Performance of APSIM-Lucerne in South Australia

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Abstract

The performance of APSIM-Lucerne was tested against a detailed plant and soil data set collected in an experiment located at Roseworthy, South Australia. Data was collected from three irrigation treatments that included supplementary summer surface irrigation (SI) and rainfed (RF) treatments. The experiment was conducted on an established stand of the highly winter-active cultivar Sceptre (winter dormancy rating of 9). Data was collected from 12 harvest cycles running from December 1999 to September 2001. Soil water content was measured fortnightly over this period to a depth of three metres using the neutron moisture meter method. Inorganic soil nitrogen was determined on four occasions. Lucerne shoot biomass was measured at regular intervals along with plant number, stem number, leaf area, leaf weight, stem weight, plant height, node number and flowering time.

Model simulations agreed well with observed data for soil water dynamics, phenology, and leaf area index. Lucerne biomass ranged between 1 and 4 t/ha and was also simulated well although some consistent over- and under-predictions were evident. In general, biomass was under-predicted during the summer-autumn period, and over-predicted during spring. Further improvements to model capability are the subject of ongoing research.

Key Words

lucerne, *Medicago sativa*, simulation, plant-available water capacity, phenology, physiology

Introduction

The integration of lucerne into cropping systems is one of the most promising options for reducing drainage and the spread of dryland salinity in grain growing regions. Lucerne can be used either as a pasture phase followed by a phase of annual crops (phase farming), or by growing annual crops over a living stand of lucerne (companion cropping). The key to developing successful phase and companion cropping systems is improved understanding of soil water and nitrogen dynamics. In phase farming a key issue is availability of water and inorganic nitrogen to crops following lucerne. Under companion cropping the central issue is competition between lucerne and the crop for soil water and inorganic nitrogen.

APSIM (1) has the capacity for simulating lucerne and a range of annual crops grown in sequence (phase farming) or in competition (companion cropping). This paper describes the performance of APSIM-Lucerne (2) against a detailed data set from Roseworthy, South Australia.

Methods

Field experiment

Three irrigation treatments (Rainfed, Sub-surface irrigation, Surface irrigation) were imposed on a one-year old stand of lucerne (cv. Sceptre) growing on a sandy loam duplex soil on Roseworthy Campus of the University of Adelaide. Only the rainfed (RF) and surface irrigation (SI) treatments are reported here. The experiment ran from December 1999 to October 2001 and included 12 harvest cycles, seven in 2000 and five in 2001. The RF treatment received rainfall only and the SI treatment received 642 and 195 mm of overhead sprinkler irrigation during the summer of 2000 and 2001 respectively. Plot size was 10 x 10 m and treatments were replicated four times in a randomised block design.

Plant number, stem number, stem height, number of nodes, leaves per stem, leaf area index, and shoot biomass were recorded at regular intervals over the duration of the 12 harvests. Flowering date (10% of plants with at least one flower) was recorded. Soil water content was determined to a depth of 3 m at fortnightly intervals using the neutron moisture meter (NMM).

Model parameterisation

Daily weather data was sourced from SILO, Bureau of Meteorology, for Roseworthy Campus. Plant available water capacity (PAWC) was determined from estimation of the drained upper limit (DUL) and lower limit (LL) for lucerne (3). Cultivar specific (cv. Sceptre) parameters for depth of rooting and flowering time were derived from the observed data. Management actions (sowing, harvests, irrigation) in the simulation exactly followed actual field operations except that the irrigation amount in 2000 was reduced by 33% (214 mm) to account for apparent losses due to the hot and sometimes windy conditions at the time of irrigation. Lucerne plant density (stem density) was set at observed values. The simulation commenced on 4/6/1998 and was terminated on 19/9/2001.

Results

PAWC was calculated as 122, 166, and 178 mm for 1, 2, and 3 m respectively. Soil water extraction was observed to depths of 120-140 cm and lucerne roots were found to 140 cm, but only at low densities (0.07 – 0.37 cm/cm^3) below 100 cm. Changes in soil water over time reveal the seasonal pattern of rainfall and the influence of summer irrigation (Figure 1). In general, there was good agreement between observed and simulated soil water for the ten individual layers (data not shown). APSIM-SoilWat2 and APSIM-Lucerne were able to adequately capture the distribution and soil water extraction patterns observed under lucerne in this duplex soil.

