Development and testing of new performance measures for milksolids production per hectare

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Abstract

With increased use of feed from outside the effective milking area on dairy farms, milksolids (MS) per effective ha is no longer a sound basis for comparing farms and evaluating options for improving efficiency and profitability. Development of new, quantitative measures for feed and land use efficiency is required. These measures should take account of the extra land used to grow all feed types used for MS production and define how well the feed grown and purchased is converted into MS. Two methods were used to re-calculate MS per ha for six high performing farms (average of 2073 kg MS per effective ha) using a wide range of imported feed. Using these calculations, the farms averaged 1513 kg MS per total ha used and 1450 kg MS per ha produced from home grown pasture and crops. Yields of home grown pasture and crop harvested per effective ha ranged from 14.7 to 17.5 t DM per ha and feed conversion efficiency ranged from 85-94 kg MS per tonne DM. These benchmarks can be used to identify opportunities to improve pasture grown, harvested and converted into milksolids on NZ dairy farms.

Keywords: milksolids per hectare, imported feed, pasture harvested per ha, feed conversion efficiency

Introduction

Sustainable, profitable dairying in New Zealand depends on maximising the efficiencies with which pasture is grown, harvested and converted into milk by grazing cows.

New Zealand dairy farmers are increasingly reliant on feed from outside the effective milking area of their farms (effective milking area = total farm area less that area that cannot be grazed) (DairyBase Reference Manual 2006). Unpublished data from Dexcel's Economic Survey of New Zealand Dairy Farmers show that from 1997 to 2005 the amount of feed brought in from outside the effective milking area increased from 0.64 tonnes dry matter per ha (t DM/ha) to 1.47 t DM/ha, a rate of +0.10 t DM/ha per year.

The amount and cost of imported feed and how effectively it is used can create large differences in the financial and physical performance of farms. These are not reflected by comparing MS production per effective milking hectare. In research farmlet comparisons, increased amounts of feed imported from outside the effective milking area increased MS production per ha but did not always increase profitability (Jensen *et al*. 2005; Macdonald 1999). In a study of 626 commercial NZ dairy farms, farmers using large amounts of imported feed produced more MS per ha compared to farms using lower amounts or no imported feed , but there were no differences in profitability between groups (Silva-Villacorta *et al*. 2005).

Importing feed on to dairy farms can improve profitability of dairy farming where it drives increases in pasture harvested per ha, is well managed and the costs of feeding are contained (Hedley *et al*. 2006). Importing feed also increases the resource use of land, fuel and fertiliser and therefore the environmental footprint of dairying. Unpublished data from Dexcel's Economic Survey shows that for every 1 ha of milking land in the Waikato another 0.3 ha of land is used to support production.

Dexcel's Resource Efficient Dairying trial (Jensen *et al*. 2005) highlighted how additional land and feed resources supporting a high feed-input farm system alters the system's financial viability and environmental impact. The efficiency with which all resources are used needs to be measured and compared to a low input system or an industry standard. Profitability measures provide one indicator of efficiency but this is not based on total land and feed resource use from the biological and environmental view. For this reason, testing and developing new measures that count all the hectares used for supplying feed for MS production on dairy farms is underway. In addition, there is a need to benchmark the highest levels of current annual energy and DM yield of pastures and forages in relation to progress towards dairy industry research targets (Anon. 2005).

Methods

To account for additional hectares supplying feed, two methods of re-calculating MS/ha were compared for six high performing dairy farms representing a wide range in the quantity of feed imported. In addition, a farmlet has been established with the aim of identifying the limit for how many MS can be produced from feed grown on a set area, without importing feed. These two methods have been developed and trialled for use by farmers and consultants.

Table 1   Example of milk solids/total ha used, calculated for a 100 effective ha farm producing 150,000 kg milksolids/ha (1500 kg milksolids/effective ha).

