact of CRW from the trials and other related CRW research

Tasks in progress

2.3 N fertiliser trials (AGMARDT 6) – collect data, maintain trials, and discuss trial progress in local farmer discussion groups/field days
3.1 Clover re-establishment trial (AGMARDT 6) – collect data, maintain trials, and discuss trial progress in local farmer discussion groups and annual field day.
4.1 Identify CRW management scenarios, apply costs, prepare templates (Dec 07)

2 Cost benefit analysis of clover re-establishment options in the presence of clover root weevil

2.1 Introduction

The clover root weevil (*Sitona lepidus* Gyllenhal (Coleoptera: Curculionidae) was first discovered on a Waikato dairy farm in 1996 (Barratt et al., 1996) and has subsequently become one of New Zealand's worst white clover pests (Eerens & Hardwick, 2003). It has spread throughout the North Island and has been confirmed in Nelson and Canterbury in the South Island.

There are two generations of clover root weevil (CRW) a year with adult weevils generally emerging in late spring and again in autumn (Gerard et al., 1999). The adults feed on clover foliage, favouring newly germinated seedlings (Hardwick & Harens, 2000), and making characteristic notches that are the most obvious symptom of weevil infestation. Adults live several months and female weevils can lay many hundreds of eggs during their lifetime. The soil-dwelling larvae are the most damaging stage, especially during winter when numbers typically exceed 400 larvae/m^2 in Waikato dairy pastures. The first instar larvae feed on nodules, then as they mature, the lateral roots and finally the nodal roots and stolons (Gerard, 2001; Gerard et al., 2004). The larvae are present throughout the year putting continual pressure on clover roots. Prior to the arrival of the weevil, no other pest species attacked clover root nodules. Therefore, while CRW competes with other pasture pests for clover roots as a food resource, it also severely compromises nitrogen fixation with subsequent effects on plant growth, physiology and contribution to pasture performance.

The use of nitrogen fertiliser is the quickest way to ensure feed supply and maintain farm profitability in CRW-infested regions. However, this remedy is not appropriate or desirable for all farms, and may not be acceptable in the long term. An alternative approach is to incorporate pasture renewal into the farm system, using a forage crop to break the clover pest and disease cycle. While CRW can re-invade within a year, nematodes and root diseases invade more slowly, and therefore the clovers are more robust and can tolerate CRW damage. Rotating through a crop prior to pasture establishment has two additional advantages. It can be used to eliminate problem weeds and to establish desirable forage species, cultivars and endophytes to produce seasonal feed profiles that optimise animal production.

While the above benefits are well known, most evidence is anecdotal and there is little data available to use in cost/benefit analyses. As part of the SFF project, a single trial was undertaken to compare the effects of different sowing options on clover establishment, including following crops or pasture. In this report we compare pasture production and quality two years after establishment and investigate the economic implications through cost benefit analysis.

2.2 Clover re-establishment trial

2.2.1 Methods

The trial was established in April 2004 on the property of Richard Henderson, a dairy farmer at Horsham Downs, near Hamilton. Three paddocks had been selected as sites, each with the same volcanic soil (Hamilton clay loam) but with contrasting pre-sowing conditions namely:

1. Turnips (1.23 ha, crop off 15/3/04)
2. Maize (2.35 ha, crop off 10/4/04)
3. Pasture (1.95 ha) old pasture removed by spraying out residual clovers with BusterTM (gluphosinate) in March 2004 and a glyphosate application immediately prior sowing)

Each site was marked out in 12 × 15 m plots in a 5 × 6 grid giving a total of 30 plots. There were five grass treatments which were sown on 21 April 2004 using two passes of a 6 m wide drill (= 12 m) down the length of each site. Seed viability had been checked and confirmed at 95% or greater. The grasses were sown to a depth of 2.5 cm with the drill. The grass treatments were:

1. Bronsyn (High wild-type endophyte (HWE)) sown at 8 kg/ha
2. Bronsyn (HWE) sown at 16 kg/ha
3. Bronsyn (AR1 endophyte) sown at 16 kg/ha
4. Quartet (HWE) sown at 20 kg/ha
5. Quartet (AR1) sown at 20 kg/ha

The white clover cultivars used were Kopu II and Tribute, while the red clovers were Collenso and Sensation. The various clover mixes were broadcast on the individual plots. The following two clover treatments were randomly allocated to plots within each grass treatment block.

