

Characterization of the growth dynamics of holostemparasitic *Cuscuta* species in the absence of hosts

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Abstract

1. *Cuscuta* species are rootless, leafless and branchless stems without meaningful photosynthesis. Hence, sink-free and source-free mechanistic growth models are possible yet remain unexplored. Furthermore, phytohormone expression has not yet been studied in the absence of hosts. 2. We use mass conservation in second-order differential equations to build mechanistic models for *Cuscuta* growth dynamics and UPLC-MS/MS to identify and mathematically score phytohormone expression. 3. We identified four sequential stages of growth – exponential, linear, parabolic deceleration and terminal stages and, in *Cuscuta chinensis*, the phases are discernable by eye. 4. Analytical solutions to the differential equations fit the growth data well and the model also predicts faster growth in *Cuscuta* species with smaller seeds, in agreement with the fact that *Cuscuta chinensis* attains terminal stage faster than *Cuscuta japonica*. 5. We found evidence for stage-specific phytohormone expression and for the existence of stem-wide phytohormone gradients, especially for the Auxin components MEIAA and ICAId in *Cuscuta japonica*. 6. We have built models for the roles of phytohormones in *Cuscuta* growth dynamics, and performed ad hoc calculations which suggest a continuously-increasing Cytokinin/Auxin ratio in growing *Cuscuta* seedlings, thereby implying a maximum value beyond-which growth slow-down begins. 7. Synthesis: We have created the first-ever source-free and sink-free plant growth models using mass conservation in second-order differential equations and in so-doing, uncovered four growth stages in *Cuscuta*, observable by eye in *Cuscuta chinensis*. We found stage-specific phytohormone expression and a likelihood of stem-wide phytohormone expression gradients. We then brought it all together by building models for the roles of phytohormones in *Cuscuta* growth dynamics and by performing ad hoc calculations which have suggested that the Cytokinin to Auxin ratio increases continuously in growing *Cuscuta* seedlings, to perhaps attain a maximum value beyond-which slow-down in growth begins.

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