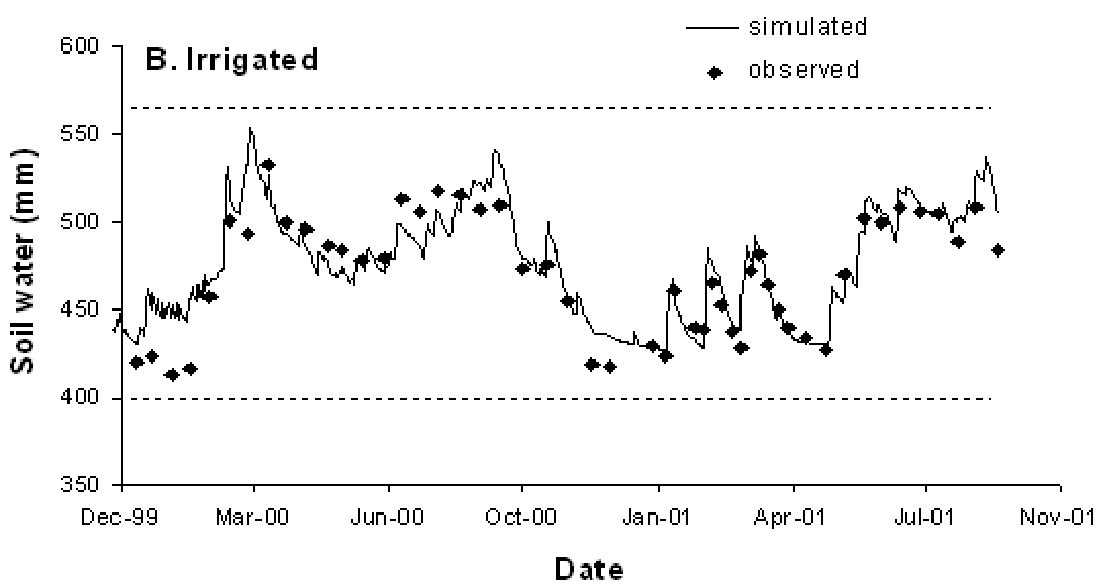


Figure 1. Observed and simulated total soil water (mm) over the 0-200 cm depth in the surface irrigated treatment. Dashed lines show drained upper limit and lower limit.

Flowering time was predicted within seven days of 11 of the 15 observed flowering times (Figure 2). The model failed to predict observed flowering time on the 5th March 2001 (harvest cycle no. 9), a period of moisture stress.

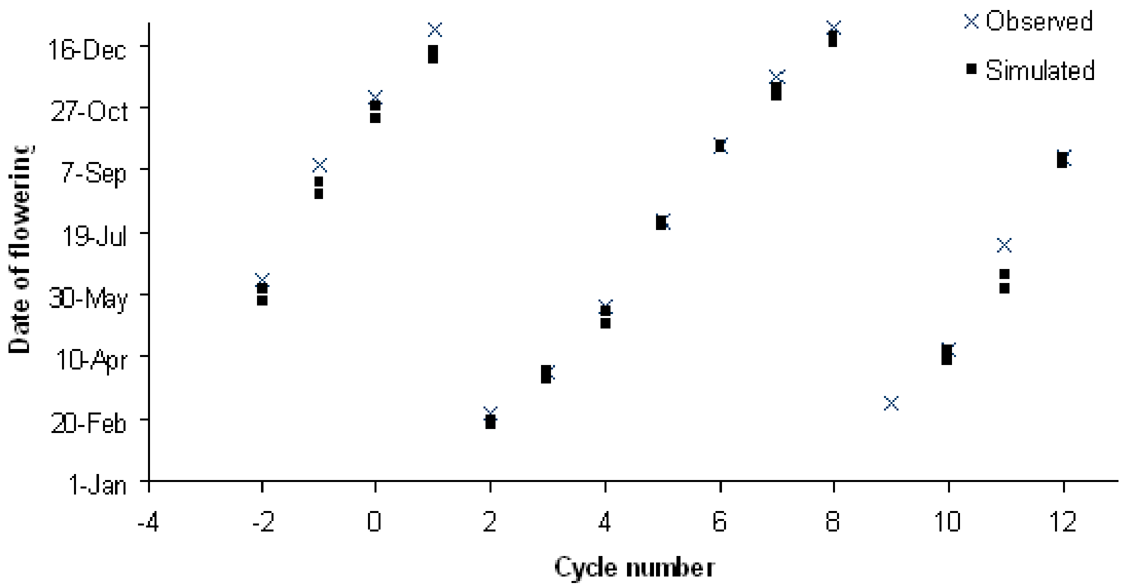


Figure 2. Comparison of observed and simulated date of flowering. Cycle number describes harvest cycle number, negative numbers refer to harvests prior to the main experiment commencing. Simulated values include start and finish dates of flowering.