1. White clover at 5 kg/ha
2. 50/50 by weight red and white clover at 5 kg/ha

The remainder of the paddocks surrounding each site was sown with Bronsyn (HWE) and Kopu II.

Clover establishment in each plot was assessed on 18 May 2004 by calculating the mean number of seedlings present within 15 randomly placed 15 cm^2 quadrats. Subsequent seedling survival was assessed similarly on 15 June 2004.

All paddocks were sprayed with Select® herbicide (3L/ha) on 12 June to control germinating broadleaf weeds such as chickweed and dock. Soil fertility in each paddock was assessed on 26 July 2004. Following establishment the pastures were grazed and managed in the same manner as all other pastures on the property. Urea was to be applied at 28 units N 6-10 weeks after sowing.

The impact of the different establishment treatments on subsequent performance was assessed by taking pasture production and composition measurements in spring 2006, summer 2007 and autumn 2007. Each paddock was assessed immediately prior to grazing within a few days of each other, and all had the same grazing intensity and the intervals between grazings.

2.2.2 Trial results and discussion

i) Soil fertility

The prior history of the paddocks had influenced soil fertility with the ex-turnip paddock having higher P and lower Mg readings than the ex-maize and ex-grass paddocks (Table 1). This suggests phosphate had been applied to the turnip paddock, possibly at unnecessarily high levels. The soil tests showed all paddocks had highly fertile soil conducive to good seedling establishment and pasture growth.

Table 1: Soil pH, P, K and Mg values for three paddocks on the Henderson Farm July 2004.

Prior History	pH	P	K	Mg
Turnip	6.2	63	14	20
Maize	6.2	39	21	31
Grass	6.1	34	17	33

ii) Seedling establishment

The seedling establishment results are not presented in this report but can be summarised as follows.

- Best clover establishment occurred in the ex-turnip paddock, averaging around 260 seedlings/m^2 in the white clover plots.
- Worst clover establishment occurred in the ex-grass paddock, averaging 115 seedlings/m^2 compared to 215/m^2 in the ex-maize paddock.
- Overall, clover establishment with Bronsyn at the low sowing rate (8 kg/ha) was approximately 24% above the conventional sowing rate (16 kg/ha) and Quartet was 10% above Bronsyn at conventional sowing rates.

