Modelling the early stages of plant development

Bachelor Project in Applied Mathematics (BEP Technische Wiskunde)
Earliest possible starting date: July-August 2015
Duration: approx. 4 months

This Bachelor Project is related to mathematical biology, plant sciences, and sustainable agriculture. The student will have an opportunity to develop a mathematical model, acquire and process experimental data - a combinations of skills often expected from applied mathematicians in real life. In particular, the Project will involve: modelling biological processes with coupled ODE's, nonlinear least-squares data-fitting, basic image processing, design of experiments, experimentation and data acquisition at Sylvius Laboratory (Leiden University), programming in Python/Matlab.

This research is an integral part of the ongoing joint effort of applied mathematicians from TU Delft and biologists from Leiden University to find a connection between the early stages of the plant development and the measured oxygen consumption data. Our current understanding is that the oxygen is consumed by the mitochondria inside the cells of a germinating seed. The population dynamics of mitochondria subject to limited oxygen supply can be modelled with a modified version of the famous logistic equation and provides excellent fits to experimental data. However, it is not clear how exactly does the growth of the mitochondrial population correspond to the germination event and further development of the plant. All we know is that the larger is the plant the more cells and thus mitochondria it will have. Also, it is not clear what is the relation between the test-tube volume (i.e. total amount of available oxygen), the initial volume of the seed (which depends on the plant species), and the observed oxygen consumption rates.

The idea of this Bachelor Project is to extend the mitochondrial model to include the test-tube/seed volume effects and to acquire and use the time-lapse video of germinating seeds to establish the connection between the deduced mitochondrial population and the actual seed/plant size.

Project Planning

1. Study the current mathematical model and extend it to include the effects of the test-tube and seed's volumes. Implement the model in Python or Matlab and test it on the available oxygen data. Design a simple experiment that would verify the model's predictions while simultaneously recording the actual plant growth (time-lapse video).
2. Perform the experiment at the Sylvius Laboratory and collect the data (it will take approximately one month, basic training, equipment and seeds provided).
3. Analyze the data and answer the following research questions:
    - What is the observed influence of the test tube (and/or seed) volume on the germination process? Does it agree with the predictions of your model?
    - What is the observed relation between the oxygen data, the mitochondrial population deduced from your model, and the actual size of the developing plant? Can this relation be formalized as a new mathematical model?
4. Write the report.

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