Effects of integrated cropping and pasture renewal on the performance and profit of dairy farms

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Abstract
Pasture renewal on the milking platform of dairy farms may or may not involve growing forage crops in the transition from old to new pasture. Old pasture to new pasture sequences with and without forage cropping were evaluated on representative farms from Waikato, Taranaki, Canterbury (irrigated) and Southland using the Farmax Dairy Pro model. If no beneficial effects of pasture renewal were assumed, cropping scenarios with turnips (Taranaki) or maize silage (Waikato) increased milksolids (MS) production per ha, but kale (Southland) and no forage crops (all regions) resulted in lower MS yields. Consequently, the profit of cropping scenarios was similar or less profitable than the base scenarios without pasture renewal or crops. If beneficial effects of pasture renewal were assumed, the use of forage crops increased profit. Non- crop options also increased profit if the new pastures persisted for at least 4 years, and increases of either 10% in pasture production or 0.5 MJ ME/kg DM in pasture quality were observed. There was little difference in profitability between crop and non-crop scenarios in Taranaki (turnips) and Waikato (maize). Profitable results from cropping and pasture renewal assumed good crop and pasture establishment, and effective utilisation of the feed generated. In general, if old and renewed paddocks perform similarly (production and quality) and both contain beneficial endophytes, the benefits of cropping or renewal are expected to be small and not economically worthwhile.
Keywords: dairy cattle, simulation

Introduction
Dairy farmers frequently use cropping to renew pastures and to provide feed to fill seasonal pasture deficits and increase lactation length. Crops commonly grown include turnips, maize and kale. These feeds are conserved and fed out or grazed *in situ*. They provide flexible, moderate quality feeds during pasture deficits, assured feed supply, and insulation against fluctuations in prices of supplements sourced off-farm. When feeds are grazed *in situ*, feeding out costs are reduced. Risks and disadvantages of cropping include potential crop failure, loss of pasture production while paddocks are in crop, and high levels of feed wastage.

The opportunity to renew pasture is a key component of the cropping cycle. Cropping before sowing in new pasture provides a pest and disease break (Liebman & Davis 2000), and an opportunity to cultivate soil fully. Cropping also increases the likelihood of establishing new grass cultivars containing selected endophytes (Bluett *et al.* 2004). New pastures have shown increased production of -15 to 50% compared to old and run out pastures (Hainsworth *et al.* 1991; Barker *et al.* 1993; W. King pers. comm.). Greater improvements in pasture production are observed when new pastures are sown after a crop or after old pasture is sprayed with a herbicide before sowing (Bluett *et al.* 2004; Hainsworth *et al.* 1991). Feed quality is higher for new pastures than for old pastures (Woodfield & Easton 2004).

It is uncertain whether it is better to adopt an old pasture-crop-new pasture or old pasture-new pasture regime. Likewise, the increase in production or quality of a new pasture, compared to old pasture that would be required to justify renewal is not known. The objectives of this study were to determine physical performance and profitability of various old pasture-crop-new pasture or old pasture-new pasture scenarios, with and without subsequent increases in pasture production and quality, and assuming that the positive effects on quantity and quality of new pastures persist for 4 or 8 years.

Material and Methods
A simulation approach was adopted using Farmax Dairy Pro (Bryant *et al.* 2010). Farmax Dairy Pro is a whole-farm decision support model that uses monthly estimates of pasture growth, farm and herd information to determine production and economic outcomes of managerial decisions. The model has been validated against several data sets, and has been proven to be accurate (within 6 kg milksolids (MS)/cow and 20 kg MS/ha for individual seasons; Bryant *et al.* 2010). In

this study, representative farms in Waikato, Taranaki, Canterbury (irrigated) and Southland were simulated. The base farms were developed from consultations with industry experts, and assuming average genetic merit for the herds. The base farms did not include a renewal or cropping component. A summary of the physical performance of these farms is provided in Table 1. DairyNZ 2009/2010 forecast expenses were used for each region. A milk price of $6.50/kg MS was assumed. Profit estimated in Farmax Dairy Pro is equivalent to Economic Farm Surplus or Operating Profit.

