

Mathematical Modelling of the Soil-Root-Mycorrhiza System

Arbuscular Mycorrhizal Fungi (AMF) are widespread symbiotic partners of most terrestrial plants and form close associations with their roots. Due to the highly destructive nature of experimental methods, data collection is limited to discrete time points and cannot track individual plants over time. We are developing a mathematical model to investigate structure and function of this symbiosis in a non-destructive and continuous manner.

Motivation for AMF:

- Vital for plant mineral nutrition
- Their role in water acquisition and drought tolerance has been less well understood.
- Experimental investigation of AMF dynamics is invasive
- Evidence for increased drought tolerance in presence of AMF (Bitterlich et al. 2018)
- Increased drought tolerance not just from increased water uptake but changed soil properties from AMF hyphae

Methodology:

1. Mathematical model of mycorrhizal root system
2. Parameterization of (a) root system and (b) mycorrhizal fungi
3. Simulation of plant behavior under different watering treatments

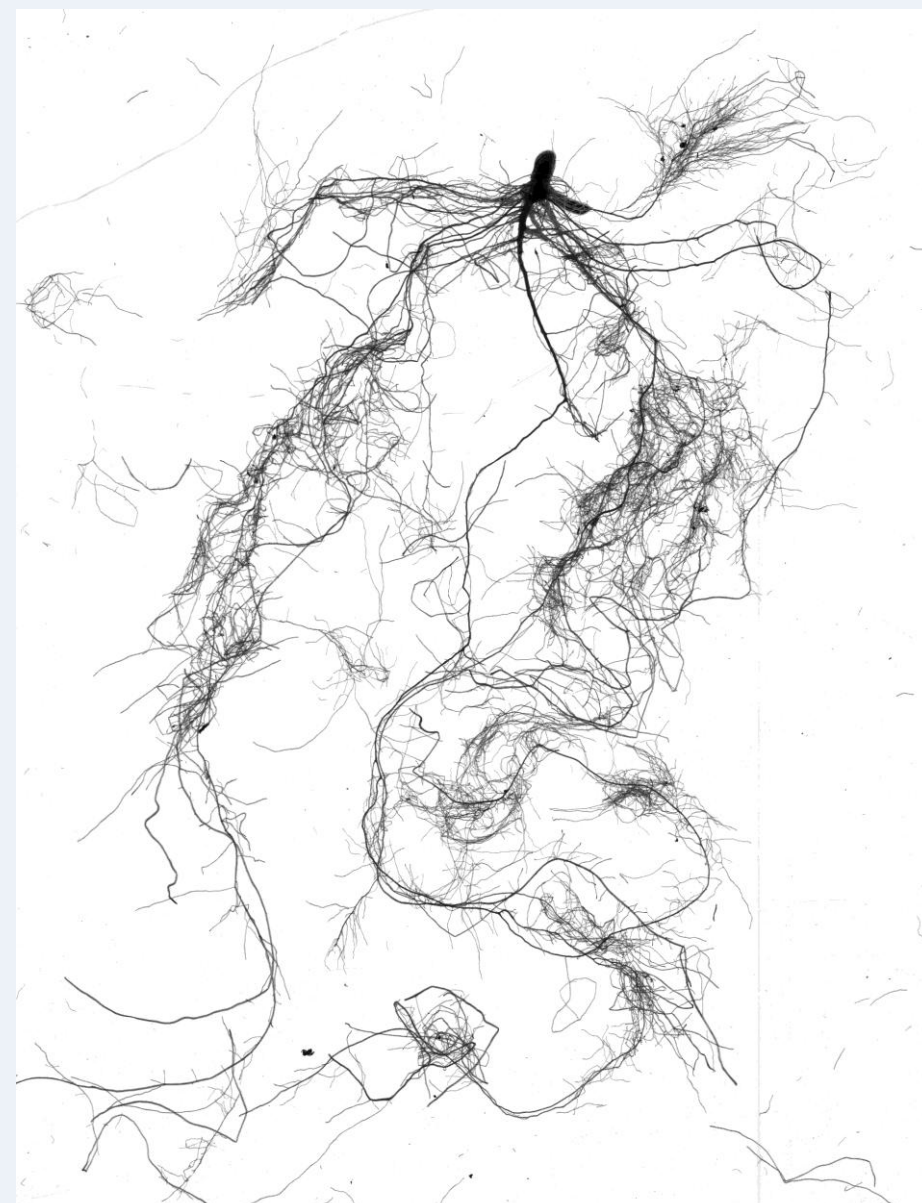
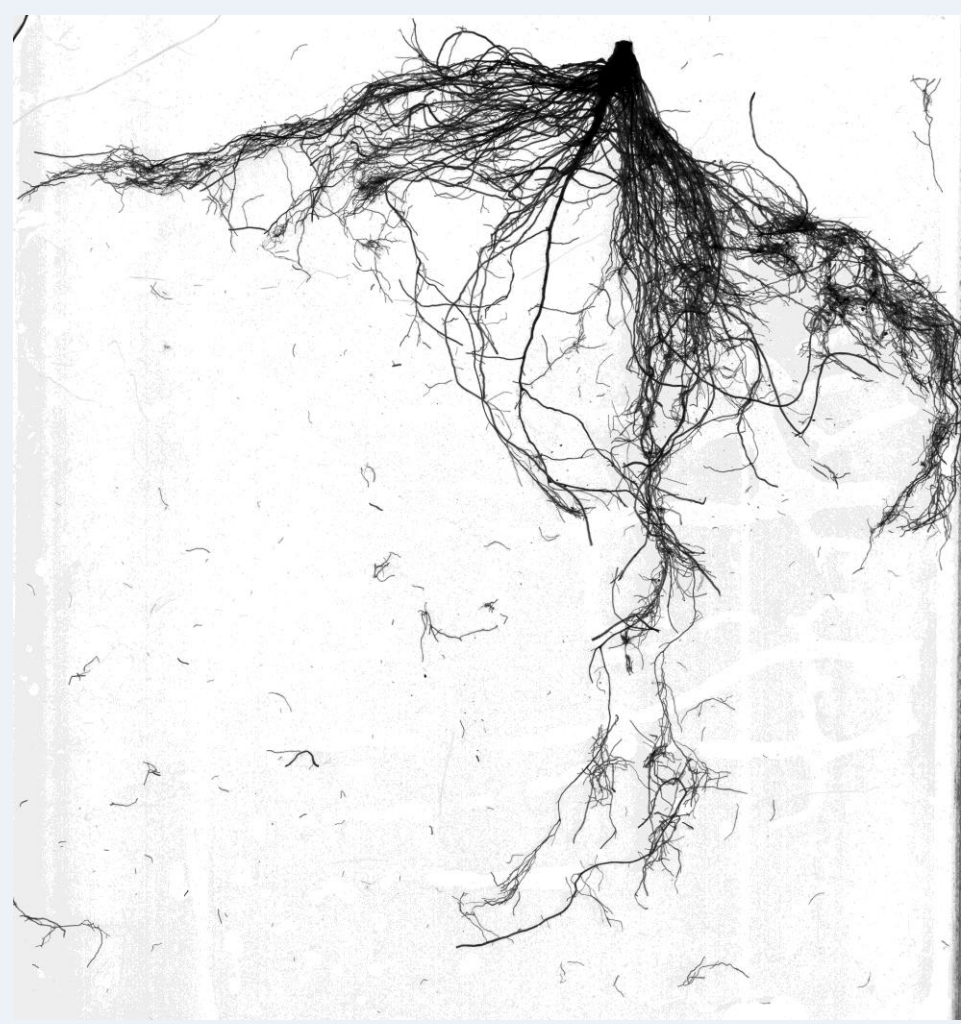


