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Systems and economic analysis of the use of maize silage within pasture-based beef production

J.G. CARRACELAS[1], C.J. BOOM[1], A.J. LITHERLAND[1], W.McG. KING[1], and I.D. WILLIAMS[2]

[1]AgResearch Ruakura, Private Bag 3123, Hamilton, New Zealand
[2]Genetic Technologies Ltd., P.O. Box 105-303, Auckland, New Zealand

ABSTRACT

The productivity and profitability of the use of maize silage (MS) within pasture-based beef production systems was evaluated using the Farmax Pro® model. Farm systems were simulated based on an intensive one-year-old steer production system with two pasture growth patterns (Waikato and Hawkes Bay), three different proportions of the farm in MS production (0%, 5% or 10%) and MS fed either during winter (W) or summer (S). MS cost 13.5 and 16.1 c/kg dry matter (DM) for Waikato and Hawkes Bay respectively. This price included the cost of growing, harvesting, ensiling and feeding. Beef schedule prices were based on $1.80/kg live weight (LW). Feeding MS increased beef production in all scenarios tested by a mean of 36% with values of 427, 581 and 576 kg net meat/ha/year for the no MS, S and W feeding systems respectively. Farm profitability (gross margin per hectare) was increased by feeding MS in W and S, with values of $934 and $754 respectively, compared with the no MS system of $636. MS feeding was still profitable at a schedule price of $1.40/kg LW and at higher MS costs up to 23 c/kg DM. Appropriate use of MS in beef production systems can substantially improve animal performance and farm profitability.

Keywords: beef production; cattle; Farmax; farm systems; maize silage; profit.

INTRODUCTION

Grazed pastures are the principal source of feed for livestock production systems in New Zealand. Energy intake is the main animal productivity limiting factor in solely pasture-based farming systems (Waghorn & Clark, 2004). Maize silage (MS) may give higher levels of animal production by providing extra energy to finish cattle at key times of the year, increasing the rate of carcass weight gain, reducing pasture consumption through substitution and creating marketing advantages (Reardon, 1975).

The carbohydrate-protein balance in an animal's diet can be improved by feeding a high-energy, low protein supplement like MS with high protein pasture forage (Reardon *et al.,* 1976; Densley *et al*., 2005). Crude protein values have been assessed for MS and pastures at 7.5% and 18.5% respectively but soluble sugars are often considerably higher in MS (35%) than in pastures (8.5%) (Corson *et al*., 1999). To avoid protein and mineral deficiencies the proportion of MS should be lower than 70% of the diet for young cattle (Clark & Woodward, 2007). The metabolisable energy content of MS can range from 10.3 to 11.3 MJ/kg dry matter (DM) (Miller *et al.,* 2005).

On-farm maize cropping for silage can substantially increase the amount of feed produced. MS yields can range from 16 to 29 t DM/ha/year, depending on variety and growth conditions (Marshall, 1975; Miller *et al.,* 2005; Densley *et al.,* 2006). Total paddock yields of 37.6 t DM/ha/year are achievable using a rotation system that combines a maize crop followed by a winter forage crop like triticale (Densley *et al.,* 2006).

Maize silage is a cost effective supplementary feed that is widely used in the dairy industry (Densley *et al*., 2001). However, there is very little published information about the economics of feeding MS to beef cattle in New Zealand.

The aim of this paper was to analyse the factors which affect the profitable use of MS within pasture-based beef finishing systems using a farm systems model. The potential beneficial environmental outcomes of implementing these farming systems were not evaluated in this study.

METHODS

The farm systems analysis was undertaken using the farm systems model Farmax, formerly Stockpol (Marshall *et al.,* 1991; Webby *et al.,* 1995; Webby & Bywater, 2007). The Farmax model requires the input of cattle liveweight gain (LWG). For this reason the supplementary feeding model Be$tFeed, developed by AgResearch for Meat and Wool New Zealand, was used to estimate LWG responses for different MS feeding rates, pasture qualities and cattle live weight (LW). The equations used to determine steer LWG were:

1. Pasture intake (DM kg/hd/d) = (-0.68 × Maize intake (DM kg/hd/d)) + (0.40 × ME of pasture (MJ/kg/DM)) + (0.018 × Cattle live weight (kg)) -1.67
2. LWG (kg/h/d) = [(0.63 × Maize intake (DM kg/hd/d)) + (0.83 × Pasture intake (DM kg/hd/d)) + (0.13 × (ME of pasture)) – (0.014 × Cattle live weight (kg)) - 2.65] × 0.95