Leaf area index simulation was in general agreement with the observations (Figure 3). LAI was under predicted during the summer-autumn periods of 2000 and 2001.

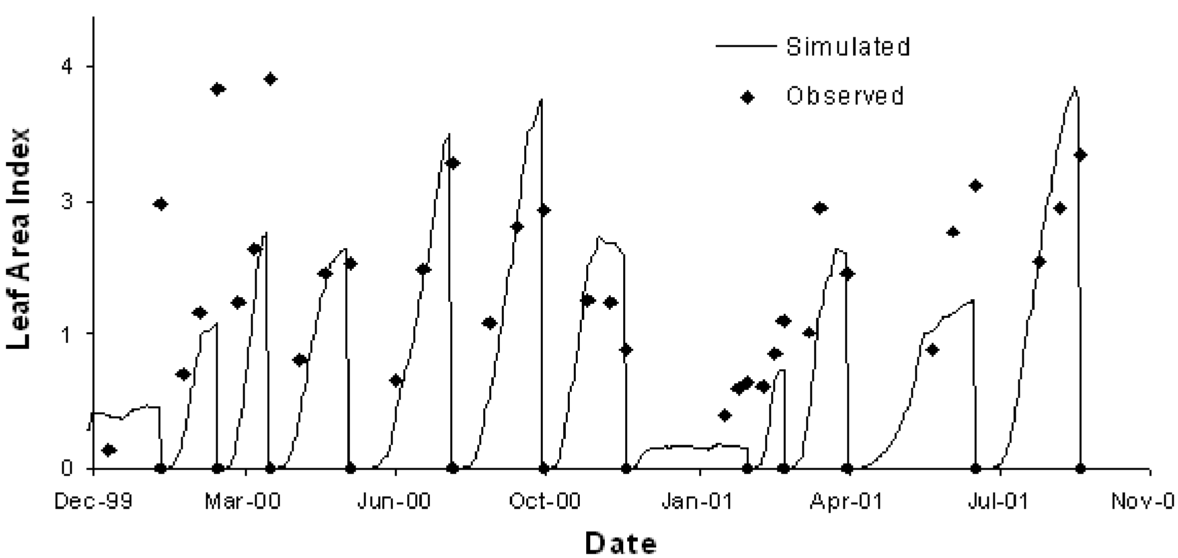
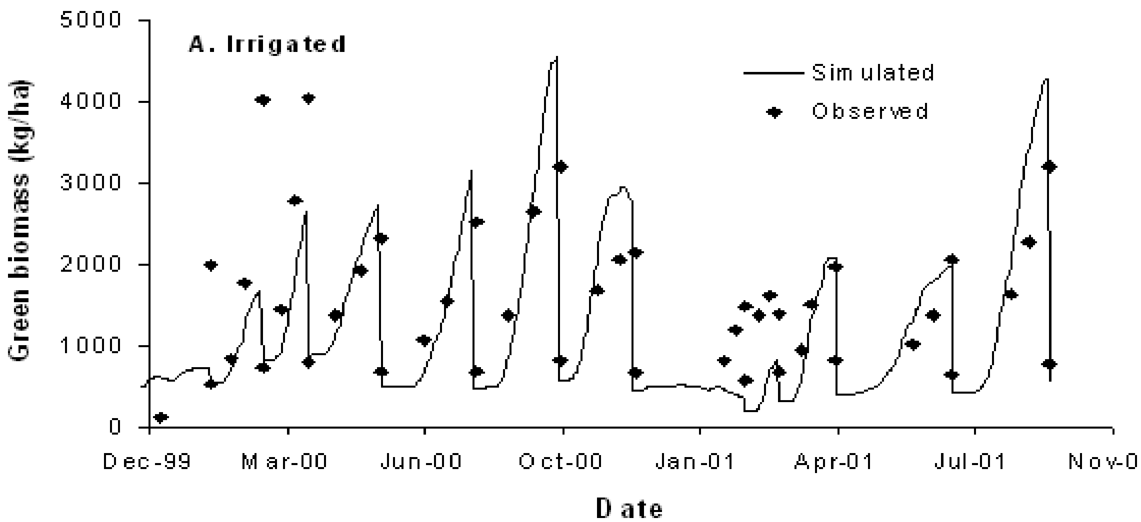


Figure 3. Observed and simulated leaf area index for the surface irrigated treatment.