Feed type	Feed imported (kg DM)	ME content of feed (MJ ME/kg DM)	Total ME imported (MJ)
Maize silage	75 000	10.5	787 500
Hay	23 622	9	212 598
		Total imported energy	1 000 098
		Divide by standard energy ha	220 000
	Additional hectares to add onto effective milking area		4.55 ha
		Total milksolids	150 000 kg MS
		Divide by total hectares used	104.55 ha
		Milksolids per total ha used	1435

Method A: Milksolids per total ha used
This is calculated as follows:
Step One: Estimating annual feed energy imported to the farm using the weight of feed imported in DM and converting to metabolisable energy (MJME) either using known (measured) energy content or standard energy values for each type of feed (Dexcel Farm fact.5-1, www.dexcel.co.nz).

Step Two: Total annual feed energy imported is divided by a standard energy hectare. The standard proposed represents 1 ha growing 21 tonne DM of maize silage of 10.5 MJ ME/kg DM or 220,000 MJ ME/ha.
An example of this calculation can be found in Table 1.

Method B: Milksolids per ha equivalent from home grown feed
This can be calculated as follows:
Step One: Calculation of total pasture and crop energy eaten is calculated as MJ ME/ha, and total kg DM eaten/ha.
An estimate of the annual energy requirements to support a level of milksolids production per effective ha can be completed using standard energy equations. Calculators to assist this process are available on the internet; e.g. from Massey University at http://www.dairy3.org.nz/page.php?9

Similar calculations are performed for a farm supplying level two physical data to DairyBase (DairyBase Reference Manual 2006) and are based on the following; Total Energy Eaten (MJ) calculated from energy used per cow for:
Milksolids – Annual milksolids production (kg)
Maintenance
Processing low/high quality feed and the cost of grazing
Pregnancy
Walking

Multiply by stocking rate (cows per effective milking ha)
= Total energy eaten MJ ME/ha
Divide this figure by the average MJ ME/kg DM of the pasture and supplements over the year.
= Total tonnes DM eaten/ha

Step Two: Calculate energy eaten from home grown feed MJME/ha
Total energy eaten/ha
Less energy eaten from imported supplements
kg DM supplements per ha x Utilisation x Quality MJ ME/kg DM
= Energy eaten/ha from home grown feed

Step Three: Calculation of tonnes of dry matter eaten/ha from home grown feed
Energy eaten (MJ ME/ha) from home grown feed (Step Two) divided by the average quality of the pasture and crop (MJ ME/kg DM, either the standard values or measured values if known).
= Tonnes DM eaten/ha from home grown feed.

Step Four: Calculation of kg DM eaten/kg MS
Total tonnes of dry matter eaten/ha (from Step One)
Divided by MS per effective milking ha.
= kg DM eaten per kg MS

Step Five: Calculation of MS/ha from home grown pasture and crop eaten
(Tonnes home grown DM eaten /ha)
(kg DM eaten /kg MS) x 1000
= MS/ha from home grown pasture/crop

Example:
Step 1: Herd of 490 kg cows, producing 483 kg milksolids requires 56 380 MJ ME/cow/yr. For a farm stocked at 3.6 cows/ha this is 202 968 MJ ME/ha.
At an average ME of 11.7 MJ/kg DM this equates to 17 348 kg DM/ha.

Step 2:1000 kg DM per cow is imported in the form of maize silage at 10.5 MJ ME/kg DM =10 500 MJ ME/cow x 80% utilisation x 3.6 cows per ha = 30 240 MJ

ME/ha.

Energy eaten from home grown feed is 202 968 - 30 240 = 172 728 MJME/ha.

Step 3: Pasture is 11.9 MJ ME/kg DM and maize silage 10.5 MJ ME/kg DM

Home grown pasture = 172 728 MJ ME/11.9 = 14 515 kg DM/ha

Maize = 30240 MJ ME/10.5 = 2880 kg DM/ha

Total DM eaten = 17 395 kg DM/ha.

Average ME eaten = 202 968 MJ ME/17 395 = 11.7 MJ ME

Step 4:

17 395 kg DM produces 1738 kg MS/ha (3.6 cows/ha. x 483 kg MS/cow) = 10.0 kg DM/kg MS

Step 5: $\underline{\text{Total home grown feed eaten}} = \underline{14\ 515}$
    kg DM eaten per kg MS   10
= 1 451 kg MS/ha produced from home grown feed

Using the above methods a comparison between six different high performing farm systems was completed.

