Computer Modelling of Cucumber (*Cucumis sativus*) Plant Structure

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L-systems modelling

An L-systems model captures the fractal-like structure of a plant through a set of rules that define how the plant's structural elements grow and expand. For example, consider the tree model consisting of leaves (L) and branches (B) shown in Figure 1 with rules depicted in the inset [1].

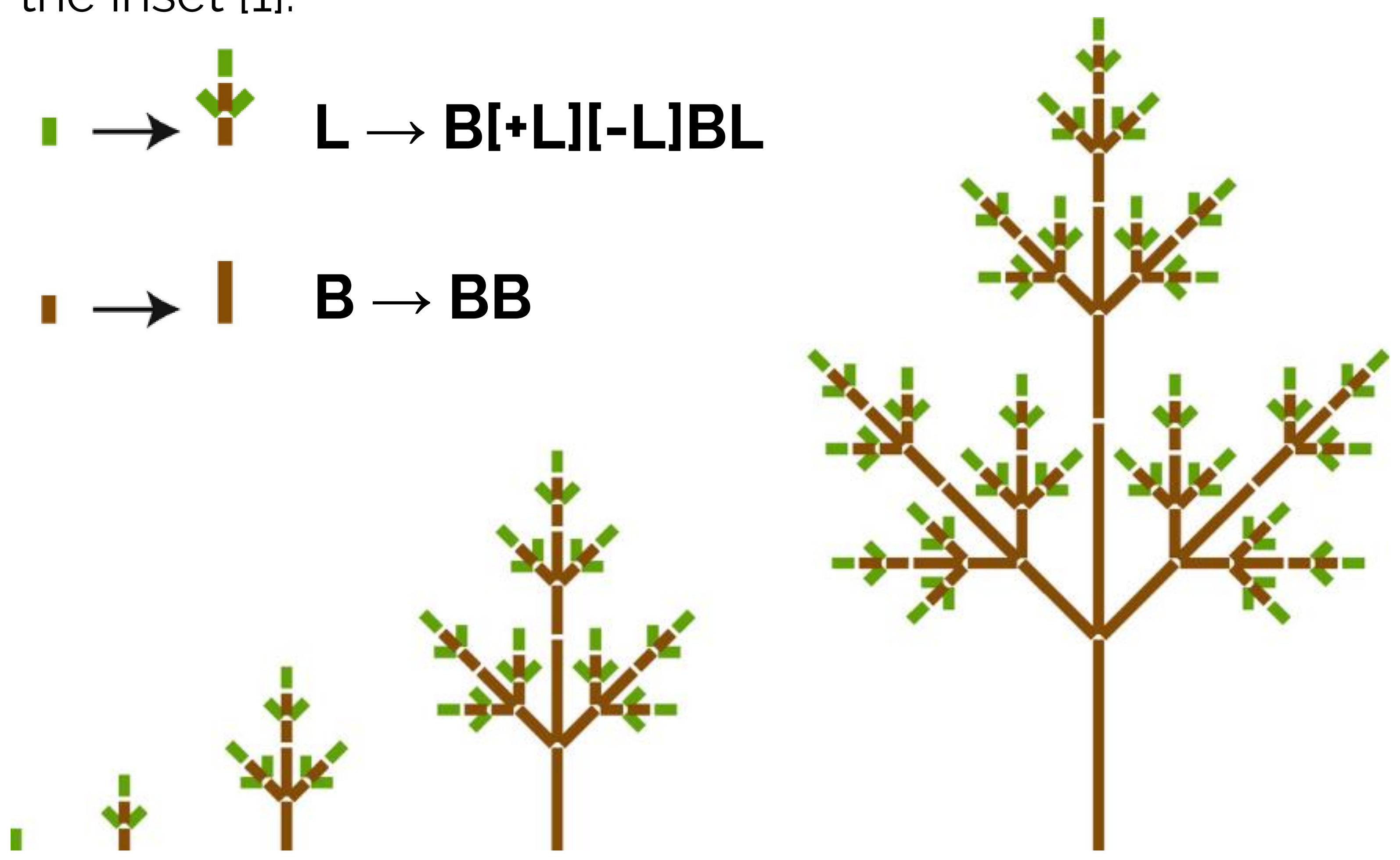


Figure 1: Example of an L-system tree model.

In the example above, the rules are simply implemented through an iterative process that results in fractal-like complexity. Note that the +/- symbols indicate a positive or negative angle and the brackets indicate closed subsets of elements.

Cucumis sativus model

In greenhouse production, cucumber plants are typically maintained as a single vine. The plant structural elements include the leading node (A), internodes (I), leaves (L), petioles (P) and fruit (F). Although the plant also produces tendrils they are promptly removed through regular crop maintenance. The L-system model then evolves according to the following rule, resulting in the expanding plant structure shown in Figure 2.