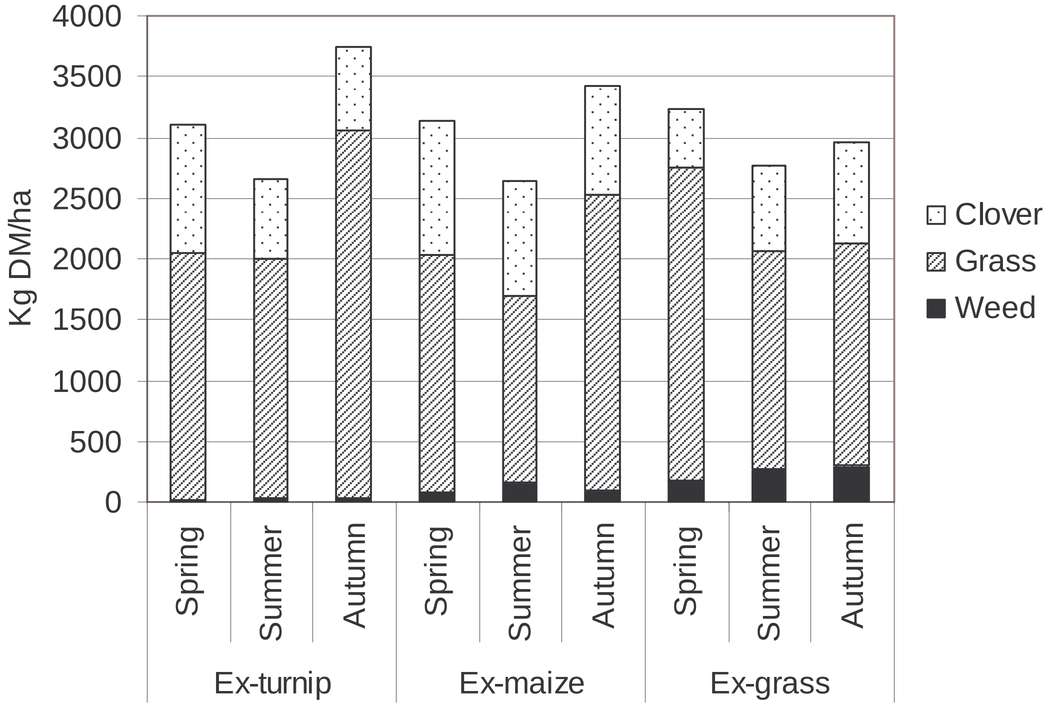
iii) Influence of paddock history

The previous history of the site had a clear influence on the composition and productivity of the two year old pasture (Fig 1). The site that had previously been in maize contained statistically significantly more clover (spring $P < 0.01$; summer $P < 0.05$) and less grass (spring $P < 0.01$; summer $P < 0.01$; autumn $P < 0.01$) than the paddock that had been in grass. Whilst the site that had previously been in turnips contained more clover than the ex-grass site in spring ($P < 0.01$), this was not evident subsequently. Possibly this was because of competition from the grasses, which were at higher levels in the ex-turnip site compared to the other sites in summer ($P < 01$) and autumn ($P < 0.01$). Overall total dry matter availability did not differ between sites in spring and summer but in autumn, the ex-grass contained less feed than the ex-turnip ($P < 0.001$) and ex-maize ($P < 0.01$) sites.

The ex-grass site contained more weeds, especially in autumn ($P < 0.001$). This indicates the quality of the ex-grass pasture is below that of the other pastures. This is likely to have contributed to the reduction in total dry matter availability in autumn and suggests the ex-grass pasture may decline in productivity more rapidly than the ex-maize and in particular the ex-turnip pasture. The weed assessments underestimated total weeds because the more cryptic grass weeds were not included.

Higher numbers of CRW larvae had been found in ex-maize (30 ± 0.6 larvae/m^2) and ex-turnip (27 ± 0.5 larvae/m^2) plots than in ex-grass (16 ± 0.2 larvae/m^2) plots in June 2005. These levels are very low and would have had no impact on pasture composition or production at that time. The difference between paddocks is most likely associated with the respective levels of clover. Previous research by Gerard et al (2007) has shown larval establishment in new pastures is positively related to clover content.

Figure 1: Comparison of the effects of paddock history prior to pasture establishment in April 2004 on seasonal clover, grass and weed dry matter availability at time of grazing in 2006/07.