The combinations tested with Farmax were 0%, 5% or 10% of farm area in MS production, MS fed within the farm during winter from June to September or summer from December to March and pasture growth profiles for the Waikato (wet summer and warm winter) and Hawkes Bay (dry summer and cool winter). A nine year average annual pasture production of 13.8 t DM/ha/year was used for Waikato, with a winter soil temperature of 8°C and an average rainfall of 1,193 mm/year. The 11 year average annual pasture production used for Hawkes Bay was 9.1 t DM/ha/year, with winter soil temperature of 6°C and an average rainfall of 847 mm/year (Information from Stockpol Version 4 pastures library).

All systems had 60 kg N/ha applied in two dressings over the whole farm during May and August with a total cost of $72/ha and a pasture response of 12 and 15 kg DM/kg N respectively.

All scenarios presented in this paper were based on a one year old intensive steer production system involving 230 kg live weight steers purchased on 1 April at 7 months of age for $490/hd and sold as stores at around 20 months of age. Only one time of cattle purchase was allowed, however, livestock could be sold at any time up until 30 March in the following year. Stocking rate was maximised based on pasture cover, timing of sales and a predetermined LWG. Sale dates were altered within each scenario to obtain the maximum gross margin (GM) and maximum pasture utilisation while keeping the scenario feasible.

Farmax uses an indicator price for livestock which is the average price over the year, taking account of seasonal trends in livestock prices. Livestock indicator prices of $1.40, $1.80 or $2.20/kg LW were used in this analysis.

The energy content of MS used for this analysis was 10.6 MJ ME/kg DM (Data supplied by feedTECH AgResearch Grasslands) while average pasture quality for both locations was 10.2 MJ ME/kg DM. Total MS production used for the Waikato and Hawkes Bay models was 25 and 21 t DM/ha respectively. The cost of producing, ensiling, and feeding MS assumed for Waikato was 13.5 c/kg DM and for Hawkes Bay was 16.1 c/kgDM. A range of MS costs of 13.5, 16.1, 19, 23, 28, 35 and 42 c/kg DM were tested. The maize crop was followed by permanent pasture. The extra cost of regrassing and the benefit of sowing new pastures were not considered in this analysis but the loss of pasture production during maize growing was included.

RESULTS

Relationship between feed supply and animal feed demand

Waikato pasture production was higher than Hawkes Bay especially from mid spring to the beginning of autumn (Figure 1). The timing of feeding MS during summer and winter was intended to optimise the farm system's pasture utilisation, animal production and profitability. Feeding MS during summer meant that animals could be retained longer and sold at a heavier weight; while feeding MS during winter allowed higher stocking rates and improved spring pasture utilisation.

Animal liveweight gain response

Be$tFeed predicted that feeding MS to steers on low quality pastures (9.5 MJ ME/kg DM), would decrease intake of pasture by 0.5 kg for every 1 kg of MS fed but total feed intake and quality would increase and therefore LWG of steers would improve by 0.2 kg LWG/kg MS. With medium quality pastures (10.5 MJ ME/kg DM) Be$tFeed predicted a substitution rate of 0.67 kg pasture/kg MS and a LWG response of 0.03 kg LWG/kg MS. When MS was fed with high quality pasture (11.5 MJ ME/kg DM) it was predicted that substitution would increase to 0.74 kg pasture/kg MS, overall diet quality would decrease and LWG would be similar.

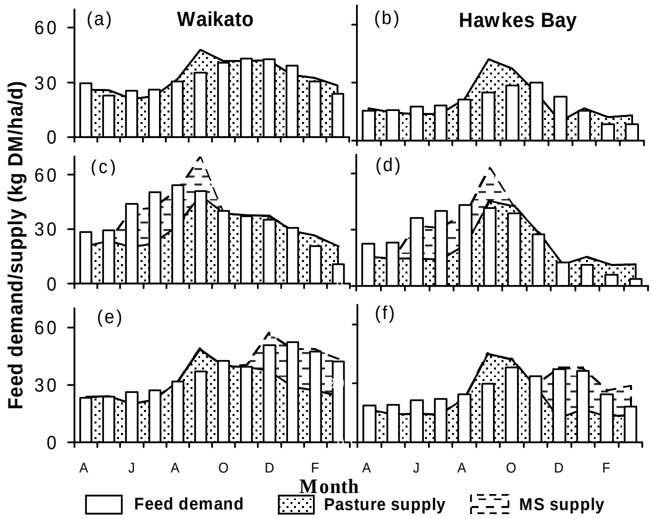
Financial and production performance indicators