These farms include two high performing commercial Waikato dairy farms (Farms 1 & 2), Lincoln University Dairy Farm (Farm 3) and three Dexcel farmlets, Super Productivity Farmlet, RED Trial Treatment E and the Strain Trial (Farms 4 – 6 respectively) (Table 2).

Establishment of a prototype "Super Productivity" farmlet:

In June 2006, a farmlet of 8 ha with 29 cows was established at Dexcel's Scott Farm near Hamilton. This project aims to determine how the boundaries to sustainable and productive dairy farming can be moved. Specifically, this is to increase the production of milksolids/total ha used by 20% to 1750 kg MS/total ha. This addresses the improvement required in the amount of feed energy grown from a defined area and having that converted into MS. All feed that contributes to this production must be grown within the farmlet boundaries.

The performance will be benchmarked against leading commercial farms on an annual basis in relation to MS production/total ha used, net herbage accumulation, pasture eaten, pasture and forage crop energy eaten, and economic farm surplus/ha.

Table 2 A comparison milksolids/total ha used for six dairy farm systems with imported feed energy converted to standard additional hectares (Method A).

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5[1]	Farm 6[2]
MS/effective milking ha	2460	2948	1772	1480	2230	1549
Estimated GJ ME/ha imported feed	105.5	202.9	31.2	0	133.6	15.1
Additional standard ha. as % of effective milking ha	47%	92%	14%	0	60%	7%
MS/total ha used	1677	1533	1552	1480	1388	1448

[1] Jensen *et al.* 2005
[2] Macdonald *et al.* 2005

Figure 1 A comparison of milksolids/effective ha, milksolids/total ha and milksolids/ha from home grown feed for six high performing farms.

□ MS per effective ha. ☒ MS per total ha ▥ MS per ha from Home Grown feed
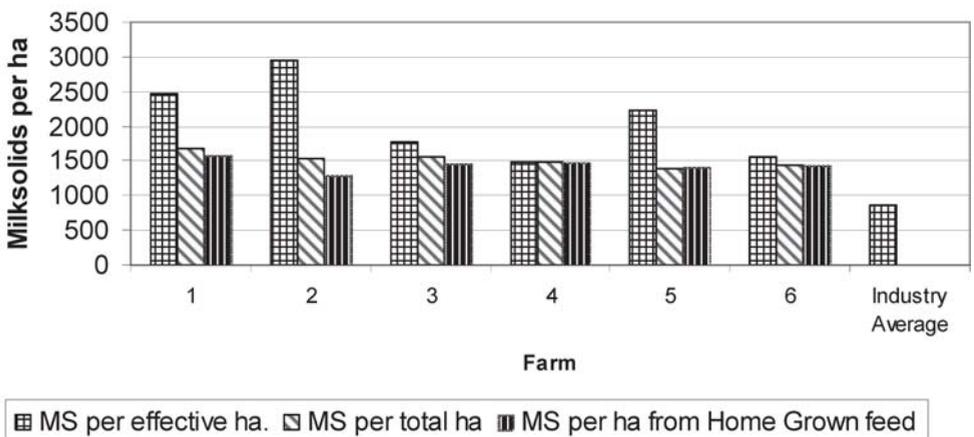
Results and Discussion

Method A: Comparing MS per total ha used with MS/effective milking ha

The production of the six selected farms ranged from 1480 to 2948 kg MS/effective ha compared with the industry average of 862 kg MS/ha. After calculating MS/total ha used the range was reduced to 1388 to1677 kg MS/total ha used (Table 2 and Fig. 1)

Method B: Calculating MS per ha equivalent from home grown feed

A comparison of the same six farms using Method B produced a range from 1299 to 1589 kg MS/ha from home grown feed and resulted in some re-ranking of the farms (Table 3). With Method B, estimates of MS production were on average 63 kg MS/ha lower than using Method A. Method B includes an estimate of the pasture and crop harvested inside the effective milking area and this increases the sensitivity of the measure where larger amounts of imported feed have been used to generate more MS. The standardised hectares method (Method A) uses an estimate of the total energy in DM offered to the herd and the area involved in supplying that feed using a standard yield per ha for all farms. Method B takes into account the efficiency with which supplement is used to produce milksolids on each individual farm. This efficiency is influenced by quality and utilisation of the supplement, and how well this supplement is integrated with the pasture harvested.