Old pasture-crop-new pasture scenarios (OP-C-NP)
A single cropping regime was applied to each regional farm, with the exception of Canterbury where a cropping option was not simulated. Key assumptions are presented in Table 2; in the first scenario, no benefits in pasture production or quality due to renewal were assumed. Simulations were subsequently repeated assuming all combinations of the benefits outlined below for renewed paddocks:

- Pasture production (kg DM/ha) boost in the first year: +10, 20 or 30 %
- Pasture quality boost in the first year: +0.3 or 0.6

Table 1 Summary of performance of the regional base farms with no renewal or cropping.

	Waikato	Taranaki	Canterbury	Southland
Effective Area (ha)	119	91	200	171
Peak cows milked	378	278	788	561
Stocking rate (cows/ha)	3.2	3.1	3.9	3.3
Milksolids (kg/ha)	1106	1033	1491	1237
Milksolids (kg/cow)	348	338	379	377
Lactation length (days)	271	261	269	254
Condition score at calving	4.8	4.7	4.8	5.0
Pasture eaten (t DM/ha)	13.1	12.7	15.9	13.2
Average pasture metabolisable energy (MJ/kg DM)	11.4	11.4	11.9	11.6
Forage crops (t DM/ha)	0.0	0.0	0.0	0.0
Bought-in feeds (t DM/ha)	1.2	0.8	2.5	1.1
Total feed eaten (t DM/ha)	14.5	14.1	18.7	14.6
Total supplements/feed eaten (%)	10.1	9.4	15.2	9.5

Table 2 Crops simulated and key assumptions for each of the regions.

	Waikato	Taranaki	Southland
Crop simulated	Maize	Turnips	Kale
Date of sowing	20 Oct	20 Oct	1 Nov
Period out of pasture rotation (days)	201	201	410
Date grazed again in pasture	4 May	4 May	15 Dec
Farm area in crop (% of farm)	10	10	10
Crop yield (t DM/ha)	22	10	14
Cost ($/ha)	3000	1500	1000
Cost of conservation ($/t DM)	50	NA	NA
Utilisation (%)	75	85	75
Metabolisable energy content (MJ/kg DM)	10.5[1]	12.0[2]	10.5[3]
Primary feeding out period	July-Sept, Jan-May	Jan-Mar	May-July

[1]Holmes *et al.* (2002), [2]de Ruiter *et al.* (2007), [3]Judson *et al.* (2009)

Figure 1 Change in milksolids production per hectare compared to the base farms due to increases in pasture production (□ = 0%, ▒ = 10%, ▓ = 20%,,■ = 30%), increases in pasture metabolisable energy (0, 0.3 or 0.6 ME) assuming a 4 (4 yr) or 8 year (8 yr) persistence for old pasture-new pasture (old-new) or old pasture-crop-new pasture scenarios.

