EFFECTS OF SUB-OPTIMAL IRRIGATION PRACTICES ON DAIRY PASTURE PRODUCTION IN SOUTH WEST VICTORIA

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Abstract

In two experiments in south west Victoria, the effect of not irrigating dairy pasture until 10 and 20 days after the onset of moisture stress in the spring and the losses caused by an under-irrigating and an excessively long irrigation interval were compared relative to optimum treatments. Both 10 and 20 day delay treatments took 35 days to fully recover after irrigation commenced with pasture losses of 670 and 1150 kg DM/ha, respectively. Irrigating a pasture with only 70% of its estimated evapotranspiration (ET-R) requirement reduced pasture DM yields by over 50% relative to one receiving 100% of ET-R. An excessively long irrigation interval where the pasture was moisture stressed for 3-4 days each cycle reduced the water use efficiency of the pasture by over half. Both sub-optimal schedules had the effect of reducing the crude protein content of the herbage, but increased the water soluble carbohydrate content. There was no effect on metabolisable energy or neutral detergent fibre.

Key words: Irrigation, pasture, schedules, yield, crude protein, dry matter, metabolisable energy, neutral detergent fibre, water soluble carbohydrates.

Although not regarded as an irrigation region, the dairying districts of south west Victoria have some 8,000 ha of licensed irrigated pasture. With the expans-ion of dairying in the region, the demand for irrigation water is increasing while the amount available is being restricted to meet environmental requirements. Further, there is an increasing realisation that many of the irrigation practices often used are poor, and not making the most efficient use of this scarce resource. In addition, some of the small private schemes on farm may not be economic.

Two common scenarios are irrigation not commenc-ing early enough in the spring and no form of irrigation scheduling being used. In part one of this study, the effects of late startup times on pasture production and the time taken for pastures to recover were monitored. ?In part two, the effect on herbage yield, herbage quality and water use efficiency of pasture from irrigation schedules that either under-irrigated pasture or had excessively long intervals were examined relative to an optimum schedule

Materials and methods

The experiments reported were conducted on a commercial dairy farm with spray irrigation, near Allansford (142^{o}38' E, 38^{o}25' S) from November 1996 to March 1997. The soil was a loamy sand described as a Brown sodosol derived from Quaternary deposits overlying Tertiary limestone. Soil fertility was moderate to low with an Olsen P level of 13.1 mg/kg and an available K level of 84 mg/kg. Soil salinity was low with a 0.05% total soluble salts content.

The pasture at the start of the trial was composed of 22% white clover (Trifolium repens), 65% perennial ryegrass (Lolium perenne), 9% other grasses and 4% broad leaf weeds.

The experiments were conducted on an adjoining area of pasture using a randomised block design of three treatments with four replicates in each case. Individual plots were 2.5 m by 2.5 m with 1.5 m pathways between plots. The plots were established on 3 October 1996 and were "conditioned" over the October and November period by mowing fortnightly to 5 cm and fertilising every four weeks with 30 kg N, 21 kg P, 34 kg K and 56 kg S/ha. When necessary, plots were irrigated with the quantity of water applied being calculated from a soil water budget using evaporation data from a "Class A" pan and rainfall collected at the site and using a crop factor of 0.8. Irrigation water was obtained from the farm's irrigation system. It was applied to the specified plots by slowly pouring it over the plot area from plastic buckets taking care to ensure that no runoff occurred. ?The summer was drier than average with 150 mm of rain being recorded at the site for the months of November 1996 through to March 1997. This compared to a long term average of 188 mm for these months.

Experiment 1 commenced on 4 December,1996 when the twice weekly maintenance irrigation applications to the delayed start-up treatments (B and C) were stopped while irrigation of the control treatment (A) continued. ?The growth of pasture was assessed by cutting a 1 m x 0.45 m quadrat with 7 - 10 days regrowth to 5 cm height from each plot every 1 or 2 days. The "critical" soil moisture content was taken as the day when the pasture DM yields of the delayed start-up treatments became significantly ($P<0.05$) lower than the irrigated control ?treatment. Treatment B plots were then allowed to dry for a further 10 days and treatment C for 20 days post the "critical" day before irrigation was recommenced. ?The specified plots were then irrigated on a twice weekly basis with their calculated water requirement. The yield of and recovery of the pasture in each treatment was monitored by cutting a quadrat within each plot with 21 days pasture regrowth every 3 or 4 days over the following weeks. This 21 day harvest interval was designed to simulate the 21 day grazing rotation length commonly recommended for irrigated pastures in the region. Each quadrat area was fertilised with 30 kg N, 11 kg P, 17 kg K and 28 kg S/ha at the irrigation following its harvest. Recovery was taken as the date at which the yield of this quadrat cut for 10 and 20 day delay treatments became not significantly different to that of the control..

