The effects of deficit irrigation strategies on soil water content under lucerne.

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Abstract
A large scale field experiment was conducted at Tatura in northern Victoria, Australia on a red-brown earth, to examine the effects of deficit, or limited, irrigation practices on a range of agronomic and water use characteristics (including soil water) of lucerne. Over four years, eight border-check irrigation treatments (the predominant irrigation methodology of the northern Victorian irrigation region) were imposed that ranged from full irrigation to no irrigation in either single, or over consecutive, irrigation seasons. Soil water contents to a depth of 2.5 m were measured at least six times per year in all irrigation treatments using neutron probes in two access tubes per plot.

Late in the irrigation season, treatment differences in soil water content ranged from 80 mm (0.8 ML/ha) to 190 mm (1.9 ML/ha) over the four years of measurements, and depended on the within-irrigation season rainfall and irrigation strategy. Soil water contents were generally drier under the treatments where irrigation had been restricted and these differences were evident even at depth (>1.5 m). In most years of the experiment, winter rainfall was insufficient to make up the deficit in soil water content by the start of the next irrigation season. These differences in soil water content had some, (up to 0.2 ML/ha), implications for irrigation water intake in the initial Spring irrigation in the following year.

Keywords: alfalfa, plant water use, restricted irrigation

Introduction
Potential climate change scenarios for the Murray-Dairy region of northern Victoria and southern New South Wales, Australia, indicate an overall decline in rainfall as well as the volume of water available for irrigation of dairy forages. One option for dairy farms to remain viable under these circumstances is to develop forage and management systems that optimise forage production under limiting water supplies. Historically, lucerne has not been a significant component of the feedbase in the Murray-Dairy region (Pembleton *et al*. 2011); however, under future climate regimes it is emerging as a potential forage species in this region because of its adaptability, nutritive characteristics, high productivity and resilience (Bouton 2012).

A large-scale field experiment was conducted at Tatura, Victoria, Australia to investigate the effects of limiting and non-limiting irrigation strategies on the agronomic and water use characteristics of lucerne over four consecutive irrigation seasons (Rogers *et al*. 2015). One of the hypotheses that was tested was whether limited irrigation would create significant differences in soil water content and whether this would have implications on lucerne's irrigation requirement in subsequent years.

Materials and Methods
A field experiment was conducted at the Department of Economic Development, Jobs, Transport and Resources, Tatura Centre in northern Victoria (36°26' S, 145°15' E, elevation 110 m) on a red-brown earth or red sodosol commencing in May 2009. Eight different border-check irrigation treatments (which varied in the timing and application of irrigation water) were applied to lucerne (cv. SARDI 7) over four consecutive irrigation seasons (generally from September to May). The treatments were:

- **T1**. Full irrigation at an interval of 75–90 mm evaporation less rainfall (E–R),
- **T2.** Fully irrigated until a harvest in January in Years 2, 3 and 4 and then no irrigation until the following irrigation season,
- **T3.** Fully irrigated until a harvest in January Years 1, 2, 3 and 4 and then no irrigation until the following irrigation season,
- **T4**. Fully irrigated until a harvest in November in Years 2, 3 and 4, and then no irrigation until the following irrigation season,
- **T5**. Dryland for 1 year, in Year 4,
- **T6**. Dryland for 2 years, in Years 1 and 4,

- **T7**. Dryland for 2 years, Years 2 and 3,
- **T8**. Dryland for 3 years, Years 2, 3 and 4.

In Year 5 all treatments were fully irrigated.

Agronomic measurements that were made on the plots included plant establishment, dry matter production, and plant persistence and are reported in Rogers *et al*. (2015). Soil water content to a depth of 2.5 m, was measured at the end of summer (except in Year 1) and autumn using a neutron probe in two access tubes per plot (calibrated for the site) and expressed in terms of soil water deficit (SWD). Other measurements included climatic data, irrigation and water runoff, and groundwater depth.

Results and Discussion

The soil water profiles at the end of summer (mid-February) and autumn (mid-May) were drier in the restricted irrigation treatments than they were in the fully-watered treatments (Table 1, Figure 1). In autumn of any given year, the difference in SWD between T1 (fully irrigated) and the driest treatments tended to range from 80 to 110 mm. However, in both Year 3 and Year 4, the difference in SWD between treatments was greater at the end of summer than at the end of autumn (viz. 190 and 170 mm respectively) as a result of the amount and timing of rainfall during mid-February to mid-May (Table 1).

