

PRODUCTION AND WATER USE OF IRRIGATED PASTURES IN NORTHERN VICTORIA

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ABSTRACT

The major user of irrigation water in northern Victoria is the dairy industry. While information on the comparative water use of forage systems would be useful for dairy farmers aiming to optimise their forage production under conditions of limited water availability, there are few data comparing water use under similar management and weather conditions. An experiment was set up to compare the production and water use of 7 irrigated forage systems used by the dairy industry in northern Victoria. Annual pastures were found to produce 60-80% of the dry matter of the perennial forages while using only 40-60% of the irrigation water. Consequently, water productivity (defined as dry matter produced per unit irrigation water applied) was generally higher for winter-growing annual forage systems than for perennial and double-cropped systems. Water productivity of the 7 forage systems varied less when total water was used than when irrigation water only was used.

INTRODUCTION

Pasture is usually the cheapest and major source of energy and other nutrients for dairy cows in the northern irrigation region of Victoria (Doyle *et al.* 2000). Traditionally, perennial pastures were the main pasture type grown for dairy cows, with irrigated annual pastures occupying about 20–30% of the irrigated milking area and summer forage crops (mainly lucerne and maize) only occupying 2% of the irrigated milking area (Armstrong *et al.* 1998).

Victoria's dairy industry uses about two thirds of the state's total irrigation water. However, irrigation water is becoming less available to the dairy industry and in recent years has become a limiting factor, particularly in northern Victoria. The water requirements of forages are largely driven by the environment, and are higher during hot/dry periods than during cool/moist periods (Allen *et al.* 1998). This suggests that a change in the mix of forages used on dairy farms may make better use of the available water.

Water productivity (WP) (defined as dry matter produced per unit irrigation water applied) is one way of comparing forages. However, there is little data comparing the dry matter (DM) production, water use and WP of a range of forage systems managed at the same site in the same year. These comparative data for different forages would be valuable to dairy farmers aiming to optimise their forage production under conditions of limited water availability.

To address these issues, a study was established to measure DM production and water use of a number of annual and perennial pastures and forage crops in an experiment over 3 years in northern Victoria. Water productivity was calculated for each forage system and used to test the hypothesis that the WP of winter annuals is greater than that of perennial and double-cropped forage systems.

MATERIALS AND METHODS

The experimental site was established in autumn 2004 using 7 forage systems (see Table 1) in a randomised complete block design with 4 replicates. The plots were 9 by 90 m.

The forage systems were border-check irrigated except for 1 system which was spray irrigated. Border-check irrigation was scheduled when pan evaporation less rainfall (E-R) was 50–60 mm, except for Lucerne between February 2005 and April 2006 (100–120 mm E-R). The Spray system was watered with about 25 mm water when E-R reached 25–35 mm.

The Persian clover received its first irrigation in mid February and last irrigation in late November. The subterranean clover received its first irrigation in early March and last irrigation in late October. In the double crop system, the oats were sown in early April and received its last irrigation in mid October and the millet was sown in mid November and received its last irrigation in mid March.

Flow meters on each plot were used to measure the volume of irrigation water applied and runoff. The soil water deficit for each treatment was calculated from neutron probe measurements to 1.3 m depth at 2 locations in each plot. These measurements were made prior to every border-check irrigation and every second spray irrigation, and occasionally after irrigation.

The forages were grazed and/or mown for hay, and fertilised according to using best management practices specific for each pasture system. The amount of dry matter consumed by the dairy cows was determined at each grazing from estimates of pre- and post-grazing herbage masses using either a rising plate meter for the pastures or quadrats cut to ground level for the oats and millet. Dry matter removed as hay was determined at each harvest by cutting swathes to a height of 60 mm using an autoscythe.

The WP of each forage was calculated using either irrigation or total (irrigation plus rainfall less runoff less increase in soil water content) water applied.

Climatic data were recorded at 15-minute intervals using an automated weather station located in a well-watered pasture near the experimental site and used to calculate the reference evapotranspiration using a modified Penman-Monteith equation (Allen *et al.* 1998). Monthly rainfall and reference evapotranspiration, and actual and average monthly maximum and minimum temperatures are shown in Figure 1.