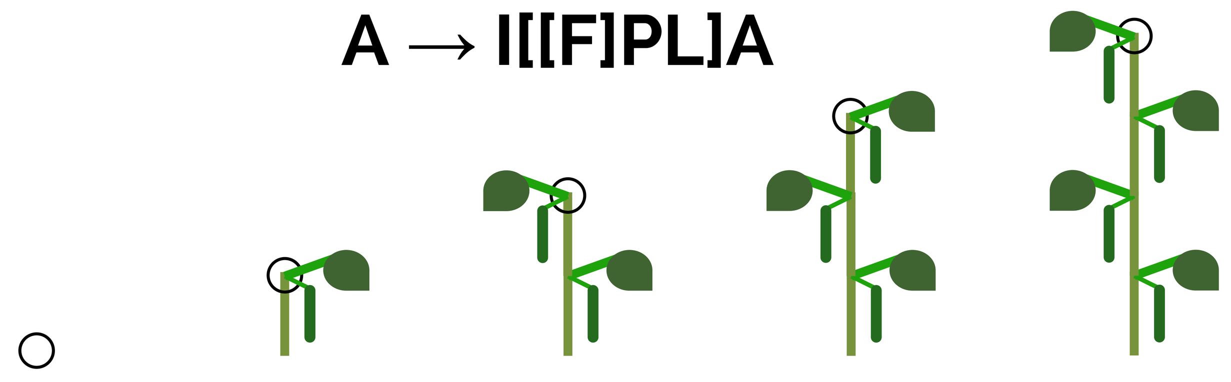


Figure 2: Simple L-system model for greenhouse cucumbers.

The model for *Cucumis sativus* employs empirically fitted growth curves for the various plant structural elements according to the following exponential decay function, as shown in Figure 3 [2].