Maize silage increased farm system profitability and production in all scenarios tested

TABLE 1: Summary of principal indicators of annual production and financial farm system performance obtained using the Farmax model for two regional growth patterns with maize silage (MS) grown on different proportions of the land area (0, 5 or 10%) and fed for 120 days in either winter (W) or summer (S). FCE = Feed conversion efficiency (kg DM eaten/kg product).

System	Gross margin ($/ha)	Net meat (kg/ha/yr)	Mean live weight at sale (kg)	Mean sale value ($/hd)	Mean live weight gain (kg/hd/d)	Total MS used (t fed/ha)	Stocking level (steers/ha)	FCE
Waikato								
0%	737	528	449	731	0.59	0	4.5	22.5
W 5%	1,087	635	442	797	0.74	1.25	5.0	18.8
W 10%	1,169	706	458	813	0.76	2.50	5.8	18.7
S 5%	926	659	506	845	0.71	1.25	4.7	19.4
S 10%	904	720	533	876	0.77	2.50	4.7	18.8
Hawkes Bay								
0 %	535	325	429	735	0.61	0	3.2	21.3
W 5%	694	450	463	800	0.77	1.05	3.6	17.4
W 10%	786	511	442	794	0.78	2.10	4.6	17.7
S 5%	639	441	449	769	0.84	1.05	3.8	18.9
S 10%	548	504	472	794	0.82	2.10	3.8	18.4

FIGURE 1: Animal feed demand (kg DM/ha/day) - open bars- and feed supply (pasture + maize silage (MS) (kg DM/ha/day)) -shaded areas- for one-year-old cattle in Waikato and Hawkes Bay, for No MS (a) and (b), MS fed in winter with 10% of the farm in MS production, (c) and (d) or MS fed in summer 10% (e) and (f) calculated using the Farmax Pro® model.



(Table 1). Winter was a more profitable time to fed MS than summer in both regions mainly due to the higher number of steers sold in winter feeding systems. Using relatively small amounts of MS during winter (5% of land area) resulted in substantial increases in profitability. Averaging across the two regions this was due to an increase in meat production (+27%), LWG (+26%), feed conversion efficiency (+17%), number of steers/ha (+12%) and value per head (+9%) in relation to the no MS system.

When MS was fed during summer, farm profitability was not improved by growing MS on more than 5% of farm area.

The most profitable system for both regions was the Winter 10% with a GM increase with respect to the no MS system of 53%. Averaging across the two regions this increase in GM was explained principally by a 45% increase in meat production with 36% more steers wintered and a 28% increase in mean LWG, a 10% increase in selling value because the sales period started around 4 months earlier and also an improved feed conversion efficiency of 17%.

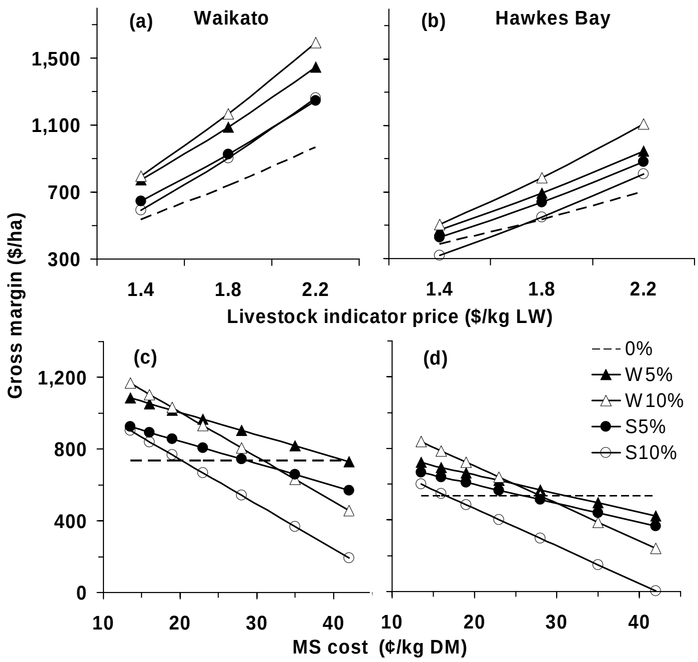
Variations in livestock prices and MS cost can substantially change profitability (Figure 2). An increase in the livestock indicator price to $2.20/kg LW resulted in a further advantage in profitability of MS use relative to a no MS system ($1387 vs. $966 /ha for Waikato and $937 vs. $704/ha for Hawkes Bay respectively). A decrease in beef prices to $1.40/kg reduced the advantage of MS, however the use of MS would still be more profitable than no MS in most of the systems tested ($702 vs. $536/ha for Waikato and $431 vs. $386/ha for Hawkes Bay respectively).