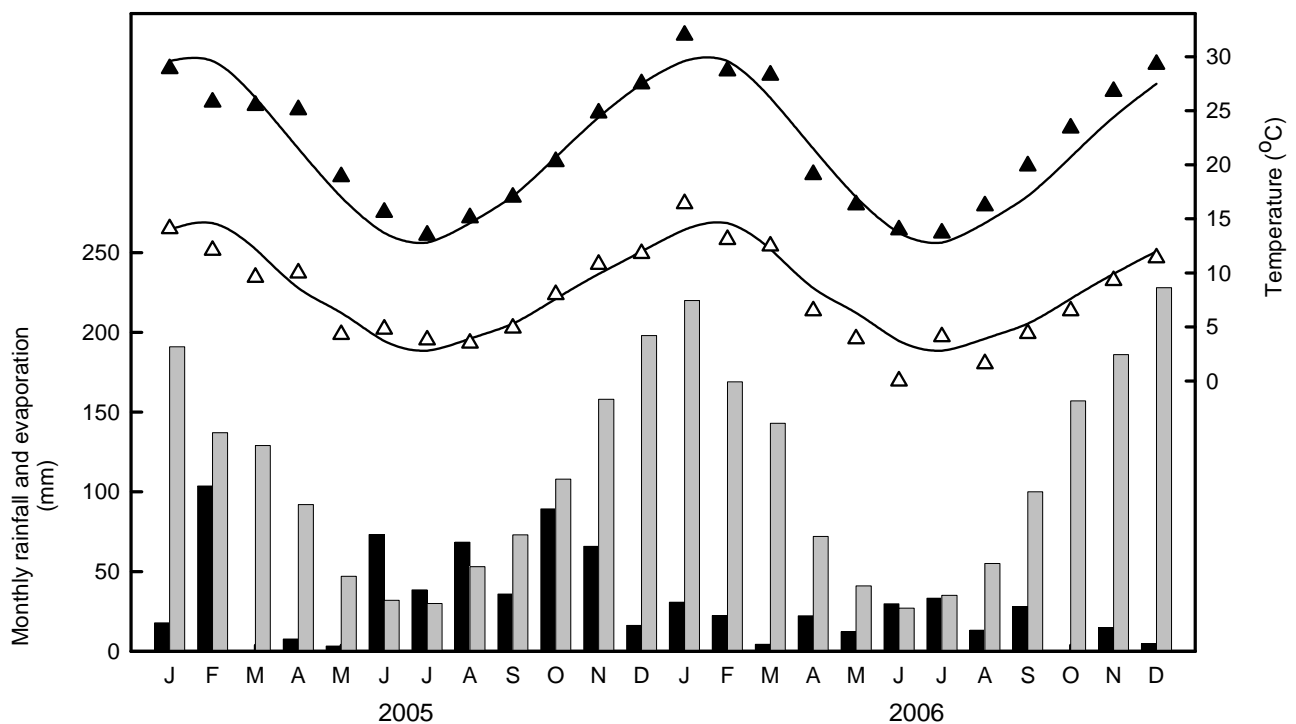


Figure 1. Monthly total rainfall (black) and reference evapotranspiration (Allen *et al.* 1998) (grey) and average daily minimum (hollow) and maximum (solid) temperatures. The long-term average temperatures are indicated by the lines.

RESULTS

Forage production was higher from the perennial pastures (perennial ryegrass and tall fescue), lucerne, double crop and Persian clover systems than from the subterranean clover systems in both 2005 and 2006 (Table 1). The proportion of forage removed that was removed by grazing was 100% for the perennial pastures, 60% for double crop (100% for millet and 30% for oats), 50% for the annual pastures (Persian and subterranean clover systems) and 0% for Lucerne in both 2005 and 2006 (data not shown).

Irrigation water use in 2005 was closely related to the length of the growing season, with around 805–835 mm used for the perennial pastures and 340–440 mm used for the border-check irrigated

annual pastures. Irrigation water use in 2006 was substantially higher than 2005, with around 1,200 mm used for the perennial pastures and 440–710 mm used by the border-check irrigated annual pastures.

Table 1. Forage removed, irrigation and total water used for the forage systems in 2005 and 2006

| Forage system | Forage removed (t DM/ha) (A) | | Irrigation water used (mm) (B) | | Total water used ¹ (mm) (C) | |
|--------------------------------------|------------------------------|------|--------------------------------|-------|--|-------|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| Perennial ryegrass/white clover | 16.6 | 14.8 | 805 | 1,199 | 1,254 | 1,414 |
| Tall fescue/white clover | 17.6 | 17.0 | 835 | 1,199 | 1,299 | 1,419 |
| Lucerne | 17.1 | 19.3 | 646 | 1,040 | 1,207 | 1,257 |
| Double crop (oats / millet) | 18.3 | 17.7 | 737 | 1,114 | 1,180 | 1,341 |
| Persian clover/Italian ryegrass | 16.0 | 12.3 | 442 | 706 | 930 | 943 |
| Subterranean clover/Italian ryegrass | | | | | | |
| Border-check irrigated | 10.1 | 9.3 | 335 | 439 | 853 | 720 |
| Spray irrigated | 11.1 | 9.6 | 299 | 356 | 830 | 635 |
| I.s.d. (P=0.05) | 1.19 | 1.62 | 60 | 83 | 69 | 83 |