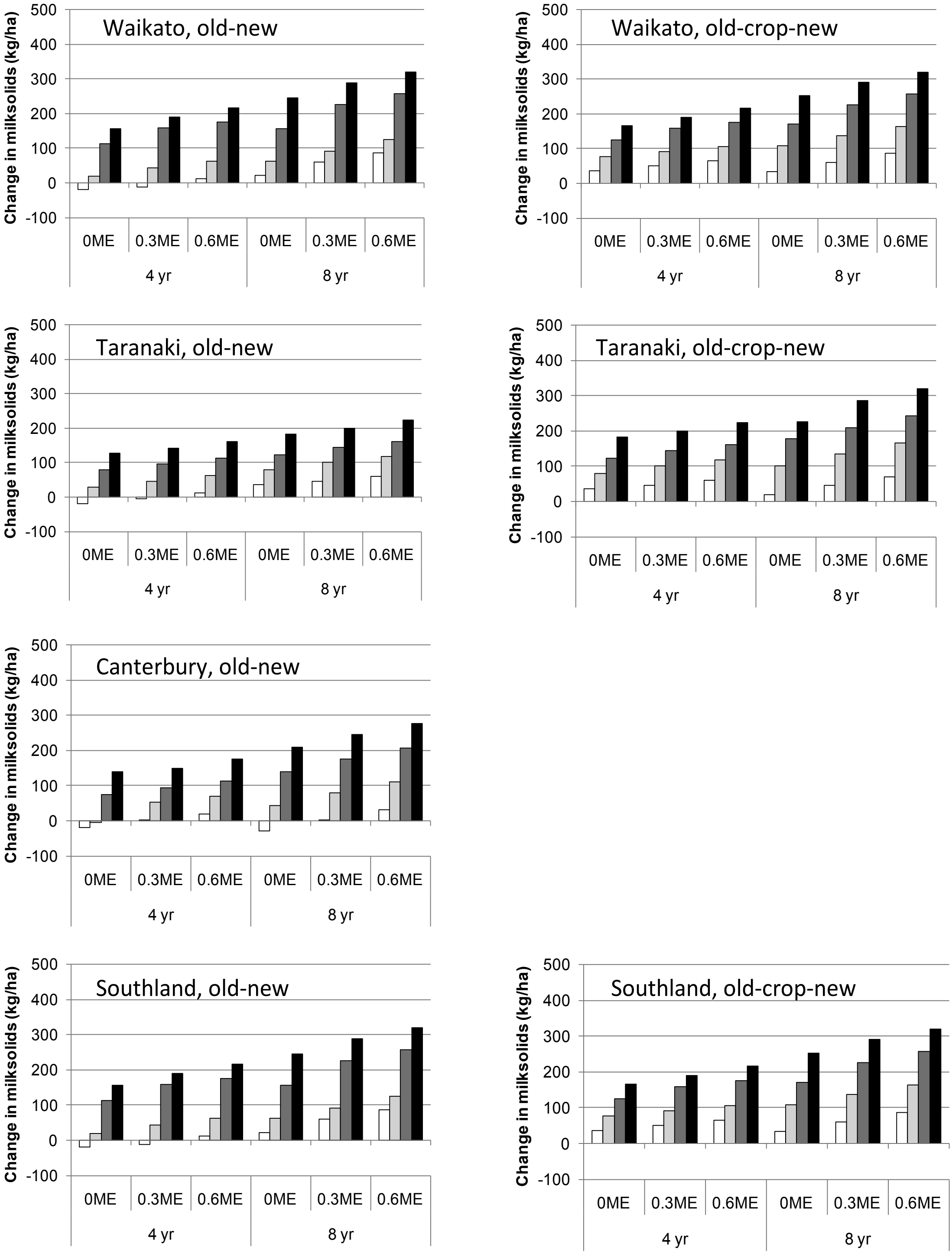
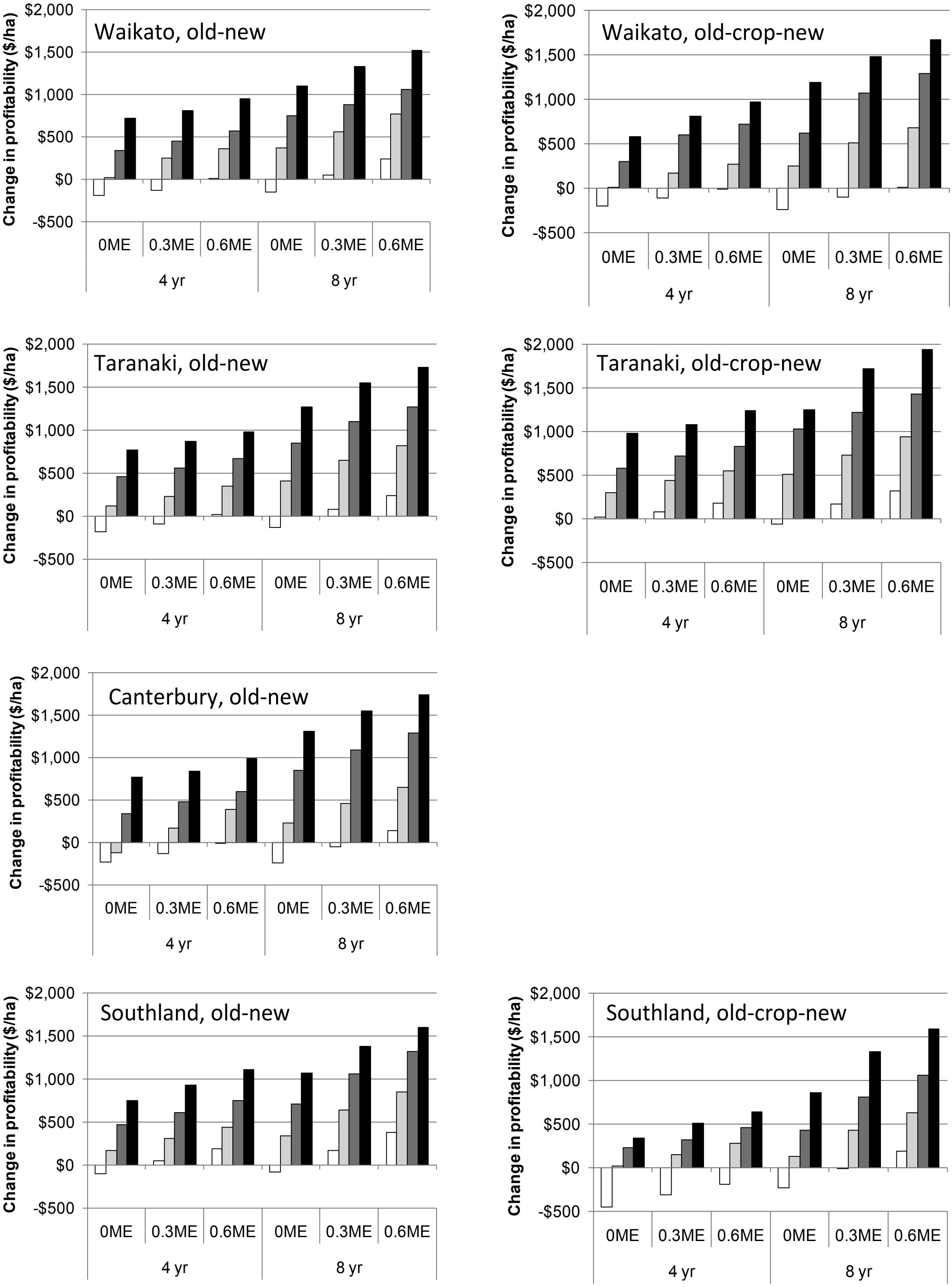