Experiment 2 commenced on 28 December, 1996. A control treatment (D) was irrigated twice weekly with 100% of the estimated evapotranspiration (ET-R) since the previous irrigation. Treatment E (delayed irrigation), simulating an irrigation interval that was excessively long, was irrigated with 100% of estimated ET-R but always 3 - 4 days after a 30 cm depth tensiometer reading exceeded 30 kpa (this being the reading determined at the "critical" day in Experiment 1). Treatment F (under-irrigated) was irrigated at the same time as the control (D) but with only 70% of the estimated ET-R. Prior to harvesting, herbage sub-samples were collected by taking 12 toe cuts per plot, oven dried (at 60^{o}C for 48 hours) and analysed for crude protein (CP) (N x 6.25), neutral detergent fibre (NDF), metabolisable energy (ME) and water soluble carbohydrates (WSC). Pasture DM yields on all plots were assessed every 21 days using a rotary lawn mower to cut two 2.5 m by 0.5 m strips through each plot to a cutting height of 5 cm and the harvested material weighed. A sub-sample was collected and oven dried (at 100^{o}C for 24 hours) for DM determination. The remainder of the pasture on each plot was then trimmed off using the mower and the clippings discarded. Fertiliser was applied to each plot at the rate of 30 kg N, 11 kg P, 17 kg K and 28 kg S/ha at the irrigation following each harvest and watered in.

Data were subjected to ANOVA and l.s.d's ($P=0.05$) applied to treatment means.

Table 1: The effect of a 10 and 20 day delay in irrigation startup time on the pasture yield (kg DM/ha) relative to the control from the day of "critical" moisture content 13 December 1996 till 7 February 1997; and the recovery period (days) from 13 December 1996.

	Treatment 'A' Control	'B' 10 day delay	'C' 20 day delay	Significance
Total Yield (kg DM/ha)	1920	1250	770	*
% Yield 'Lost'	0%	35%	60%	
Recovery Period (days)	0	45	55	

(* = P<0.05, l.s.d. = 473)

Table 2: Dry matter yield of pasture (kg DM/ha) of treatments being subjected to delayed irrigation (E) or under-irrigating by 30% (F) relative to an optimum irrigation treatment (D).

Harvest Date	D Control	Treatment E Delayed	F Under-irrigated	Significance (P<0.05)	l.s.d. (P=0.05)
23 January	860	580	610	*	175
12 February	1050	430	580	*	158
26 February	700	320	320	*	86
21 March	950	680	520	*	119
TOTAL	3560	2010	2030	*	485

Table 3: Water use efficiency of pasture (t DM/ha/ML of water applied) of treatments being subjected to delayed irrigation (E) or under-irrigated by 30% (F) relative to an optimum irrigation treatment (D).

Harvest Date	D Control	Treatment E Delayed	F Under-irrigated	Significance (P<0.05)	l.s.d. (P=0.05)
23 January	0.57	0.39	0.59	*	0.11
12 February	1.25	0.52	0.99	*	0.20
26 February	1.05	0.48	0.70	*	0.14
21 March	1.27	0.92	1.00	*	0.18
MEAN	1.04	0.57	0.82	*	0.15

Table 4: Crude protein (CP), water soluble carbohydrates (WSC), neutral detergent fibre (NDF) and metabolisable energy (ME) contents of herbage from the 26 February harvest grown under delayed (E) or under-irrigated conditions (F) relative to an optimum irrigation treatment (D) in Experiment 2.

Quality Parameter	Treatment D Control	E Delayed	F Under-irrigated	Significance (P<0.05)	l.s.d. (P=0.05)
CP (%DM)	27.3	26.0	26.0	*	1.1
WSC (%DM)	5.4	7.2	6.6	*	1.1
NDF (%DM)	44.4	42.9	44.0	N.S.	3.1
ME (MJ/kg DM)	11.4	11.4	11.2	N.S.	0.3

Results

Delays of 10 and 20 days past the "critical" day (13 December) in irrigation startup time resulted in lower pasture DM yields (P<0.05) than the fully irrigated control (Table 1). The 10 day delay in startup time resulted in a 35% reduction in pasture DM yield for the period 13 December - 7 February. When harvested on a 21 day rotation, it took 45 days after the "critical" day for pasture yields to recover. The 20 day delay resulted in a 60% reduction in pasture DM yield with a 55 day recovery period. Both 10 and 20 day treatments took 35 days for the pastures to fully recover after irrigation was recommenced.