Producing MS at a higher cost in Waikato up to 23 c/kg DM was still more profitable than no MS system for most systems except for Summer 10%. When MS cost in this region was increased to 35 c/kg DM, only Winter 5% was still more profitable than no MS. At 42 c/kg DM all the systems were less profitable than no MS system. Hawkes Bay showed a similar trend but only Winter 5% was more profitable than no MS when it was produced at 28 c/kg DM. Further increases in MS costs to 35 and 42 c/kg DM were not economically viable for this region.

DISCUSSION

Despite the high cost of producing MS, Farmax modelling showed that the use of MS within beef farming systems could improve productivity and profitability. Winter was a better time to feed MS than summer. This was explained mainly by a 15% and 8% increase in stocking rate when MS was fed in winter than summer for Waikato and Hawkes Bay respectively. Feeding MS in winter also allowed a

FIGURE 2: Gross margin ($/ha) obtained with three livestock indicator prices ($/kg LW) at a maize silage (MS) production cost of 13.5c/kg DM in the Waikato and 16.1c/kg DM in the Hawkes Bay (a) and (b), and with seven MS production costs (c/kg DM) at a livestock indicator price of $1.80/kg LW in the Waikato and Hawkes Bay (c) and (d), for different proportions of the land area (0%, 5% or 10%) being used to grow MS in winter (W) or summer (S), calculated using the Farmax Pro® model.



proportion of steers to be sold on the high value spring market. In both regions, the profitability of MS feeding during winter increased as the proportion of the farm used to grow MS increased. This was mainly due to an increase in the total number of animals sold and higher meat production/ha. However, when MS was fed during summer, farm profitability was not improved by growing MS on more than 5% of the farm area. In the summer fed MS systems, pasture cover during winter limited the increase in stocking rate because of the rule that all livestock must be purchased on 1 April. If spring or summer purchase was allowed then higher levels of MS summer feeding may have increased profitability.

At livestock indicator prices of $1.40 to $2.20/kg LW and MS cost of 13.5 and 16.1 c/kg DM for Waikato and Hawkes Bay respectively, feeding MS in winter was always profitable. It was also profitable in summer with the exception of Hawkes Bay in Summer 10%. At a market price of $1.80/kg LW, the break even cost of MS was in excess of 23 c/kg DM for Hawkes Bay and 28 c/kg DM for Waikato except for Summer 10% scenarios. The highest breakeven cost of MS was 42 c/kg DM for Winter 5% in the Waikato.

The average calculated LWG used in our study of 1.07 kg/hd/d during the MS feeding period for Waikato and Hawkes Bay was in line with information provided by farmers and with the results reported by Reardon *et al*. (1976). Feeding MS improved average LWG from 0.54 to 1.07 kg/hd/d with no substantial differences between winter and summer for both regions. The calculated LWG response to MS was on average 0.14 kg LWG/kg MS. This result was in line with LWG responses to feeding maize grain or pasture silage to pasture-fed steers reported by Boom and Sheath (1998). Average calculated pasture substitution rate in our work was 0.64 kg/kg MS. This result was also in line with those reported by Reardon (1975), Boom and Sheath (1998) and Clark and Woodward (2007).

In conclusion, substantial increases in profitability can be achieved by growing MS, even on a small percentage of total land area (5%). Feeding MS during winter at approximately 3 kg/hd/d resulted in a LWG of around 1.00 kg/hd/d and increased the number of animals sold in periods where there was a significant increase in livestock value. Results reported in this paper were obtained using a simulation model with some survey of farmer's experience for validation. However, demonstration of profitable use of MS to beef cattle finishing systems is required to further support the results reported here and to evaluate the potential environmental impacts.

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