Figure 2 Change in profitability compared to the base farms due to increases in pasture production (□ = 0%, ▫ = 10%, ▪ = 20%,,■ = 30%), increases in pasture metabolisable energy (0, 0.3 or 0.6 ME) assuming a 4 (4 yr) or 8 year (8 yr) persistence for old pasture-new pasture (old-new) or old pasture-crop-new pasture (old-crop-new) scenarios.



MJ ME/kg DM
- Persistence: 4 or 8 years

Persistence was represented by simulating approximately linear reductions in pasture production and quality over time. For instance, for +10% pasture production and +0.3 MJ ME/kg DM increase in quality combination with a 4 year persistence, we represented four blocks constituting 40% of the farm with pasture production and quality increases. In this instance, production and quality increases ranged from 10% and +0.3 MJ ME/kg DM (in the first year after renewal) to 2.5 % and 0.075 MJ ME/kg DM (in the fourth year after renewal) to represent a linear decline over time.

Old pasture-new pasture scenarios (OP-NP)

Direct old pasture-new pasture (OP-NP) scenarios were represented, and it was assumed that new pastures would be excluded from the grazing rotation for 40 days after sowing. Pasture renewal commenced on the 20th of March for Waikato and Taranaki, and the 1st of December for Canterbury and Southland. Pasture renewal costs of $600/ha were assumed. The same renewal effect combinations of improved pasture production and quality at various persistence levels as outlined above were applied to OP-NP scenarios in all regions.

Decision rules

In OP-C-NP scenarios, supplements or crops were fed in response to pasture deficits and at times common for feeding these crops/supplements. In scenarios where pasture production was increased, the following rules were applied to ensure pasture covers at start and end were within ±20 kg DM of the base simulations:

Higher pasture intakes per cow, with no increase in cows per ha

Delayed dry-off date, with longer lactations (days in milk)

No additional supplements were bought in, and nitrogen application rates and dates stayed the same.

