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Improved modelling of lucerne (*Medicago sativa* L.) production for grazing livestock

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Introduction

Lucerne (or alfalfa; *Medicago sativa* L.)-based pastures play an important role in livestock and mixed farms (crop-livestock) in Australia. If lucerne is to be more widely adopted, it will be important that landholders are able to plan to maximize its benefits to their livestock enterprises (usually as a part of a diverse feed base), as well as assess the benefits and minimizing the costs of lucerne phases to subsequent crops. However, the ability to accurately model lucerne plant physiology across the full spectrum of environments, genotypes and cultivars remains elusive. This study aimed to review and revise the description of lucerne (*i.e.* the lucerne "parameter set") in the GRAZPLAN pasture growth model (Moore *et al.,* 1997) to improve its predictions of growth rate and nutritive value; and validate the predictions of the new parameter set against experimental data sets from different areas within Australia.

Materials and Methods

As lucerne is grown across a large spectrum of climate zones, soil types and farming systems, datasets were gathered from field experiments conducted across Australia (Table 1). A final set of 7 experiments from 6 locations was chosen based on the availability of adequate site characterization in terms of soil properties and local meteorological conditions during the experiment, the length of record, whether shoot biomass accumulation was recorded for at least 10 intervals, the inclusion of a number of genotypes (differing in their winter activity - often called dormancy) in the experiment, as well as the availability of data other than shoot production (*e.g.* chemical composition of the shoot material, leaf: shoot proportion, root data, soil water dynamics *etc.*).

Table 1: Details of experimental datasets used in the evaluation of the new GRAZPLAN parameters for lucerne (Climate summaries are for 1950-2013.) The Cootamundra experiment was the only one with forage nutritive value; both Cootamundra and Quairading also had soil water information. Activity classes were winter inactive (WI), semi-winter active (SWA), winter active (WA) and highly winter active (HWA).

<table>
<tr><th rowspan="2">Location (descriptor)</th><th rowspan="2">Latitude</th><th rowspan="2">Average temperature (°C)</th><th rowspan="2">Average rainfall (mm)</th><th rowspan="2">Soil type</th><th colspan="4">Cultivar classes represented</th></tr>
<tr><th>WI</th><th>SWA</th><th>WA</th><th>HWA</th></tr>
<tr><td>Forth</td><td>41° 20’ S</td><td>12.1</td><td>975</td><td>Red Ferrosol</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Cranbrook</td><td>42° 01’ S</td><td>12.9</td><td>632</td><td>Red Ferrosol</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Tamworth (Boschma)</td><td rowspan="2">31° 15’ S</td><td rowspan="2">16.7</td><td rowspan="2">678</td><td rowspan="2">Chromosol Brown</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Tamworth (Lodge)</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Hamilton</td><td>37° 84’ S</td><td>13.1</td><td>681</td><td>Chromosol Brown</td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Cootamundra</td><td>34° 40’ S</td><td>15.1</td><td>660</td><td>Yellow Dermosol</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>Quairading</td><td>32° 02’ S</td><td>17.6</td><td>366</td><td>Gravelly pale deep sand</td><td></td><td></td><td>X</td><td></td></tr>
</table>

These datasets were used for GRAZPLAN validation and where necessary for model development. In the situations where necessary experimental information on plant physiology was not available from field datasets, model development used data available in literature. The main model developments related to:

- The cycle of flowering under cutting and grazing,
- Model logic describing reduced shoot activity during winter,

- Alterations to parameters for growth-limiting factors,
- Allocation of growth between roots, leaves and stems,
- Extension of the rooting front,
- Changes to the dynamics of herbage quality

Results and Discussion

Mean prediction errors (MPE, *i.e*., the root mean squared deviation of PGR (pasture growth rates) as a proportion of the mean PGR) in the validation simulations (ranged from 0.33 at Forth to 0.81 and 0.96 in the two Tamworth experiments. The average MPE across sites was 0.65. Barrett *et al.* (2005) obtained mean prediction errors ranging from 0.20 to 0.76, with an overall MPE of 0.45. In the study by Cullen *et al.* (2008) for a similar climatic range of sites, the MPE range from 28 to 46%, and as in this study, variation was highest in warm temperature/subtropical environments and lower in temperature environments.

Fig. 1 shows that when summarized across seasons and experiments, the new parameter set captures most of the variation in the seasonal *patterns* of lucerne growth. The general over-prediction of growth rates in autumn (Fig. 1) is presumably due to the intensity of water limitation not being accurately modelled overall. The model explains 82% of the variation across seasons and experiments, with an overall RMSD of only 11 kg/ha/d.

