ABSTRACT: Stem cell maintenance in multilayered shoot apical meristems (SAMs) of plants requires strict regulation of cell growth and division. Exactly how the complex milieu of chemical (WUSCHEL and cytokinin) and mechanical signals interact to determine cell division plane orientation and shape of the SAM is not well understood. By using a newly developed mathematical model, combined with experiments, three hypothesized mechanisms have been tested for the regulation of cell division plane orientation as well as of cell expansion in the deeper SAM cell layers. Simulations predict that in the apical cell layers, WUSCHEL and cytokinin regulate the direction of anisotropic cell expansion, and cells divide according to tensile stress. In the basal cell layers, simulations also show dual roles for WUSCHEL and cytokinin in regulating both cell division plane orientation and the direction of anisotropic expansion. This layer-specific mechanism maintains the experimentally observed shape and structure of the SAM as well as the distribution of WUSCHEL in the tissue. Moreover, by using a dynamical signaling model, an additional mechanism underlying robustness maintenance of WUSCHEL gradient through its negative regulator, has been identified. Sensitivity analysis and perturbation study were performed to show validity of the mechanism across different parameter ranges. Currently, a coupled computational framework is being developed by integrating sub models representing a dynamical signaling network and cell mechanics to explore how the WUSCHEL expression domain and the tissue structure are maintained throughout the growth.

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