

Saline groundwater use by lucerne and its biomass production in relation to groundwater salinity

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Introduction

Prior to clearing land for agriculture, deep-rooted natural vegetation covered the landscape. At that time, there was no groundwater rise and little or no secondary salinity. Clearing land for agriculture has changed the water-balance of the landscapes, resulting in an increasing area of land in Western Australia becoming affected by secondary dryland salinity. The cause of this salinity is excessive recharge under traditional agriculture, leading to rising groundwater levels. To effectively reduce land and water salinity, a deep-rooted perennial is needed to mimic the extent and distribution of leaf area that existed prior to clearing.

Lucerne (*Medicago sativa*), which has deep roots and covers the whole paddock, is one of the best perennial pasture for preventing salinity. During the lucerne phase (4-6 yrs) in a cropping rotation, excess soil moisture is utilized by lucerne and recharge is reduced or eliminated (Brown and Cleary 1978, Miller *et al.* 1981, Ward *et al.* 2001, Verburg *et al.* 2007, etc). Ferdowsian *et al.* (2002) showed that the effectiveness of lucerne in salinity control management was dependent on the attributes of the groundwater flow system. In many areas lucerne is grown close to the edge of salt-affected land, where its roots encounter saline groundwater. These observations lead us to two questions:

1. Does lucerne extract any water from these saline aquifers?
2. Can the production of lucerne be related to groundwater salinity?

To answer these two questions we established lucerne in 12 lysimeters (PVC tubes, 2m x 250mm) under field conditions. The results show that (a) there were large differences in lucerne productivity due to salinity of the groundwater, (b) lucerne used large amounts of saline groundwater but the rate of groundwater extraction significantly decreased as salinity increased, (c) rainfall enhanced the productivity of lucerne and its impact increased as groundwater salinity increased.

Method and material

The trial consisted of 4 treatments (500, 1000, 1600 and 2500mS/m), each treatment was replicated three times. The chosen salinities are typical groundwater salinities in >80% of lucerne growing areas in Western Australia. Saline groundwater was collected from bores in an agricultural area. Electrical conductivity of the collected water was 1660mS/m. To achieve treatment salinity levels, salt or rain water was added to the bore water.

Inoculated winter active Sardi 10 lucerne cultivar was planted in twelve lysimeters. The tubes were 2m long and were made of 250mm PVC storm-water pipe. Each tube had 300mm of blue metal for storing groundwater; a filter above blue metal, to prevent sand and soil movement; 50mm of quarry dust over the filter; 1.7m of subsoil (source between 1 to 3m depth, from lucerne growing areas) and 100mm of topsoil (gravelly-sandy-loam) from a lucerne paddock. Equivalent of 2.8 t/ha of lime was added to the topsoil to increase its pH from 4.7 to 6.2 (in water). Extraction or addition of water was from an inlet/outlet pipe connected to the lowest part of the lysimeters. A breathing hole was provided at 0.3m above the lowest part.

At the beginning of each month, 4.5L of new water was added to each sump. The maximum water levels in the sums, were 90mm below the top level of blue metal. This was to break the capillary pores and prevent salt accumulation in the root zone. The remaining water was drained at the beginning of every month and discarded. To estimate the salt loss, EC of the remaining groundwater was measured. Plants were cut when they started to flower. Plant material was dried to measure their biomass production. Linear regression models were fitted to dry matter and water use data.

Results and discussion

Groundwater use and dry matter production in relation to groundwater salinities

Salinity had significant effects on groundwater use ($P < 0.001$) and dry matter production ($P = 0.001$). Both groundwater use as well as dry matter production decreased as groundwater salinities increased (Table 1 and Figure 1). Lucerne used even the saltiest groundwater but its extraction rate was reduced from 71mL/day to 30mL/day as groundwater salinity increased from 500mS/m to 2500mS/m.

Table 1: Dry matter production and water use reduced as groundwater salinities increased.

Salinity of groundwater (mS/m)	500	1000	1600	2500	<i>p-value</i> ¹	<i>R-squared</i> ¹
Water Use (mL/day)	71.4	55.8	48.4	29.6	<0.001	83%
Dry Matter Production (kg/ha/day)	41.0	33.1	32.8	24.2	0.001	60%

¹from linear regression on the replicate data

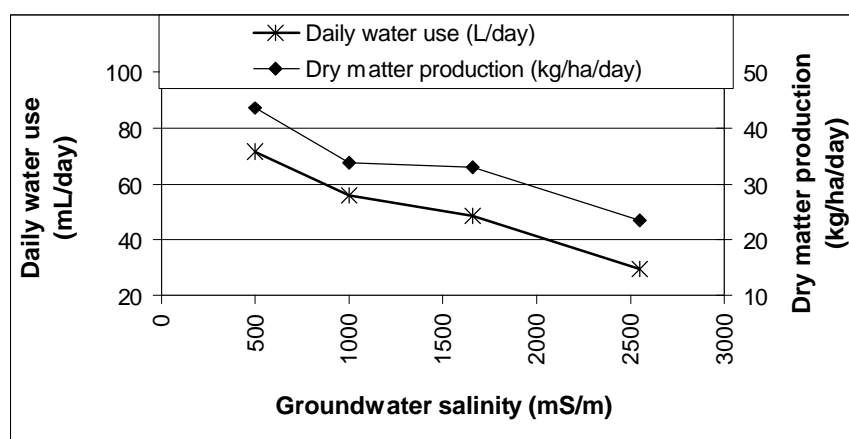
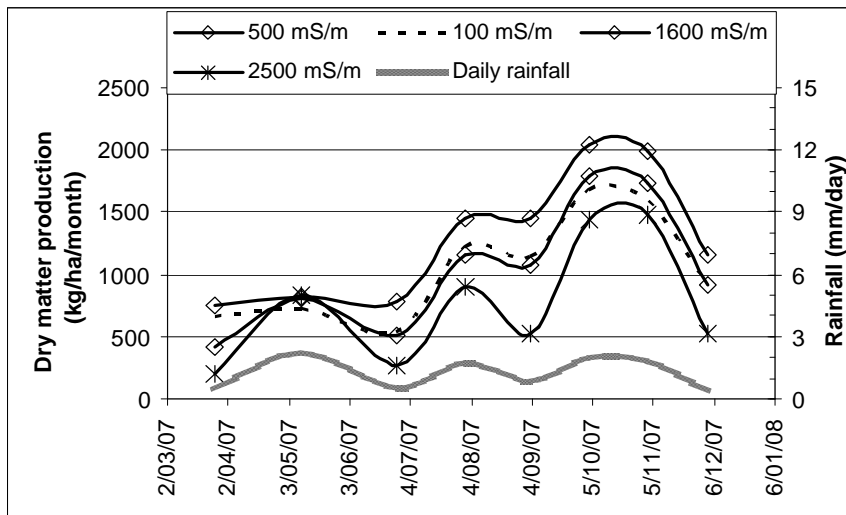


