Water use efficiency of irrigated forage systems in northern Victoria

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Abstract

We have recently commenced a 3-year experiment to determine the water use efficiency of annual and perennial forage systems used in the irrigated dairy industry in northern Victoria. The forage systems will be grazed and/or mown for hay, using best management practices recommended for local farmers. The forages are perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), tall fescue (*Festuca arundinacea*) and white clover, lucerne (*Medicago sativa*), Persian clover (*Trifolium resupinatum*) and Italian ryegrass (*Lolium multiflorum*), subterranean clover (*Trifolium subterraneum*) and Italian ryegrass, and a double crop system of oats (*Avena sativa*) and millet (*Echinochloa crusgalli*). All six treatments will be flood irrigated. The seventh forage treatment is subterranean clover and Italian ryegrass under spray irrigation. Measurements will include dry matter removed by grazing or haymaking, forage quality (energy, protein and fibre contents), irrigation water applied, run off, and water content of the soil profile before and after irrigation. The data will be used to compare the production, water use and water use efficiency of the forage systems. Comparison of water use with crop water requirements predicted from weather data will enable validation of crop factors for northern Victoria.

Media summary

The water use efficiency of a range of annual and perennial forage systems used in the irrigated dairy industry in northern Victoria will be measured over 3 years.

Key Words

perennial pasture, annual pasture, dairy industry.

Introduction

The dairy industry uses approximately 50–60% of the total irrigation water used in the Goulburn-Murray irrigation system in northern Victoria. While there is some data available on the water use efficiency (WUE) of forages for dairy production, there are few data comparing the WUE of forage systems under similar management and weather conditions (Greenwood 2003). Comparative data on the WUE of different forages would be useful to dairy farmers aiming to optimise their forage production under conditions of limited water availability.

Pasture is the cheapest and major source of energy and other nutrients for dairy cows in the northern irrigation region of Victoria (Doyle *et al.* 2000). Perennial pastures, consisting of perennial ryegrass, white clover and paspalum, are the main pasture type grown for dairy cows. Irrigated annual pastures (including subterranean clover or Persian clover mixed with short-lived ryegrass), occupy about 20–30% of the total irrigated pasture area used by the dairy industry (Armstrong *et al.* 1998), although this proportion varies considerably between farms, and is higher in southern NSW. The area sown to lucerne and maize is relatively small, with Armstrong et al. (1998) estimating that only 2% of the milking area was sown to forage crops on the average farm.

Intuitively, annual pastures which grow from autumn through to spring, should have a higher annual water use efficiency than perennial pastures. Doyle *et al.* (2000) estimated that DM removal from perennial pasture would need to exceed 16 t DM/ha to have a similar water use efficiency to annual pastures. These estimates of water use efficiency for annual pastures were based on published DM removals

(Stockdale 1986; Kelly and Mason 1987) and estimates of water use (Stockdale 1986). However, survey data, where DM removals were back-calculated from milk production and supplement use, found a trend for farms with higher proportions of perennial pasture to have higher water use efficiencies (Armstrong *et al.* 1998). Hence, there is a need to compare, under similar conditions, the water use efficiencies of a range of annual and perennial pastures and alternative forage crops.

Drainage beyond the rootzone of crops and pastures in the irrigated regions of northern Victoria, and elsewhere in southern Australia, is a major concern as it is associated with rising water tables and salinity (Meyer *et al.* 1996). However, drainage beyond the rootzone of crops and pastures is influenced by a number of factors including pasture or crop type, irrigation method, soil characteristics and depth of water table. Hence the estimation of deep drainage below a range of forage systems would be useful for validating water balance models (Humphreys *et al.* 2003).

To address these issues, DM removal and components of the water balance of a number of annual and perennial pastures and forage crops will be measured in a controlled experiment over 3 years in northern Victoria. The aim, for each of these pasture and forage systems, is to calculate the water use efficiency, to compare the water use data with estimates based on weather data, and to estimate deep drainage.

Methods

Site location

The site is located at DPI, Kyabram (36?19' S, 145?3' E, elevation 105 m), 3 km south of Kyabram in northern Victoria. The soil is a red-brown earth (Stace et al. 1968) or red sodosol (Isbell 1996), known locally as a Lemnos loam (Skene and Poutsma 1962). The soil has a loamy-textured A horizon, about 10–15 cm thick, overlying an alkaline clay B horizon.