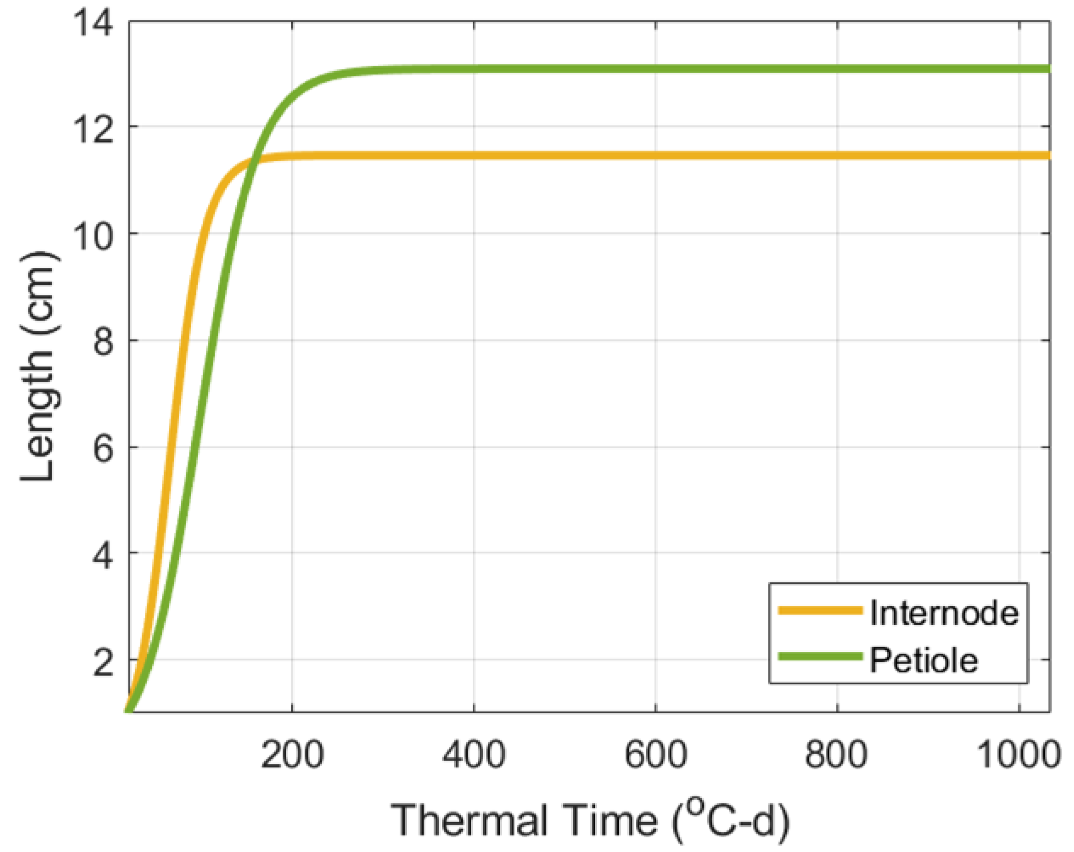
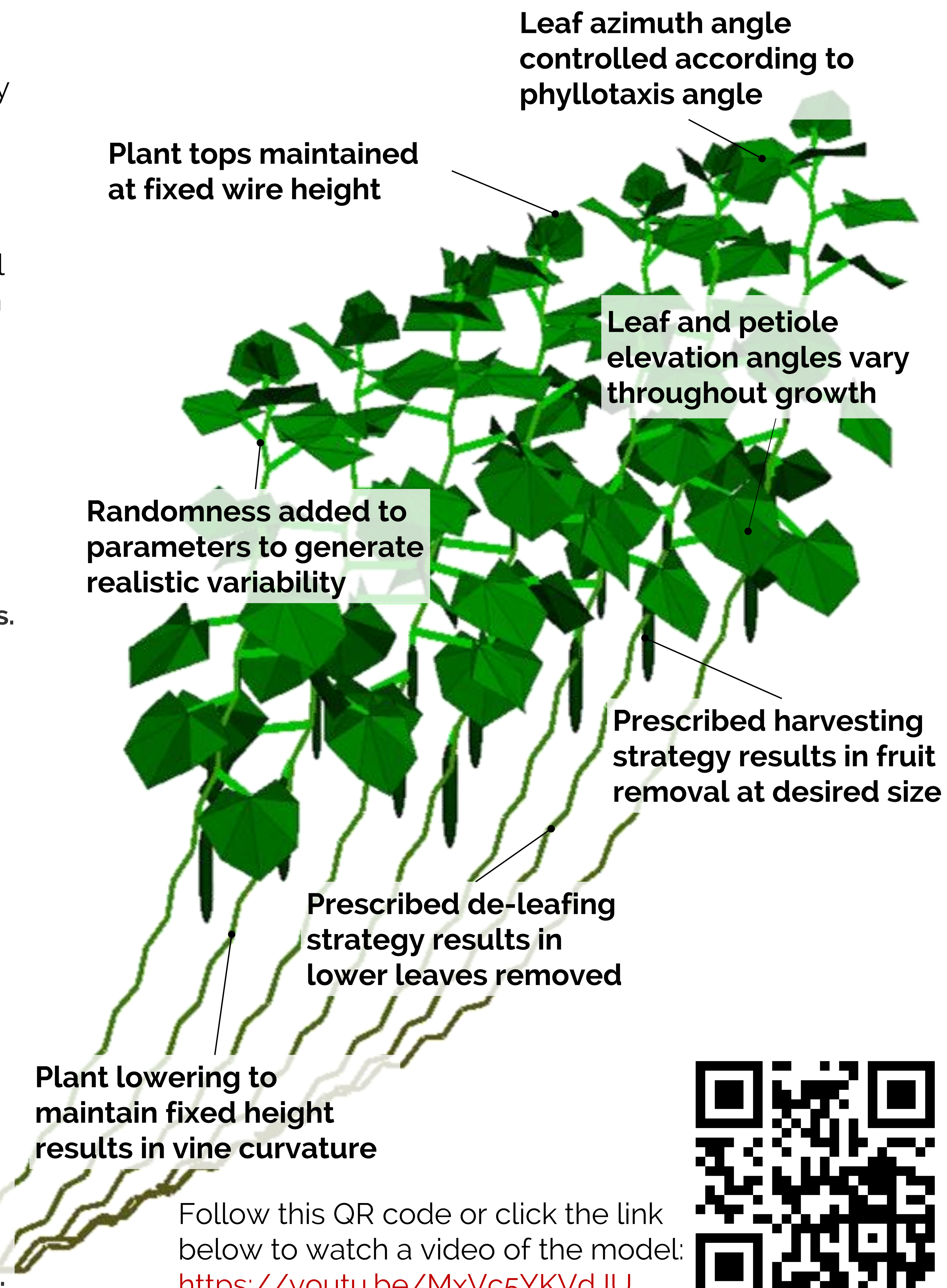


Figure 3: Growth curve shapes for plant structural elements.

This computer model allows us to predict the overall crop structure when designing and developing robotic harvesting systems. There is a potential to expand the model to include effects of environmental conditions, predict yield and investigate the implications of changing crop management practices.



Follow this QR code or click the link below to watch a video of the model: https://youtu.be/MxVc5YKVdJU

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[1] Prusinkiewicz P., Cieslak M., Ferraro P., Hanan J. (2018) *Modeling Plant Development with L-Systems*. In: Morris R. (eds) Mathematical Modelling in Plant Biology. Springer, Cham. https://doi.org/10.1007/978-3-319-99070-5_8

[2] Kahlen, K. (2006). *3D Architectural Modelling of Greenhouse Cucumber (Cucumis Sativus L.) using L-Systems*. Acta Hortic. 718, 51-58. https://doi.org/10.17660/ActaHortic.2006.718.4