The effect of both the delayed irrigation (E) and the under-irrigated (F) treatments in experiment 2 was to reduce (P<0.05) the DM yield of the pasture at every harvest, with losses exceeding 40% over the duration of the trial when compared to the optimum schedule (D) (Table 2). At the peak February irrigation period (harvest of 26 February), under-irrigating by 30% (F), resulted in a reduction of over 50% in pasture DM yield for that period.

The water use efficiency (t DM/ha/ML of water applied) of the pasture was reduced by the use of sub-optimal irrigation schedules (Table 3). Both the delayed irrigation and under-irrigated treatments had lower (P<0.05) water use efficiencies than the optimum treatment at all harvests with the exception of the first (23 January) harvest. At this first harvest, only the delayed irrigation treatment had lower (P<0.05) water use efficiency than the control. During the peak February irrigation period, the water use efficiency of the delayed irrigation was halved while it was reduced by one third for the under-irrigated treatment relative to the control.

The two suboptimal irrigation schedules had the effect of reducing the crude protein content (CP) and increasing the water soluble carbohydrate (WSC) contents of the herbage relative to the optimum treatment (Table 4). The neutral detergent fibre (NDF) and the metabolisable energy (ME) content of the herbage on the other hand were not affected. No differences in the white clover content of the pasture sward was found for any treatment or harvest.

Discussion

Clearly there are major penalties in terms of lost pasture production, and hence lost milk production and returns if irrigation is not commenced before pasture comes under moisture stress at the start of the irrigation season. These losses will initially result from reduced growth rates as leaf expansion rates slow with increasing moisture stress (1). With further stress, other morphological effects including reduced tillering and an in-crease in the death of tillers and old leaves will be occurring (4). These factors affect the development of leaf area for light interception and photosynthesis which are particularly important in determining the yield of the pasture. These effects on the stressed plants will explain much of the large herbage DM yield losses incurred and the long recovery periods found with the delayed irrigation startup treatments.

These same plant physiological and morphological responses to moisture stress will be causing the reduced yields from the delayed and under-irrigated treatments. ?The finding that under-irrigating by 30% resulted in an over 50% reduction in pasture DM production during February together with the substantial reductions in water use efficiency suggests that it is more efficient to fully irrigate a pasture rather than deliberately under- irrigate a pasture. In other words if irrigation water supplies are limited, more herbage will be grown by fully irrigating a smaller area of pasture than deliberately under-irrigating by 30% or more a larger area of pasture. ?The reduced pasture yields and poor water use efficiency results for the delayed irrigation treatment illustrate the dangers or inefficiencies of trying to irrigate too much area with inadequate equipment. This result confirms productivity losses caused by long irrigation intervals in other regions (2, 3, 4).

The reduced CP content of the herbage grown under the sub-optimal schedules relative to the control can be explained by a reduction in N uptake by plants in response to water deficits ?(1). From an animal nutrition point of view, these decreases in CP content with sub-optimal schedules are not major, but could be important when balancing the animal protein requirements where large amounts of low protein supplements such as cereal grains are also being fed. The corresponding increases in the WSC content of herbage from the sub-optimal schedules are likely to be a result of the periodic restrict-ions to plant growth caused by moisture stress towards the end of each irrigation cycle concentrating the WSC in the plant tissue. This increase was then not expressed in any significant difference between treatments in estimates of ME content and as such is unlikely to have any effect on likely animal performance from the herbage.

Conclusions

Delaying the startup time of irrigation until 10 or 20 days after the pasture has become moisture stressed resulted in major reductions in pasture yield and recovery periods after irrigation commenced of over 35 days.

The herbage yield and water use efficiency of irrigated pasture is very sensitive to sub-optimal irrigation schedules. Where water supplies are limited, it is more efficient to fully irrigate a smaller area of pasture rather than deliberately under-irrigate a larger area. Sub-optimal irrigation schedules had the effect of lowering the CP content and raising the WSC content of herbage grown.

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