iv) Influence of perennial ryegrass variety

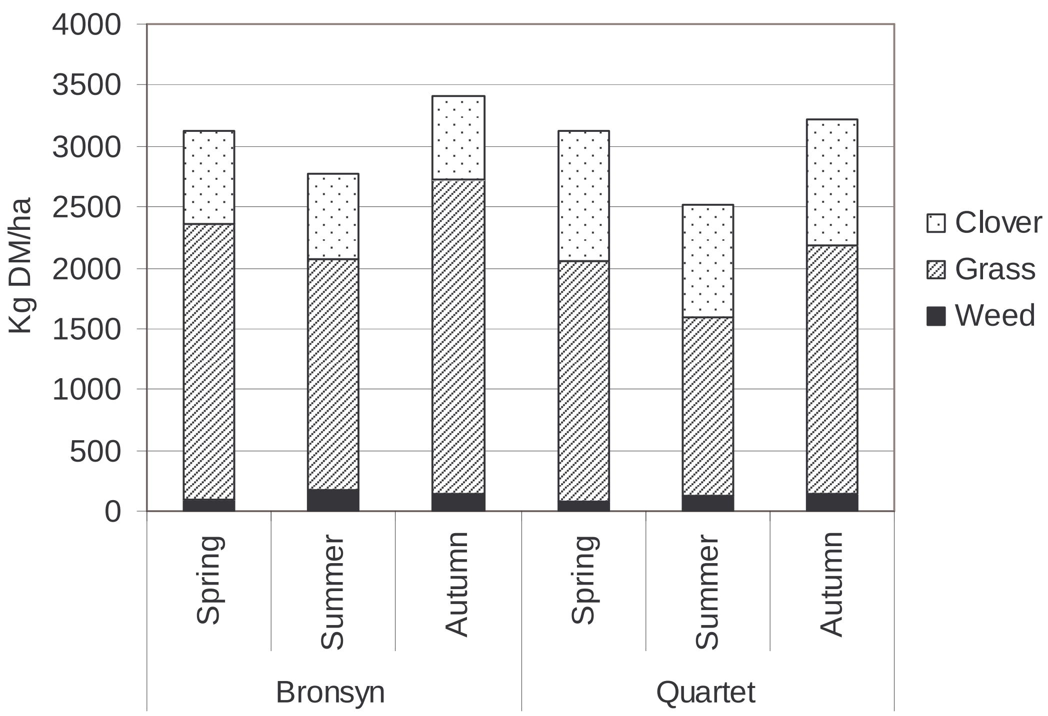
At conventional sowing rates of 16 and 20 kg/ha respectively, plots sown in Bronsyn had higher levels of ryegrass than plots sown with Quartet (Fig. 2: spring $P < 0.05$; summer $P < 0.01$; autumn $P < 0.001$). Conversely more clover was present in Quartet plots than Bronsyn plots (spring $P < 0.05$; summer $P < 0.05$; autumn $P < 0.001$).

There was no difference in total available pasture in spring, but the Bronsyn plots had higher total DM levels than Quartet plots in summer ($P < 0.01$) and autumn ($P < 0.05$). It is important to note that it is possible that within each paddock, Quartet plots may have been grazed more intensively than those containing less palatable plants. Therefore, even though the sampling took place immediately prior to the next grazing, different post-grazing plot residues may lead to underestimations of total production in the Quartet plots relative to Bronsyn plots.

Bronsyn is a diploid perennial ryegrass widely used in dairy, sheep and beef systems and as it is known to yield more in summer and autumn than standard ryegrasses, it was not unexpected that it could out-perform Quartet in these seasons.

Quartet is a tetraploid perennial ryegrass that is larger, more upright and lower tillering than Bronsyn. Therefore it is a more favourable companion plant to white clover. Tetraploids also have higher palatability and feed value than diploid ryegrasses. Therefore tetraploid/white clover perennial pastures are likely to have higher animal production indices than diploid pastures.

Figure 2: Comparison of the effects of perennial ryegrass variety on seasonal clover, grass and weed dry matter availability at time of grazing in 2006/07 in pastures established in April 2004.



v) Influence of endophyte option

Endophyte had no effect on pasture availability or composition except in autumn 2007 when grasses containing the high wild-type endophyte accounted for 8% more DM than AR1 grasses ($P < 0.05$).

Ergovaline, an alkaloid produced by the wild-type endophyte but usually below detectable levels in AR1, protects wild-type infected ryegrass from black beetle attack but can exacerbate heat stress in grazing animals. In the Waikato, ergovaline levels peak in autumn (Bluett et al., 2005) and the resultant differences in alkaloid levels between wild-type and AR1 grasses is likely to influence herbivore feeding choices. The AR1 plots may have been grazed more intensively or suffered greater black beetle damage than high endophyte plots. While monitoring herbivore feeding was beyond the scope of the trial, it may have contributed to the observed differences

2.3 Comparison of economic benefits of clover re-establishment options

The economic benefits of pasture renewal has been analysed and reported recently by Stevens et al. 2007. In all scenarios the models assumed extra pasture production responses were from 10 to 30% and the renewal rate was 10% of the farm

For sheep and beef systems, four base pasture production models from the Farmax® database were used. The modelling outputs showed pasture renewal with an associated cropping programme was profitable in every case, with the financial benefits in current CRW-infested regions ranging from $17-$89/ha in Central North Island hill country to $40-$111/ha in Manawatu flat finishing country. Key to capturing the benefits was optimising the cropping in each scenario. Further economic benefits could be added by changing endophyte type. The improvement associated with a 10% increase in lamb growth was of a similar economic value to a 10% increase in pasture growth in the two North Island models.

