Feeding Systems and Water Use Efficiency in Irrigated Dairying in Northern Victoria and Southern New South Wales

P. T. Doyle¹, D. P. Armstrong¹, J. E. Knee¹, K. E. Pritchard¹ and O. A. Gyles²

¹Department of Natural Resources and Environment, Kyabram Dairy Centre, Institute of Sustainable Irrigated Agriculture, 120 Cooma Rd, Kyabram, Victoria, Australia 3620. ²Department of Natural Resources and Environment, Institute of Sustainable Irrigated Agriculture, Ferguson Rd, Tatura, Victoria, Australia 3616.

ABSTRACT:
The effects of feeding practices on water use efficiency (WUE), defined as the amount of milk fat plus protein produced per megalitre of water, on irrigated dairy farms were examined in two studies. High WUE was associated with higher pasture consumption per hectare, higher stocking rates and higher milk production per cow when compared with the characteristics of low WUE farms. The proportion of energy in the cow's diet from brought in supplements did not affect WUE, and there were high and low supplement users in efficient and inefficient farms. This indicates that some farmers have the managerial skills to use supplements effectively in pasture-based dairy systems, while others were probably substituting supplement for pasture in the cow's diet.

Key Words: Water Use Efficiency, Feeding Systems, Dairying, Irrigation

INTRODUCTION

In northern Victoria and southern New South Wales, where annual rainfall is about 400 mm, dairy production is dependent on irrigation water to grow perennial and annual pastures and fodder crops. Milk production in the region has increased by 50% during the last decade and accounts for over 25% of Australia's milk production (ADC 1994, 1998).

Limits on the availability of water, rising production costs and environmental issues, such as rising watertables and nutrient runoff, have made investigating production and economic water use efficiency (WUE) important to the future of the industry. WUE on irrigated dairy farms is influenced by irrigation practices, including water re-use, feed production and nutritive characteristics, stocking rate, supplementary feeding practices and efficient conversion of consumed energy into milk (Armstrong et al., 1998).

While there has been a marked increase in the amount of supplements fed over the last 15 years (Doyle et al., 1996), more than 60% of the energy consumed by lactating cows is produced on the milking area on the majority of farms (Armstrong et al., 1998). Feed costs comprise over 30% of the milk production costs on Victorian dairy farms. The costs associated with growing pasture and purchasing supplementary feeds vary between years, but production efficiency is based on optimising pasture utilisation. This occurs because investments in growing pasture are both short and long term, while the costs of brought in feeds fluctuate markedly within and between years depending on supplies of grain and conserved fodders.

For the irrigation region, efficient use of water is important in minimising costs and in contributing to ecological sustainability. In this paper we consider production WUE, defined as the amount of milk produced from pasture from a given volume of water (i.e. kg milk fat + protein per megalitre), from two studies on irrigated dairy farms.

MATERIALS AND METHODS

Study 1 involved a survey of 170 dairy farmers in northern Victoria and southern New South Wales selected at random from the 3000 farms in the region. The survey area extended along the Murray River from Swan Hill (35 21’S, 143 33’E) to Cobram (35 55’S, 145 39’E) and from Murchison (36 37’S, 145 13’E) to Finley (35 38’S, 145 34’E). Detailed information was collected for the 1994-95 and 1995-96 seasons. Information on water use, milk production, supplementary feeding, farm size and type, herd size and cow type, pasture management, and irrigation management and layout was collected by personal interview, and from milk factory and water supply agency records. Armstrong et al. (1998) has reported full details of the survey.

As some farms had outblocks, comparisons between farms were based on the milking area with any areas not grazed by lactating cows excluded. The milking area was converted to ‘perennial pasture equivalent’ hectares using the following assumptions:

i) 1 ha of annual pasture watered less than 5 times in a season was equivalent to 0.5 ha of perennial pasture, or to 0.6 ha of perennial pasture if watered 5 times or more.

ii) 1 ha of dryland pasture was equivalent to 0.2 ha of perennial pasture.

Irrigation water applied included water purchased through Goulburn-Murray Water or Murray Irrigation agencies plus water from drains, depressions and bores. Effective rainfall was defined as the rainfall available for pasture growth and was calculated using recorded rainfall, evaporation records and estimates of ineffective
rainfall, as described by Armstrong et al. (1998). Total water used included irrigation water plus effective rainfall.

It was not practical to make direct measures of pasture growth or consumption. Hence, pasture consumption was calculated using a modification of the Production Efficiency Analysis methodology (D. Earle, personal communication). This involved estimating the amount of metabolisable energy (ME) required for milk production, stock maintenance and also energy incorporated in conserved fodder. Estimated ME from 'brought in' supplements was subtracted. An average ME value for pasture (10.5 MJ/kg DM) was then used to calculate the amount of pasture consumed (t DM) over a milking season.

The ME requirements were calculated using equations from MAFF (1975, 1982) as follows:

1. ME in milk (MJ/L) = 1.694 * [0.386 * milk fat (%) + 0.205 * milk protein (%) + 5.8 - 0.236],
2. ME to maintain a cow during lactation (MJ) = lactation length * [8.3 + (0.091 * LW)],
3. ME required for pregnancy during lactation (MJ) = 1205 - [(300 - lactation length) * 8],
4. ME requirements to maintain a dry cow = 80 MJ/day, a 0-1 year-old replacement = 40 MJ/day, and a 1-2 year-old replacement = 75 MJ/day.
5. ME in brought in grain (barley, wheat and triticale) = 12.5 MJ/kg DM.
6. ME in brought in hay or silage = 8-9 MJ/kg DM, depending on the description of the type and quality, provided by the farmer.