Forage treatments

The annual and perennial pastures and forages compared in this experiment are:

- Perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*)
- Tall fescue (*Festuca arundinacea*) and white clover
- Lucerne (Medicago sativa)
- Persian clover (*Trifolium resupinatum*) and Italian ryegrass (*Lolium multiflorum*), irrigated from mid February to late November
- Subterranean clover (*Trifolium subterraneum*) and Italian ryegrass, irrigated from early March to late October
- Subterranean clover and Italian ryegrass, as above but with spray irrigation
- Doubled cropped oats (*Avena sativa*) and millet (*Echinochloa crusgalli*). The oats will be irrigated from late March to mid October and the millet from early November to early March.

All treatments will be flood irrigated using a border check system unless otherwise specified. The experimental design will be a randomised complete block with 4 replicates, giving a total of 28 plots.

Site establishment and management

Site establishment commenced in February 2004. The site was graded to a slope of 0.14% with a drain at the end of each plot. Each plot (9 m by 90 m in size) was be hydraulically isolated from adjacent plots using plastic to 0.7 m depth and a checkbank formed between each plot. Plots are individually fenced to allow grazing with dairy cattle.

The pastures and forages were sown, fertilised, irrigated, and grazed and/or mown using best management practices for each treatment.

Pasture measurements

The amount of herbage consumed at each grazing of the annual and perennial pastures will be assessed using a sward sampling technique similar to that used by Stockdale and King (1983). The amount of herbage consumed at each grazing of the winter cereal and millet will be determined by cutting quadrats to ground level before and after grazing. Lucerne yield will be estimated at each harvest using an autoscythe.

Samples taken prior to grazing or cutting will be used for determining nutritive value and botanical composition. Nutritive value analyses will include *in vitro* dry matter digestibility (DMD) by a cellulase-pepsin technique (Clarke *et al.* 1982), organic matter content by ashing at 520 ?C for 3 hr, total nitrogen (N) by combustion using a Leco FP-248 (Leco Australia) and neutral detergent fibre using a modification of Van Soest *et al.* (1991). A second subsample will be sorted into components to determine species composition.

Water measurements

Volumes of water applied to, and running off from, each plot will be measured at each irrigation using flow meters. Water content of the soil profile will be measured immediately prior to and after every irrigation using a neutron probe in two access tubes per plot. Groundwater table depth will be measured using testwells in two of the seven treatments.

These data will be used to calculate water use efficiencies, compare patterns of water extraction between species, and model deep drainage.

Estimation of evapotranspiration

The FAO 56 method (Allen *et al.* 1998) will used to calculate crop evapotranspiration by multiplying the reference evapotranspiration by a crop coefficient (K_c). Daily reference evapotranspiration will be calculated using the modified Penman-Monteith equation from data collected by an automatic weather station at the site. Crop coefficients for different stages of growth for forages are provided by Allen *et al.* (1998). These crop coefficients need to be adjusted for the frequency of wetting of the soil surface, and local weather conditions (mainly wind speed and relative humidity).

Evapotranspiration will also be estimated from the change in soil water content for short periods when there is no rainfall, irrigation, runoff or deep drainage. These estimates of crop water use will be compared with the FAO 56 evapotranspiration estimates.

Estimation of deep drainage

Deep drainage will be estimated from the water balance equation. Estimation of the error (Ward *et al.* 1998) will provide an upper and lower boundary on the amount of deep drainage from each treatment.

Water use efficiency calculations

Water use efficiency (kg DM/ha.mm) for each forage treatment will be calculated from the measured seasonal DM removal and the total water applied seasonally (including rainfall, with allowances made for runoff and changes in soil water storage). Water use efficiency will also be calculated from annual DM removal and the total irrigation water applied annually.

Results

The experimental site was established and measurements commenced in autumn 2004.

Conclusion

This experiment will determine the water use efficiency, on a seasonal basis, of a number of annual and perennial pastures and a doubled cropped forage system in northern Victoria. The work will enable the validation of the crop coefficients provided in FAO 56 and so allow the prediction of the water requirements of these forages when grown in the Goulburn Valley of northern Victoria. The data will assist dairy farmers to make more informed decisions about their choice of forages to grow.

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