¹ Total water used (irrigation + rainfall – runoff – increase in soil water content)

Rainfall in 2005 (488 mm) was higher than the long term average (455 mm) and that in 2006 (229 mm). However, some runoff in 2005 reduced the amount of effective rainfall (defined as rainfall less runoff), particularly for the perennial pasture, Lucerne and double crop systems (data not shown). Net changes in soil water content during any year were generally less than 50 mm except for Lucerne in 2005 when the soil water content declined by 132 mm.

Irrigation WP for 2005 was higher for the annual pastures (30–37 kg DM/ha.mm) than for either the perennial or double crop systems (21–27 kg DM/ha.mm) (Table 2). The lower rainfall and higher evaporation demand in 2006 than in 2005 meant that the irrigation WP was lower than that for 2005 for both the annual (17–27 kg DM/ha.mm) and for the perennial and DCrop systems (12–19 kg DM/ha.mm), with several of the perennial systems not differing ($P < 0.05$) to the annual systems. When all water used was included in the calculation of WP, the differences between systems were much smaller in both 2005 (12–17 kg DM/ha.mm) and 2006 (11–15 kg DM/ha.mm).

Table 2. Irrigation and total water productivity for the forage systems in 2005 and 2006

| Forage system | Irrigation water productivity (kg DM/ha.mm) (A / B) ² | | Total water productivity ¹ (kg DM/ha.mm) (A / C) ² | |
|--------------------------------------|--|------|--|------|
| | 2005 | 2006 | 2005 | 2006 |
| Perennial ryegrass/white clover | 20.7 | 12.3 | 13.3 | 10.5 |
| Tall fescue/white clover | 21.3 | 14.2 | 13.6 | 12.0 |
| Lucerne | 26.6 | 18.6 | 14.2 | 15.4 |
| Double crop (oats / millet) | 24.9 | 15.9 | 15.5 | 13.2 |
| Persian clover/Italian ryegrass | 36.2 | 17.4 | 17.2 | 13.0 |
| Subterranean clover/Italian ryegrass | | | | |
| Border-check irrigated | 30.4 | 21.3 | 11.9 | 12.9 |
| Spray irrigated | 37.3 | 27.0 | 13.4 | 15.1 |
| I.s.d. (P=0.05) | 3.5 | 2.4 | 1.4 | 1.3 |

¹ Total water used (irrigation + rainfall – runoff – increase in soil water content)

² see Table 1 for input data

DISCUSSION

Irrigation WP was generally higher for winter growing annual forage systems than for perennial and double-cropped systems. There are several reasons for this. Firstly, the seasonal distribution of rainfall meant that rainfall less runoff comprised a higher proportion of total water use for the annuals than for the perennial and double-cropped systems in both 2005 (55% vs. 35%) and 2006 (31 vs 17%). Secondly, the water requirements of forages are higher during hot/dry periods than during cool/moist periods as it is largely driven by the environment (Allen *et al.* 1998). Thus by not growing over summer, annual pastures used 40-60% less irrigation water than the perennial forages for only a 20-40% reduction in forage production. Therefore, in farming situations where irrigation water is scarce, farmers should consider increasing the proportion of winter annual forages. However, other factors such as the nutritive characteristics of each forage, growing, conservation and feeding out costs, and how well each forage fits a farmer's system, also need to be considered by farmers and their advisers when deciding which forage system will best suit the needs of their farm.

Water productivity of the 7 forage systems varied less when total water was used than when irrigation water only was used. Thus, while WP for total water is of interest to better understand the agronomy of the system, the irrigation WP is of much more interest to farmers and service providers who are seeking to make the best use of a limited water supply. Therefore, the definition of WP will influence the relative ranking of species and will depend on the use to which it is being put.

Irrigation water requirements in 2006 was 50% higher than in 2005 due to both lower rainfall and higher evapotranspiration. These irrigation water requirements highlight considerable year to year variation as low rainfall years are usually high evaporation years, and vice versa. Therefore it is essential that the water requirements for a range of annual and perennial forages be determined using historical weather data in order to assist farmers and their advisors in choosing which forages should be grown on their farm.

ACKNOWLEDGMENTS

This research was funded by "Our Rural Landscapes"—a Victorian government initiative. We are grateful to Richard Dabrowski, Graeme Phyland, Liz Byrne and Daryl Wilson for technical assistance.

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