Results

Old pasture-crop-new pasture scenarios with turnips (Taranaki) or maize silage (Waikato) increased MS production per hectare when compared to the base scenario, even when no renewal effect was assumed (Fig. 1). However, lower MS yields were seen for kale (Southland) when no renewal effect was assumed. For turnips the increase in MS yield ranged from 32 kg/ha and 10 kg/cow (no renewal effect) to 320 kg/ha and 105 kg/cow for the +30% pasture production, +0.6 MJ ME/kg DM and 8-year persistence combination. For maize conserved as maize silage the increase in MS yield ranged from 36 kg/ha and 11 kg/cow (no renewal effect) to 319 kg/ha and 100 kg/cow for the +30% pasture production, +0.6 MJ ME/kg DM and 8-year persistence combination. For the OP-NP scenarios, MS production was reduced when no renewal effect was assumed, but milksolds yields were significantly higher when 8-year persistence was assumed.

With no renewal effect assumed, OP-C-NP scenarios broke even or were less profitable than the base scenario without renewal or crops (Fig. 2). However, if the OP-C-NP scenario subsequently improved pasture production or quality, this renewal method was highly profitable. Similarly, the OP-NP scenario was profitable when pastures persisted for at least 4 years, and either a 10% increase in pasture production or 0.5 MJ ME/kg DM increase in pasture quality was observed in the first few years after sowing. If no pasture production gains were realised via OP-NP, a 0.4 to 0.5 MJ ME increase in quality was needed to increase profitability. Increased pasture quality in the 10% of farm renewed each year is worth about $44 and $78/ha for every additional 0.1 MJ ME/kg DM, assuming 4 and 8-year persistence of new pasture. On average, and assuming 4-year and 8-year persistence, every 10% increase in pasture production on renewed paddocks is worth $305 and $442/ha, respectively.

Discussion

Pasture renewal via cropping, instead of OP-NP, was most profitable for turnips in Taranaki. On this farm system, turnips provided the highest quality feed, incurred the least grazing wastage, and were grazed *in situ*. Even if no gains in pasture production or quality were realised, turnips broke even at 10 t DM/ha. This is consistent with the findings of Clark (1995). In Southland, it was more profitable to undergo an OP-NP regime than to incorporate a crop. For Southland, an additional 10% increase in pasture production would be required from cropping compared to OP-NP to make cropping worthwhile. Kale performed poorly in terms of profit in this scenario, due to the high assumed wastage, low yields for the period the paddock was out of the rotation and poor quality (10.5 MJ ME/kg DM). Kale is a very common winter feed in Southland and Canterbury, but it is generally grown on support blocks and not on the milking platform. The results of this study suggest this is the best option, as kale grown on the milking platform removes that area from the grazing rotation for more than a year and does not provide enough extra feed to substitute for the lost pasture production. In Southland, OP-NP appears to be the best option for pasture renewal on the milking platform. In the Waikato, there was little difference in profitability of an OP-NP or OP-C-NP regime. Maize was intermediate in terms of profitability because of high wastage and costs and average quality assumed, despite high yields in a period of 6 months. For Waikato and Taranaki, renewal via crops is a viable option if the simulated crop yields can be realised.

The results of this study are highly dependent on its assumptions for crop yields, quality, wastage, and management of crop-related feed and extra pasture produced via renewal. For example, maize silage would be more attractive if wastage could be minimised, for example, with a feeding pad, and/or higher yields could be realised. Yields higher than 22 t DM/ha for maize are common (Densley *et al.* 2001). Planting kale to provide the majority of winter feed may assist to reduce damage to existing pasture over winter. Likewise, we have not considered climate variability affecting pasture production or crop yields, and their subsequent impact on profitability of forage cropping. Nevertheless, our results assume best management practice where, in the case of maize silage, the farmer feeds supplements during pasture deficits and extends lactation to increase MS/cow via increased days in milk. In addition, turnips and kale were gradually introduced into the cow's diet, and were subsequently fed to average levels (2.2 to 6.0 kg DM/cow/day for turnips, and 3.5 to 8.5 kg DM/cow/day for kale) to minimise wastage. Judson *et al.* (2008) demonstrated that offering excessive amounts (>15 kg DM/cow/day) of kale lead to greater wastage. In all scenarios, we assumed increased intakes and performance per cow to ensure similar pasture covers of the base, cropping and renewal scenarios. Failure to achieve this in practice, or increasing stocking rate sufficiently to utilise the extra pasture, would have produced different results. Cropping and pasture renewal expose farmers to risks associated with poor establishment and/or subsequent poor performance. These risks have not been factored into these analyses.