The farm where the ranking shifted the most was farm 2, a farm with the highest total feed supply, the highest proportion of imported feed and the most varied types of supplementary feed. The more self-contained a farm is in relation to feed supply, the easier it is to estimate total land resource use because there are fewer steps and less estimates.

Prototype farm

The prototype farm (Farm 4) provides a benchmark because all feed is produced in a known area and is of similar type which reduces the number of assumptions used for feed utilisation and feed quality. In its first season of operation the prototype farm achieved 1480 kg MS/total ha from an estimated 16.4 tonne DM/ha eaten. This is 15% short of the target production of 1750 kg MS per ha.

Achieving 1750 kg MS/total ha used

The comparisons demonstrated that leading NZ dairy farms are currently producing at a level of just over 1500 kg MS/total ha used. To achieve this, they are strategically using feeds brought in from outside the dairy farm to obtain a pasture and forage consumption approaching 200 GJ ME/ha (Table 4) and are converting feed to milk production at 85-95 kg MS/t DM. The DM harvested from the milking area for the highest MS/ha farm is estimated at 17.5 t DM/ha (using Dexcel's Profit Doctor). To achieve 1750 kg MS/total ha used at the current level of feed conversion efficiency for this farm (91 kg MS/t DM, Table 4), on average 19.5 tonnes DM/ha (i.e. an additional 1.7 tonnes DM/ha) would need to be harvested. Assuming this extra feed contains 11.5 MJ ME/kg DM, this is an additional 19.5 GJ ME/ha (a total of 220 GJ ME/ha). Assuming that the current rate of utilisation of the feed is 75% of what is currently grown (Macdonald *et al*. 2001), then current DM grown on this farm is likely to be 23.3 t/ha . If there were no gains in feed utilisation, then increasing the DM grown to 25 t DM/ha is required. Alternatively an increase in feed utilisation to 82% of current feed grown would capture the extra feed required to achieve 1750 kg MS/ ha, as would an improvement in feed conversion efficiency, to 100 kg MS/t DM.

Table 3   A comparison of milksolids/ha for six farms using two methods for accounting for additional land used for supplying feed.

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Mean
Method A	1677	1533	1552	1480	1388	1448	1513
Ranking	1	3	2	4	6	5	
Method B	1589	1299	1467	1480	1420	1443	1450
Ranking	1	6	3	2	5	4	

Table 4   Estimates of feed eaten (t DM/ha), feed conversion efficiency (kg MS/t DM) and home grown energy eaten (GJ ME/ha) for six farms.

| | Farm 1 | Farm 2 | Farm 3 | Farm 4 | Farm 5 | Farm 6 | Industry |
	1	2	3	4	5	6	average[1]
Feed eaten	27.1	33.4	19.6	16.4	26.2	16.42	12.2
Feed conversion	91	88	90.4	89.7	85	94	77
Home grown energy eaten	201.1	169	197	186	195	179	Not calculated

[1] W. Montgomerie pers. comm.

Conclusion

The quickest and easiest method of recalculating MS/effective ha to a value that provides a better indicator of resource use is Method A. While there is reasonable agreement between the two methods, the use of standardised hectares in Method A may not reflect efficiencies gained by individual farms. Method B is more farm specific and requires more complex calculations for each farm. It is likely that farmers will struggle to collect and use the data for this calculation themselves although inputs for this calculation can be produced for them from DairyBase. (DairyBase Reference Manual 2006). Encouraging farmers to assess farm performance beyond MS/effective ha will allow identification of opportunities to improve pasture grown, harvested and converted into milksolids. It will also allow researchers to identify opportunities and monitor progress against industry research targets for feed use on farms.

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