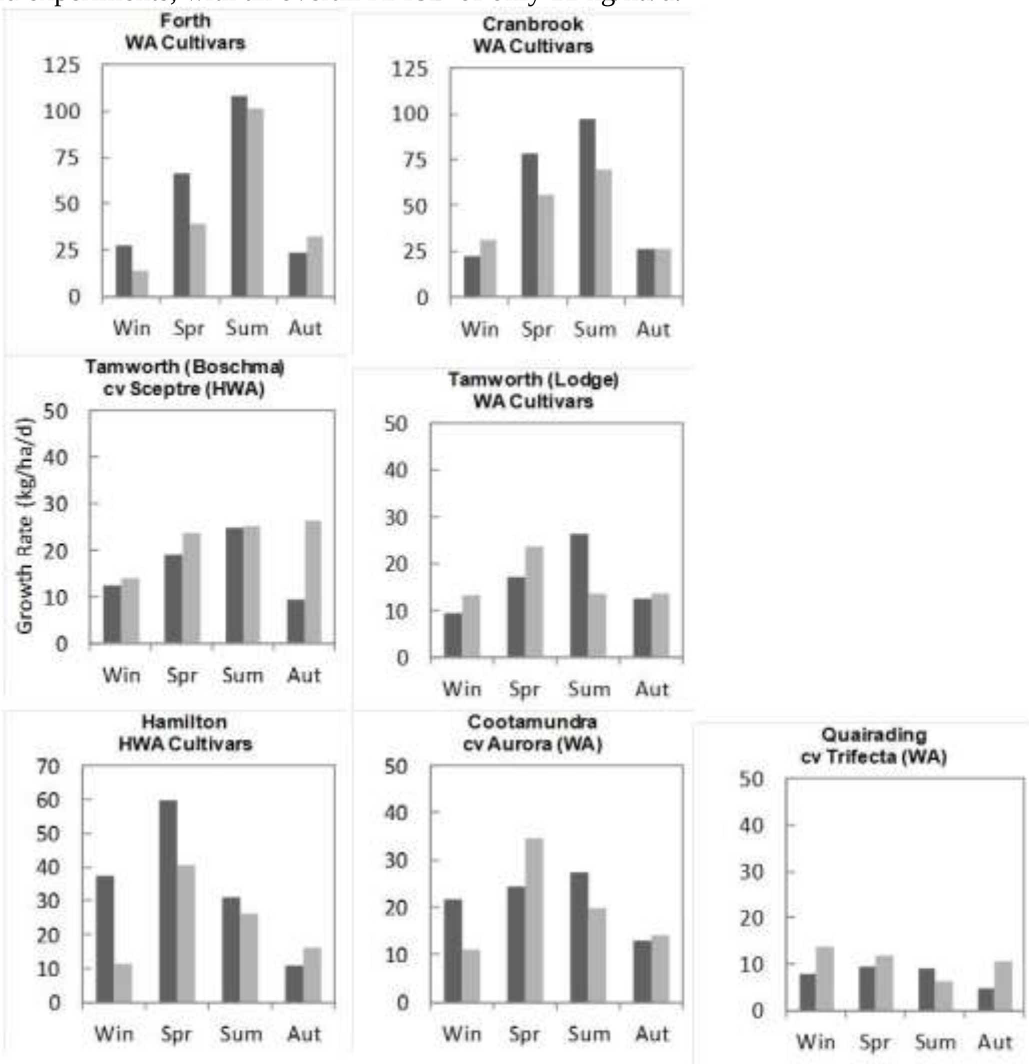

Fig. 1: Average daily growth rate (kg/ha/d) of lucerne modelled with experimental data (light) and GRAZPLAN prediction (dark) and over four seasons for various locations throughout Australia. Seasons are: winter (Win), spring (Spr), summer (Sum) and autumn (Aut). Site names are explained in Table 1.

The new lucerne parameter set was used to simulate long-term patterns of growth rate in permanent, dryland lucerne monocultures managed by cutting. The modelled median lucerne growth rates follow a similar seasonal pattern to the corresponding experimental datasets at Forth, Cootamundra and Tamworth. At Hamilton, however, the long-term simulation has a higher summer than spring growth rate, and at Quairading a permanent lucerne stand is predicted to grow very little over summer, unlike the lucerne ley pastures in the Quairading experiment.

Conclusion

This study has rigorously quantified the strengths and limitations for lucerne of the re-parameterized GRAZPLAN model. The new parameter set and model developments bring clear improvements over the previous version and can confidently be used for predicting lucerne with over a wide range of climates and farming systems. With the availability of further detailed datasets that contain detailed plant physiology and phenology data in response to environmental changes, as well as below ground measurements of different genotypes in different climate zones will greatly assist further model development.

References

Barrett, P. D., A. S. Laidlaw and C. S. Mayne. 2005. GrazeGro: a European herbage growth model to predict pasture production in perennial ryegrass swards for decision support. *European J. Agron* 23: 37-56.

Cullen, B. R., R. J. Eckard, M. N. Callow, I. R. Johnson, D. F. Chapman, R. P. Rawnsley, S. C. Garcia, T. A. White and V. O. Snow. 2008. Simulating pasture growth rates in Australian and New Zealand grazing systems. *Australian J. Agric. Res*. 59: 761–768.

Moore, A. D., J. R. Donnelly and M. Freer. 1997. GRAZPLAN: Decision support systems for Australian grazing enterprises. III. Pasture growth and soil moisture submodels, and the GrassGro DSS. *Agric. Sys*. 55: 535-582.

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