These data suggest that pasture renewal and forage cropping can be economically viable if crops are correctly managed to ensure high yields, and if new pastures are managed appropriately after sowing to ensure increased production and quality. It is also important to address factors such as low fertility, weeds and pests to maximise gains after pasture renovation. The most suitable crops for use as part of a pasture renewal regime have metabolisable energy concentrations equal to or higher than that of pasture, can either be grazed *in situ* or produce high yields per ha in a short growth period. To realise the greatest gains, it is essential the poorest performing paddocks are cropped or renewed first, to ensure the largest net gain per paddock. Overall, a 2.5 to 5% increase in pasture production would justify renewal if pasture persisted for at least 4 years. If all existing pastures contain novel endophytes that do not produce toxins (lolitrem B, ergovaline) and perform similarly (production and quality), the benefits of cropping or renewal are expected to be small and not economically worthwhile.

REFERENCES

Barker, D.J.; Lancashire, J.A.; Moloney, S.C.; Dymock, N.; Stevens, D.R.; Turner, J.D.; Scott, D.; Archie, W.J. 1993. Introduction, production, and persistence of five grass species in dry hill country. 8. Summary and conclusions. *New Zealand Journal of Agricultural Research 36*: 61-66.

Bluett, S. J.; Thom, E. R. ; Dow, B. W. ; Burggraaf, V. T.; Hume, D. E. ; Davies, E., Tapper, B. A. 2004. Effects of natural reseeding and establishment method on contamination of a novel endophyte-infected perennial ryegrass dairy pasture with other ryegrass/endophyte associations. *New Zealand Journal of Agricultural Research 47*: 333-344.

Bryant, J. R.; Ogle, G.; Marshall, P. R.; Glassey, C. B.; Lancaster, J. A. S.; García, 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.

Clark, D. A. 1995: Summer milk – pasture and crops. Proceedings of the Ruakura Dairy Farmers' Conference. pp. 10-16.

Densley, R.; Miller, D.; Kolver, E.S. 2001. Breaking the feed barrier using maize silage. *Proceedings of the New Zealand Grassland Association 63*: 289-294.

de Ruiter, J.M.; Dalley, D.E.; Hughes, T.P.; Fraser, T.J.; Dewhurst, R.J. 2007. Types of supplements: their nutritive value and use. pp. 97-115. *In*: Pasture and supplements for grazing animals. Eds. Rattray, P.V.; Brookes, I.M.; Nicol, A.M. New Zealand Society of Animal Production, Occasional Publication 14.

Hainsworth, R. J.; Thomson, N. A.; McCallum, D. A.; Judd, T. G. 1991. Evaluation of dryland species and new ryegrass cultivars to increase pasture productivity in coastal Taranaki. *Proceedings of the New Zealand Grassland Association 53*: 55-58.

Holmes, C. W.; Brookes, I. M.; Garrick, D. J.; Mackenzie, D. D. S.; Parkinson, T. J.; Wilson, G. F. 2002. Nutrition: food intake and nutritive value. pp. 263–294. *In*: Milk production from pasture. Massey University Press, Palmerston North, New Zealand.

Judson, H. G.; Edwards, G. R. 2008. Survey of management practices of dairy cows grazing kale in Canterbury. *Proceedings of the New Zealand Grassland Association 70*: 249-254.

Liebman, M.; Davis, A. S. 2000. Integration of soil, crop and weed management in low-external-input farming systems. *Weed Research 40*: 27-47.

Woodfield, D. R.; Easton, H. S. 2004. Advances in pasture plant breeding for animal productivity and health. *New Zealand Veterinary Journal 52*: 300-310.