Prediction of canopy photosynthesis for cocksfoot pastures grown under different light regimes

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Introduction Plants in field environments can experience frequent fluctuations in irradiance from full sun to shade caused by cloud cover, overstory shading (e.g. silvopastoral systems) and within canopy shading. Research with widely spaced radiata pine (*Pinus radiata* D. Don) has suggested that due to its shade tolerance cocksfoot (*Dactylis glomerata* L.) is a suitable grass for silvopastoral systems. However, there is limited explanation of the physiological basis for the responses, and consequently no predictive capacity. This limits the application of results to environments, sites and seasons outside of those in which they were measured. The objectives of this study were to simulate net daily canopy photosynthesis rates incorporating the leaf photosynthesis models into a canopy photosynthesis model when only shade was limiting, and to determine the optimum net canopy photosynthesis and LAI for each light regime.

Materials and methods The mathematical model of canopy photosynthesis developed for cocksfoot (Peri *et al.*, 2003) consists of four steps: (1) calculation of leaf light distribution and interception at different canopy depths; (2) calculation of gross canopy photosynthesis incorporating variations in photosynthetic capacity of individual cocksfoot leaves; (3) calculation of total respiration; (4) calculation of net canopy photosynthesis. Daily net canopy photosynthesis (*Pn*) was predicted for cocksfoot under different light regimes by integration of leaf photosynthesis models developed for the light-saturated rate (*Pmax*), the photosynthetic efficiency (α) and the degree of curvature (θ) of the leaf light-response curve. Values of the incident intensity of photosynthetic photon flux density (PPFD) on an area of leaf at the level *Z* in the canopy (*Iz*) were calculated under the following light regimes and intensities: (i) full sunlight (100% transmissivity), (ii) continuous moderate shade (50% transmissivity), (iii) a fluctuating light regime with alternating periods of full sunlight and severe shade (5% of the open PPFD) at intensities of: 10, 20, 30, 40, 50, 60, 70, 80 and 90% transmissivity. This range was used to represent overstorey canopies of different density or size.

Results *Pn* was parabolic against LAI in all simulations, but as light intensity decreased, the maximum *Pn*, optimum LAI and values of *Pn* after the maximum also decreased. As photosynthetic photon flux density (PPFD) fell from full sunlight to 10% of open PPFD in a fluctuating light regime, maximum *Pn* (Pn_{max}) decreased approximately linearly from 33.4 g CO_2/m^2/d to zero (Figure 1). Also, it was predicted that for a continuous light regime (50% transmissivity) Pn_{max} was higher than for a fluctuating light regime with the same intensity (10.4 vs 8.4 g CO_2/m^2/d).

Conclusions The light regimes of cocksfoot plants modified the utilisation of solar energy for net canopy photosynthesis. Continuous light regime overestimated *Pn* by 20% compared with fluctuating light regimes of the same light intensity over a day. Artificial slatted structures are more suitable for simulating the response of understorey pasture species in silvopastoral systems.

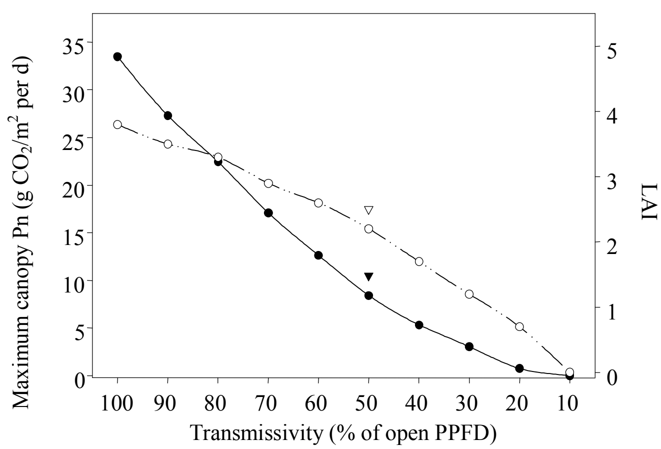

Figure 1 Predicted maximum daily net canopy photosynthesis (Pn_{max}) (●) and optimum leaf area index (LAI) (○) against different intensities of fluctuating light regime for a cocksfoot pasture. Pn_{max} (▼) and optimum LAI (▽) values for a continuous 50% transmissivity light regime are also indicated.

References

Peri, P.L., D. J. Moot & D. L. McNeil (2003). A canopy photosynthesis model to predict the dry matter production of cocksfoot pastures under varying temperature, nitrogen and water regimes. *Grass and Forage Science*, 58, 416-430.