Shoot biomass for individual harvests ranged from less than 500 kg/ha to over 4,000 kg/ha (Figure 4). Annual lucerne dry matter production (t/ha/year, 7 harvests in 2000 and 5 in 2001) was 8.3 (9.9, simulated amount in brackets) in 2000 and 3.2 (5.0) in 2001 under RF conditions, and this increased to 20.3 (19.4) in 2000 and 10.1 (10.7) in 2001 with supplementary summer irrigation. In the SI treatment (Figure 4A), simulated biomass was greater than observed in September 2000 and 2001, and less than observed during the late summer early autumn period in both years. Similar, though smaller, trends occurred in the RF treatment (Figure 4B).



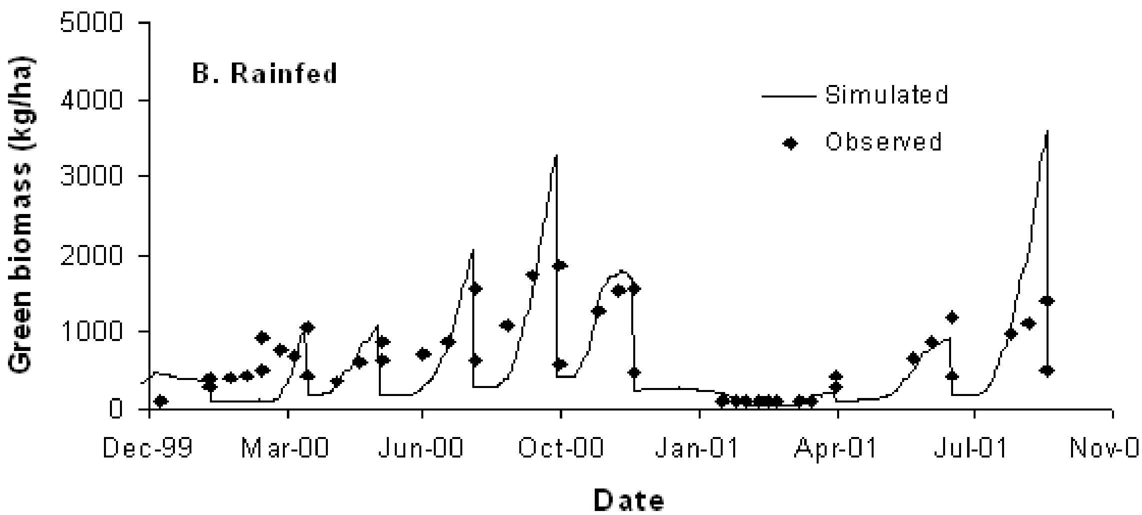


Figure 4. Observed and simulated shoot biomass over twelve harvest cycles in A. irrigated treatment and B. rainfed treatment.

Conclusion

APSIM was able to adequately simulate growth, development, and water use of lucerne at Roseworthy. Further improvements to the simulation of phenology, autumn decline in radiation-use efficiency, response to water stress, and inclusion of carbohydrate root reserves, are the subject of ongoing research. The emerging capability for reliable simulation of lucerne growth and water use will find many applications in research on the productivity and sustainability of agricultural systems. Examples include analysis of water use and productivity of phase and companion farming systems involving lucerne and a range of annual crops.

Acknowledgements

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References

(1) Keating, B.A., Carberry, P.S., Hammer, G.L., Probert, M.E., Robertson, M.J., Holzworth, D., Huth, N.I., Hargreaves, J.N.G., Meinke, H., Hochman, Z., McLean, G., Verburg, K., Snow, V., Dimes, J.P., Silburn, M., Wang, E., Brown, S., Bristow, K.L., Asseng, S., Chapman, S., McCown, R.L., Freebairn, D.M. and Smith, C.J. 2002. Eur. J. Agron. (in press).

(2) Robertson, M.J., Brinsmead, R.B., Carberry, P.S., Huth, N.I., Turpin, J.E., Probert, M.E., Poulton, P.L., Bell, M., Wright, G.C. and Yeates, S.J. 2002. Aust. J. Agric. Res., 53: 429-446.

(3) Dalgleish, N. and Foale, M. 1998. Soil Matters. Monitoring soil water and nutrients in dryland farming. CSIRO, Toowoomba.