Figure 1: Groundwater use and dry matter production decreased as groundwater salinities increased

Seasonal variability in dry matter production in relation to rainfall and groundwater salinities

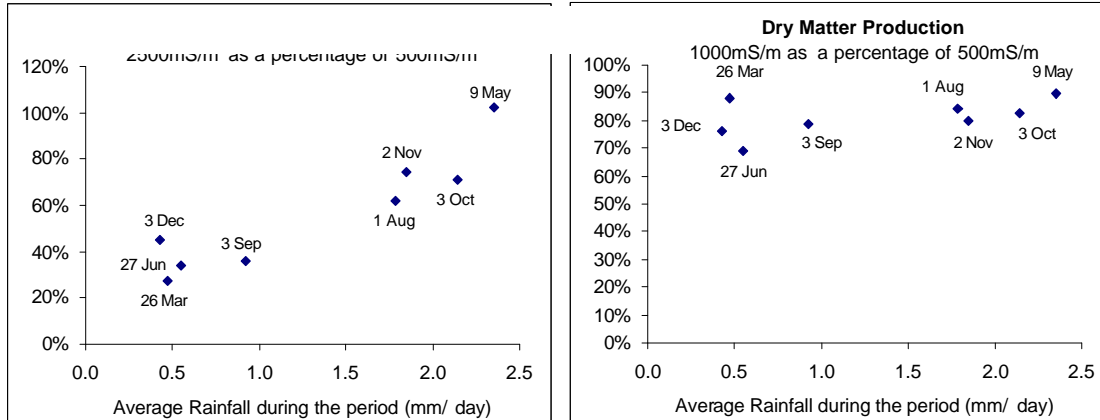
The patterns of seasonal dry matter production were similar for all groundwater salinities (Figure 2). All treatments produced more dry matter during spring months and less during autumn months. More than 70mm of rainfall during April 2007 increased the dry matter production from the three saltiest treatments (1000, 1600 and 2500mS/m) to that of freshest one (500mS/m; Figure 2).

Figure 2: Dry matter production in relation to rainfall and groundwater salinities



The ratio of dry matter production from the saltiest groundwater (2500mS/m) as a percentage of yield from 500mS/m, increased significantly ($R^2 = 0.84$, $p=0.001$) as the rainfall increased (Figure 3a). In contrast the ratio of production from 1000mS/m as a percentage of yield from 500mS/m did not change ($p=0.18$) in relation to rainfall (Figure 3b). The case for 1600mS/m treatment (not presented) had also a significant trend ($R^2 = 0.70$, $p=0.009$), but was not as pronounced as the 2500mS/m trend relationship.

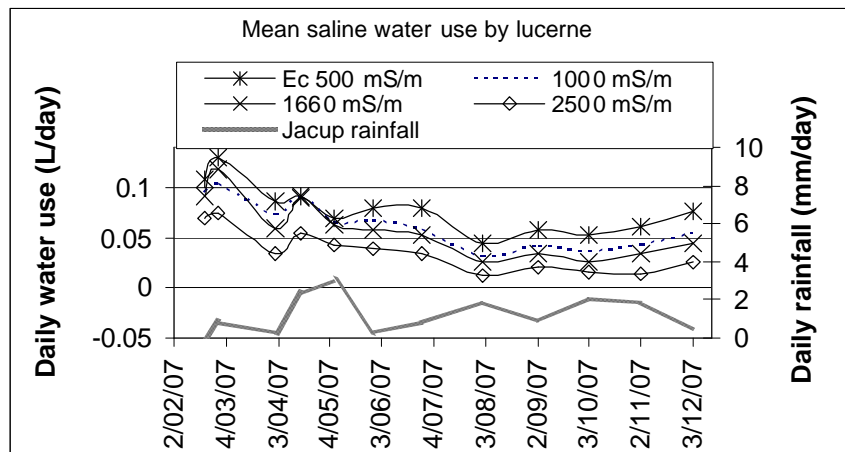
Figure 3a & 3b: Dry matter production 2500 & 1000mS/m as a percentage of 500mS/m



Seasonal variability in groundwater use in relation to rainfall and groundwater salinities

The patterns of seasonal groundwater use were similar for all groundwater salinities (Figure 4). There were significant ($p < 0.001$) differences between the treatments and those with access to fresher groundwater, used more water than the ones accessing saltier waters. Unlike with dry matter, the ratio of water use from the highest to lowest salinity did not correlate well with applied rainfall.

Figure 4: Seasonal variability in groundwater use in relation to rainfall and groundwater salinities



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