Physiological Controls on Carbon Fluxes and Biomass Production in Miscanthus: Insights From a Process-Based Agroecosystem Model

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Background/Objective

Biomass crops serve as essential feedstocks for energy and bioproducts. However, dedicated perennial biomass crops such as *Miscanthus x giganteus* (Miscanthus) remain underrepresented in process-based agroecosystem models, limiting robust evaluation of their economic and environmental performance. To address this gap, researchers developed a data-constrained representation of the sterile triploid Miscanthus (IL clone) within the process-based agroecosystem model *ecosys*.

Approach

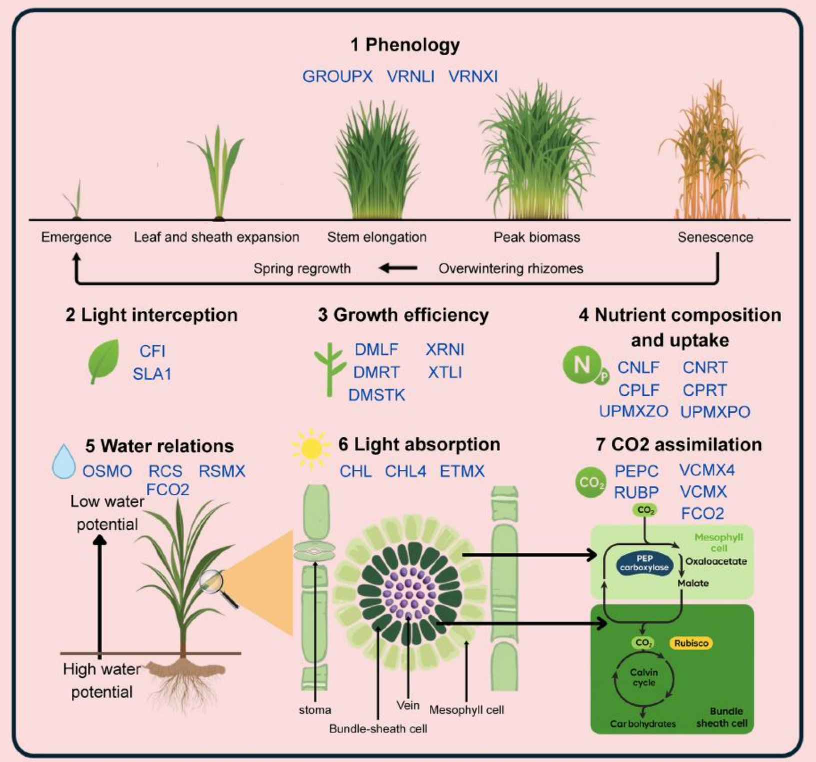
Researchers developed a data-constrained Miscanthus parameterization in *ecosys*. They first configured planting, harvesting, and fertilization practices to reflect field management and constrained Miscanthus phenology with PhenoCam-derived Green Chromatic Coordinate data. Using global sensitivity analysis, they then identified 11 key physiological parameters governing plant carbon, water, and nutrient processes and subsequently conducted ensemble simulations by perturbing these parameters and calibrating the model against eddy covariance data and field-measured biomass.

Results

Parameter response analysis showed that different photosynthetic processes influence productivity in different ways. Protein allocation determines whether productivity increases whereas electron transport capacity controls additional gains once protein allocation approaches saturation. These findings demonstrate that parameter importance depends on physiological context and on which photosynthetic processes remain limiting. Calibration and validation against observations show that *ecosys* reliably reproduces carbon and water fluxes as well as above- and belowground biomass prediction with post-calibration gross primary productivity R^2 improving from 0.67 to 0.95 during the calibration period and remaining high during validation.

Significance/Impacts

This work provides a mechanistic foundation for regional miscanthus-based simulations and assessments.



Schematic representation of processes (1-7) and associated *ecosys* parameters (blue text) for Miscanthus implementation.

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