An Architectural Modelling Study of Chickpea-Sowthistle Interactions

S-Zahra-Hosseini Cici[146], Steve Adkins[34], Brian Sindel[45] and Jim Hanan[12]

[1]Advanced Computational Modelling Centre, [2]ARC for Integrative Legume Research, [3]School of Land and Food Sciences, University of Queensland, [4]CRC for Australian Weed Management, [5]University of New England, [6]Shiraz University, Iran jim@maths.uq.edu.au

Keywords: L-systems, Plant architecture Informatics, Integrated weed management, Legume, Chickpea, Sowthistle

It is now widely accepted that integrated weed management (IWM) approaches, making use of the competitive ability of the crop canopy and the application of other cultural practices, will ultimately reduce the level of dependence on herbicide use (Swanton and Murphy, 1996). To help understand the complexity of the different IWM choices available, computational models could be used by the agronomist, plant breeder or agricultural practitioner to simulate, visualise and evaluate different ways of enhancing crop competitiveness with its common weeds. In this study, the effect of chickpea (*Cicer arietinum* L.) canopy on sowthistle (*Sonchus oleraceus* L.) performance is evaluated using an architectural modelling (Prusinkiewicz *et al.*, 1997) approach. In order to determine the potential for canopy manipulation to improve chickpea competitive ability (an important legume in sustainable agriculture) with sowthistle (a common weed in chickpea), an experiment was conducted in which sowthistle plants were grown under two densities of chickpea and in full sunlight (Cici *et al.*, 2006).

To capture the 3D architecture of the chickpea and sowthistle, plants were grown separately in a sandy, well watered and fertilized soil and a sonic digitizer system was used to follow a number of aspects of morphology, topology, and geometry in a non-destructive way over time. The resulting data sets were analysed and used to develop a realistic, dynamic architectural model for each species using L-systems (Lindenmayer, 1968).

A quasi-Monte Carlo light environment model (Lemieux *et al.*, 2004) was used to connect the model of chickpea canopy (Cici *et al.*, 2005) with a virtual sowthistle calibrated to respond to light availability (Cici *et al.*, 2006). This chickpea-light environment-sowthistle (CLES) model (Fig 1) captured the hypothesis underlying this research study: the architecture of virtual chickpea changed the light environment inside the canopy, which influenced the morphogenesis of virtual sowthistle that in turn determined the sowthistle responses to different canopy management strategies. The model was validated against data from glasshouse experiments and the literature. Both the simulated and observed data showed that the most significant canopy features of chickpea for enhancing its competitive ability with sowthistle are increasing its leaf production rate (phyllochron) and leaflet size or decreasing the branching delay.

The potential power of the CLES model becomes more obvious when it is used for choice of cultivar, row spacing and seeding rate. As part of an IWM program, this work provides a basis for a computer model to help choose more competitive cultivars to ensure better weed suppression, thus reducing the need for herbicide application.

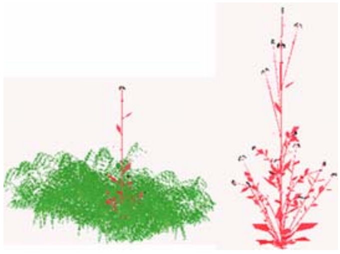

Fig 1. The CLES model showing a side view of a virtual field of chickpea with a sowthistle growing in the middle (left) and a sowthistle in full light (right image) when plants were 75 days old

Acknowledgment

The first author wishes to thank the invaluable volunteer help of Mr. Farri during 3 years of conducting extensive glasshouse experiments for this study. Thanks are also extended to Mick Cieslak and Time Rouger for the light model.

References

Cici SZH, Hanan J, Sindel BM and Adkins S (2006). Phenotypic plasticity of sowthistle and its offspring in response to light availability. In Proceedings of the Fifteenth Australian Weeds Conference, Adelaide, Eds. Preston C, Watts JH and Crossman ND. 172-175. Weed Management Society of South Australia.

Cici SZH, Sindel B, Adkins S and Hanan J (2005). Using L-systems to simulate chickpea cultivars and their shading abilities. In Proceedings of the Fifth International Congress on Modelling and Simulation, Melbourne, Australia, Eds. Zerger A and Argent R. 1230-1236. Modelling and Simulation Society of Australia and New Zealand.

Lemieux C, Cieslak M and Luttmer K (2004). RandQMC User's Guide. pp. 62. University of Calgary, Calgary, Canada.

Lindenmayer A (1968). Mathematical models for cellular interactions in development. *Journal of Theoretical Biology*. 18: 280-315.

Prusinkiewicz P, Hammel M, Hanan J and Mech R (1997). Visual models of plant development. In Handbook of Formal Languages. Eds. Rozenberg G and Salomaa A. 535-597. Berlin, Germany.

Swanton CJ and Murphy SD (1996). Weed science beyond the weeds: the role of integrated weed management (IWM) in agroecosystem health. *Weed Science*. 44: 437-445.