The three dairy models were simulated using Udder™ and showed financial benefits ranging from $48-$160/ha in Northland/Bay of Plenty to $92-$299/ha in Canterbury. When the current cost of grass to grass pasture renewal was compared with the benefits, the Northland/Bay of Plenty farm needed to achieve a 12% increase over current production levels to break even, while the Waikato and Canterbury had a break-even value at below 10%.

Given that changing to new endophytes and optimising the amount of the farm in crops was shown in the above study to be of economic benefit, the analyses in this report will focus on two areas, namely: paddock prior history and diploid vs. tetraploid pastures.

2.3.1 Assumptions

The base assumptions common to both the following models were as follow:

- The area renewed was 10% of the farm per annum.
- The new pasture would revert back to base production after 10 years, with most of the decline during the first five years.

- Grass to grass renovation lifts pasture growth by 10%.
- Base clover levels were 10%.
- Clover levels do not fluctuate during year.
- Each 10% increase in clover content gives a 4% lift in animal production (Cosgrove, 2005).
- Changing to tetraploid ryegrass increases animal production by 8%.
- Soil fertility or weed status following crops or grass has no influence on subsequent pasture productivity.

Pasture production response scenarios

The models used the following pasture response scenarios, which are based on the trial results.

Prior history response

- Base
- Base + 10% extra pasture growth and 5% lift in animal production (ex-grass)
- Base + 16% extra pasture growth and 6% lift in animal production (ex-turnips)
- Base + 12% extra pasture growth and 9% lift in animal production (ex-maize)

Diploid vs tetraploid (crop area optimised)

- Base
- Base + 10% extra pasture growth and 5% lift in animal production (diploid)
- Base + 5% extra pasture growth and 9% lift in animal production (tetraploid)

2.3.2 Sheep and Beef

The sheep and beef modelling were done using Farmax®. To build on and allow direct comparison with the previous work done by Stevens et al. (2007), the farm type chosen was central North Island hill country which tends to have limited area for cultivation and pasture renewal. To allow comparison with the dairy model, the models were run for the pasture responses after the crop, i.e. the feeding or selling of maize or turnips was not included. However, within the model it was assumed that the amount of crop within the system was optimized to ensure the best possible stocking rate per annum to achieve maximal pasture utilization.

Additional assumptions were:

- Crop establishment costs $600/ha.
- Pasture renewal after crops costs $350/ha.
- Winter crop and silage optimised to maximise pasture utilisation.

Model outcomes

As found by Stevens et al. (2007), the modelling showed that pasture renewal provided a greater return per hectare than old pasture (base scenario) irrespective of paddock history or grass variety (Table 2).

The gains achieved by re-establishing pasture after a crop ($106-$108/ha) were twice those for grass to grass re-establishment ($53/ha). It must be noted that the differences would have been accentuated by the inability to fully utilize pasture without a crop in the grass to grass scenario.

Even though animal production was higher, the model indicates that this does not compensate for the reduced levels of pasture production achieved using tetraploid compared to diploid grasses, if used on a whole farm scale.

2.3.3 Waikato dairy farm

The benefits of the pasture renewal options in a dairy system were evaluated using Udder™ and information from the Dexcel Annual Economic Survey database. With the trial data from the Waikato, the model was based on a typical Waikato dairy farm running 291 cows at close to optimum stocking rate, no irrigation and using 124 kg N/ha/year. To build on and allow direct comparison, the same milk value ($4/kg milk solids) and costings were used as in the previous work reported by Stevens et al. (2007).
Additional assumptions

With Udder™ not accommodating slower growth immediately after sowing for pasture renewal, the evaluation was from the time of pasture establishment. The lost production during the pasture renewal process was not factored into the model, but relatively speaking it was deemed to have an insignificant effect.