The liveweight (LW) of lactating cows for different breeds was assumed to be 520 kg for Friesians, 470 kg for Friesian x Jersey cows, and 420 kg for Jerseys. These weights were used to calculate the number of standard 520 kg cows in each herd. The energy consumed by non-milking stock grazing the milking area was converted to an equivalent number of standard milking cows and added to the herd energy consumption. Similarly, energy consumed by milking cows when agisted away from the milking area was converted to a number of standard cows and subtracted from the herd energy consumption. Hence, stocking rates represent the number of equivalent 520 kg milking cows per 'perennial pasture equivalent' hectare of milking area.

Milk production included an estimate of the additional amount of milk that would have been produced if extra lactating cows had been carried on the milking area, in place of the young and other stock. This allowed a comparison between farms that carried different proportions of non-milking stock on the milking area. Estimated total milk production was then multiplied by average fat and protein percentages to give amount of milk fat and protein. The amount of milk produced from 'brought in' supplements was estimated and subtracted from the total milk production. The assumptions used were:

i) 1 MJ ME from grain or pellets produced 4.55 g milk fat and 4.00 g milk protein. This equates to an average response of approximately 1 L milk for each kg of grain fed.

ii) 1 MJ ME from hay or silage produced 4.55 g milk fat and 3.64 g milk protein.

This amount was subtracted from the total milk production to give an estimate of the amount of milk produced from pasture.

Production WUE was calculated by dividing the estimated milk production from pasture by the total amount of water used (irrigation plus effective rainfall).

The farms were ranked in order of water use efficiency. Contingency tables were derived to compare the top and bottom deciles, and the remaining 80%, with respect to variables such as, pasture consumption per ha, supplement use and stocking rate. The high efficiency farms (top 10%) were compared to the low efficiency farms (lowest 10%) using chi-square analysis.

In study 2, 20 irrigated dairy farms were monitored over 4 lactations, 1995-96 to 1998-99. The methodology used to collect information and calculate WUE was as described above. These farms were not randomly selected but they represent a range of farming systems. Contingency tables were derived to compare the high and low efficiency farms, with respect to pasture consumption and the use of supplementary feed, using chi-square analysis.

RESULTS

In study 1, there was a large range in WUE with the top 10% of farms producing almost 3 times as much milk/ML as the lowest 10% of farms (table 1). The high WUE group had higher (p<0.01) pasture consumption (11.5 v. 5.5 t DM/ha) and milk production (from pasture) (1076 v. 375 kg fat + protein/ha) than the low group. They also had higher (p<0.01) stocking rates than the low efficiency group, and higher (p<0.01) milk production per cow.

The proportion of energy consumed by the milking herd that was from pasture averaged 75% across the survey population, but varied from 30 to 100%. There was no difference (p>0.05) between level of supplementary feeding in the high and low WUE groups (table 1). There were high and low supplement systems in both groups of farms.

In study 2, there was a significant (p<0.01) relationship between WUE and pasture consumption across years. There were no relationships between WUE and brought in energy as a proportion of total energy consumed by the herd.
Table 1. Characteristics of irrigated farms with high (highest 10%) and low (lowest 10%) water use efficiency from a survey conducted in 1994-95 and 1995-96

<table>
<thead>
<tr>
<th></th>
<th>Highest 10% of farms</th>
<th>Lowest 10% of farms</th>
<th>Signi. of diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water use efficiency (kg fat + protein/ML)</td>
<td>94</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>Milking area (ha)</td>
<td>48</td>
<td>83</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Pasture consumed (t DM/ha²)</td>
<td>11.5</td>
<td>5.5</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Milk fat + protein production (kg/ha³)</td>
<td>1076</td>
<td>375</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Stocking rate (cows/ha³)</td>
<td>3.2</td>
<td>1.8</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Milk fat + protein production (kg/cow)</td>
<td>396</td>
<td>277</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>% energy consumed from brought in feeds</td>
<td>29</td>
<td>27</td>
<td>ns</td>
</tr>
</tbody>
</table>

a Milk production adjusted for ‘brought in’ supplementary feeds and non-milking stock.

b Perennial pasture equivalent ha.

DISCUSSION

It was not possible from the survey approach to establish if the high estimated pasture consumption on the high water use efficiency farms resulted from growing more pasture or utilising more of what had grown. It is likely to be a combination of these factors. It appears that high pasture utilisation (proportion of the pasture grown that is consumed) is important to obtaining high WUE.

Stocking rate is a key factor influencing pasture utilisation and consumption on irrigated dairy farms (Doyle et al., 1996, Stockdale et al., 1997). In pasture-based dairy systems, supplements are used to fill energy deficits between pasture supply and herd demands when stocking rates are increased, and to increase per cow production. The increase in WUE associated with increased pasture consumption and stocking rate was expected. However, we also expected increased WUE to be associated with increased use of supplementary feeds, in particular to fill feed gaps. This was not the case in either study.

The farms with high WUE fed supplements while maintaining high pasture consumption, while the low efficiency group appeared to be feeding supplements that substituted for pasture. The higher per cow production of the cows on the more efficient farms indicates they were fed better. As both groups of farms brought in similar quantities of supplementary feed, it appears that a greater quantity, and possibly quality, of pasture was available to the cows on the high efficiency farms and/or the supplements were used more effectively. In recent years, considerable attention has been focused on understanding interactions between pasture and supplements (Stockdale et al., 1997; Stockdale 1999) to provide better guidelines to farmers on how to optimise milk production from their feed resources. Ultimately this will be important to further improvements in WUE on many irrigated dairy farms.

ACKNOWLEDGEMENTS

We would like to acknowledge the funding provided by the Department of Natural Resources and Environment Victoria, the Murray Darling Basin Commission and the Dairy Research and Development Corporation.

REFERENCES


E-mail: peter.doyle.nre.vic.gov.au