Table 1. Soil water deficits (mm to a depth of 2.5 m) for each of the eight irrigation treatments at the end of summer (Years 2 to 4) or autumn (Years 1 to 4).
* Indicates that restricted irrigation was in place at the time of measurement

	Soil water deficit (mm to a depth of 2.5 m)						
Treatment	Year 1 2009/10	Year 2 2010/11		Year 3 2011/12		Year 4 2012/13	
	autumn	summer	autumn	summer	autumn	summer	autumn
T1	69	21	41	59	132	97	132
T2	69	25*	108*	178*	166*	205*	223*
T3	122*	20*	110*	160*	146*	177*	192*
T4	61	24*	128*	220*	192*	266*	242*
T5	68	17	33	50	127	229*	211*
T6	154*	15	31	47	120	190*	172*
T7	62	45*	147*	252*	213*	147	193
T8	69	31*	141*	235*	192*	252*	229*
lsd (*P*=0.05)	19.8	10.9	19.6	25.9	16.1	39.0	36.6

When the winter rainfall was low or average, such as in 2011 (prior to Year 3) or 2013 (prior to Year 5 -viz. 133 mm and 229 mm respectively), the lower soil water contents in autumn tended to carry over to the next irrigation season such that there were differences in irrigation water intakes of up to 0.2 ML/ha at the first spring irrigation between the fully watered and restricted irrigation treatments (Figure 1 and Table 2). In years when the winter rainfall was higher (e.g. in 2010, prior to Year 2, when it was 394 mm from May until the first irrigation in November 2010), there was little difference in the irrigation water intake at the initial spring irrigation between irrigation treatments (Table 2).

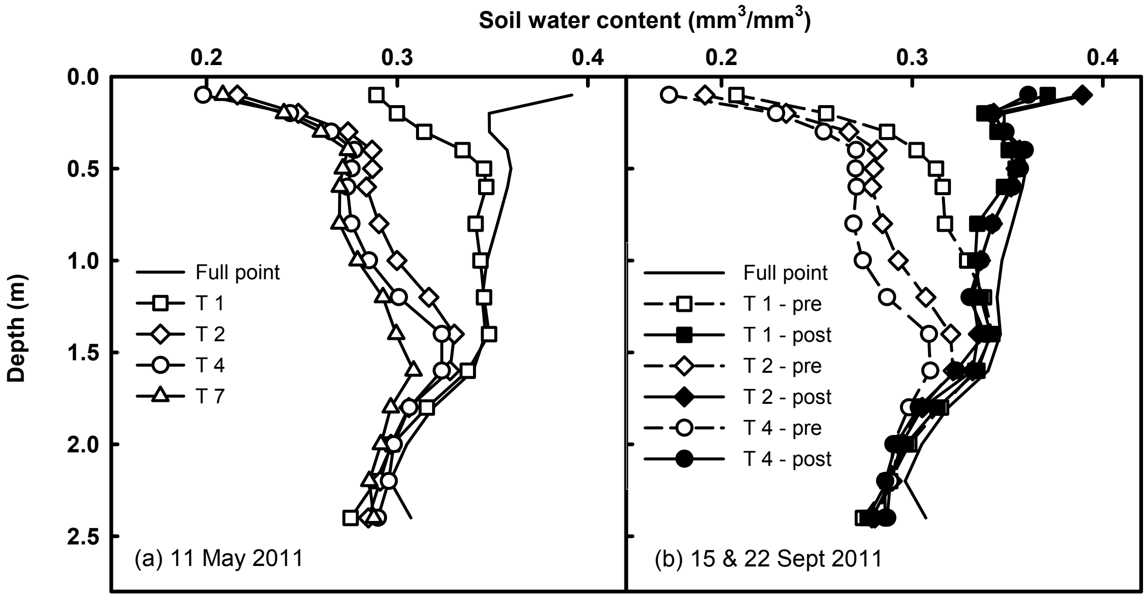

Figure 1. Soil water content profiles of the most extreme treatments late in the irrigation season for Year 2 (2010/11) (a) and pre- and post- the first spring irrigation in Year 3 (2011/12) (b).

Table 2. Irrigation intake (mm) at, and date of, the first Spring irrigation in each of the eight irrigation treatments.
* Indicates that restricted irrigation was used in the previous irrigation season

	Irrigation intake (mm) at the first Spring irrigation			
	Year 2	Year 3	Year 4	Year 5
Treatment	18 Nov 2010	21 Sep 2011	6 Sep 2012	16 Oct 2012
T1	96	96	100	89
T2	99	118*	102*	102*
T3	95*	114*	98*	101*
T4	94	109*	106*	115*
T5	89	91	-	107*
T6	96*	92	-	114*
T7	-	- *	110*	93
T8	-	- *	- *	110*
lsd (*P*=0.05)	4.9	7.8	9.8	9.2

Conclusion

Restricted irrigation of lucerne reduced soil water contents to a depth of 2.5m which, in some years with dry winter / early springs, affected irrigation water intake in the initial Spring irrigation of the following year. Thus, depending on the winter / early spring rainfall, restricted irrigation can have implications on irrigation water-use and irrigation water productivity in subsequent years.

References

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