Model outcomes
As with the sheep and beef systems all pasture renovation options provided higher returns than old pasture in the Waikato model, even with the cost of pasture renewal included ($600/ha which is equivalent to $60/ha on a whole farm basis at a 10% renewal rate).

Pasture established after a crop gave greater economic returns, particularly maize which increased returns 61% above grass to grass pasture.

Whereas pastures using tetraploid ryegrass gave lower returns than diploid ryegrass in the sheep and beef model, the dairy model indicated a $56/ha benefit. Under the dairy model, even though carrying capacity was reduced on tetraploid pastures, animal production increased resulting in higher milk solids/ha overall.

Table 2: Outcomes of pasture re-establishment options in a central North Island sheep and beef farm

		Base	New re-established pasture				
			Paddock history			Grass variety[2]	
Pasture type		**old**	**Ex pasture[1]**	**Ex maize**	**Ex turnips**	**Tetraploid**	**Diploid**
Increase in pasture growth	%	0	10	12	16	5	10
Pasture production	kgDM/ha/yr	9189	10126	10292	10659	9648	10126
Stocking rate	SU/ha	11.5	12.8	14.9	15.2	14.1	14.8
Intake	kgDM/ha	6345	7047	8203	8373	7774	8122
Target increase in animal prodn	%	base	5%	9%	6%	9%	5%
Target meat & wool	kg/ha	211	232	236	245	222	232
Actual meat & wool	kg/ha	211	236	268	270	252	261
Gross margin	$/ha	$393	$446	$499	$501	$465	$482
Margin	$/ha		$53	$106	$108	$72	$89

[1] No crop in scenario
[2] based on means from all paddocks, both with and without a crop

Table 3: Outcomes of pasture re-establishment options on a typical Waikato dairy farm

		Base	New re-established pasture				
			Paddock history			Grass variety[1]	
Pasture type		**old**	**Ex pasture**	**Ex maize**	**Ex turnips**	**Tetraploid**	**Diploid**
Increase in pasture growth	%	0	10	12	16	5	10
Increase in animal prodn	%	0	5	9	6	9	5
Cows wintered		291	320	328	335	310	320
Cows milked		285	314	321	328	304	314
Total milk solids (ms)		94128	105766	111896	111375	106085	105766
ms/ha		970	1090	1154	1148	1094	1090
Gross margin	$/ha	1706	2042	2247	2196	2098	2042
Margin	$/ha		336	541	490	392	336

[1] based on means from all paddocks, irrespective of prior history.

2.4 Conclusions

The results from this unreplicated paddock scale trial support anecdotal observations that re-establishing pasture after a crop not only markedly improves clover establishment, but also will improve subsequent pasture quality, productivity and persistence, and in turn farm profitability. The Farmax® model showed the economic benefits of combining cropping and pasture establishment doubled that which can be achieved by grass to grass pasture renewal. By incorporating crops into pastoral farming systems, farmers can reduce the impact of chronic weeds, pests and diseases, eliminate most of the old pasture plants and establish new pasture cultivars with confidence. Optimising the amount of cropping within the system using tools such as Farmax® will be critical to ensure sufficient stock is present to fully utilise spring production.

The farm system appears important in the selection of pasture species. Farmax® showed that if used throughout the whole farm, tetraploid ryegrass would reduce farm profits compared to diploid ryegrass. In contrast Udder™ indicated increased returns due to a combination of lower stock numbers but increased production per animal.

3 Progress towards remaining milestones

SFF
3.2 Cost/benefit analysis of clover re-establishment options (Dec 07)
3.3 Clover re-establishment pamphlet (June 08)
4.1 Identify CRW management scenarios, apply costs & prepare templates (Dec 07)
5.1 Collate information, determine format with farmer/industry input and prepare publication (June 08)

AGMARDT

6. Prepare final report at conclusion of the field trials

There appears to be poor alignment in timing between SFF and AGMARDT milestones with regard to cost/benefit analyses, especially as the field trials are on-going till June 2008. However, the 2007 analyses have been undertaken using data to date with the understanding that later data will be incorporated prior to public release in 2008.

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