Fig 3: 2D scans of root systems of tomato plants. Left: AMF infected. Right: AMF resistant strain of tomato plants. These scans are being used to parametrize the root system of tomato plants. Unpublished data, presented with permission of the co-authors Dr. Michael Bitterlich (Humboldt Universität zu Berlin) and Dr. Jan Gräfe (Leibniz Institute of Vegetable and Ornamental Crops e.V., Grossbeeren)

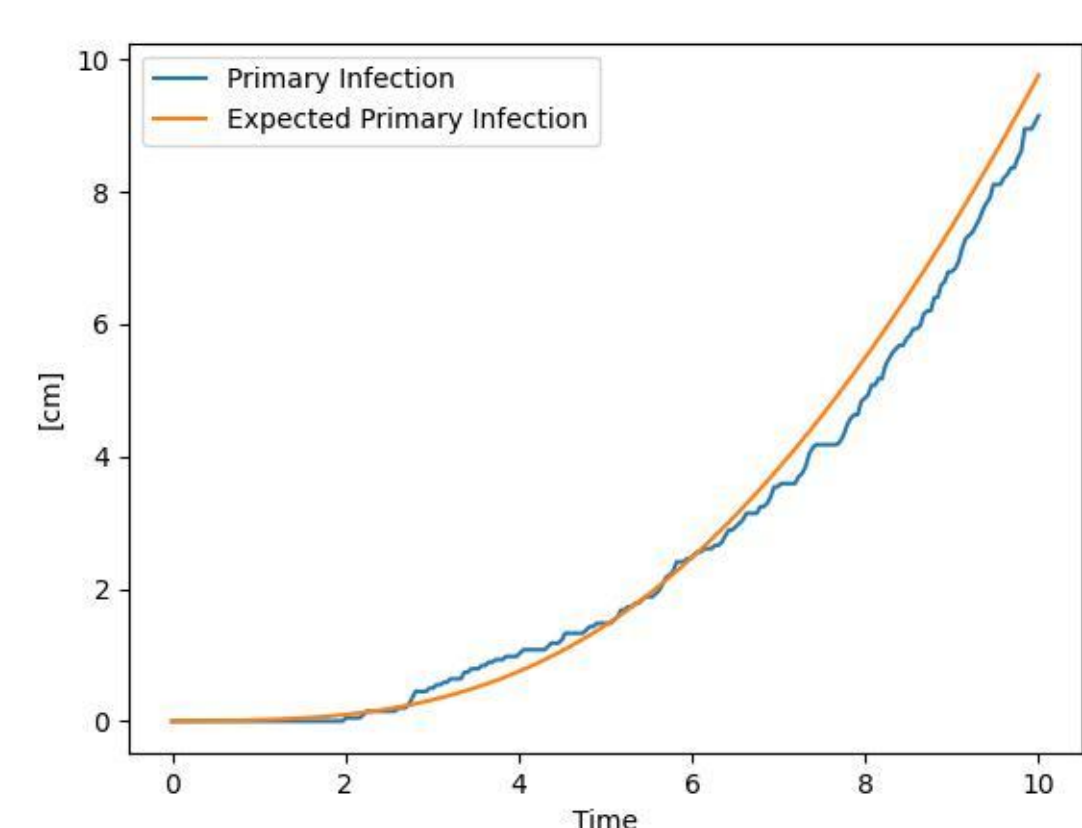
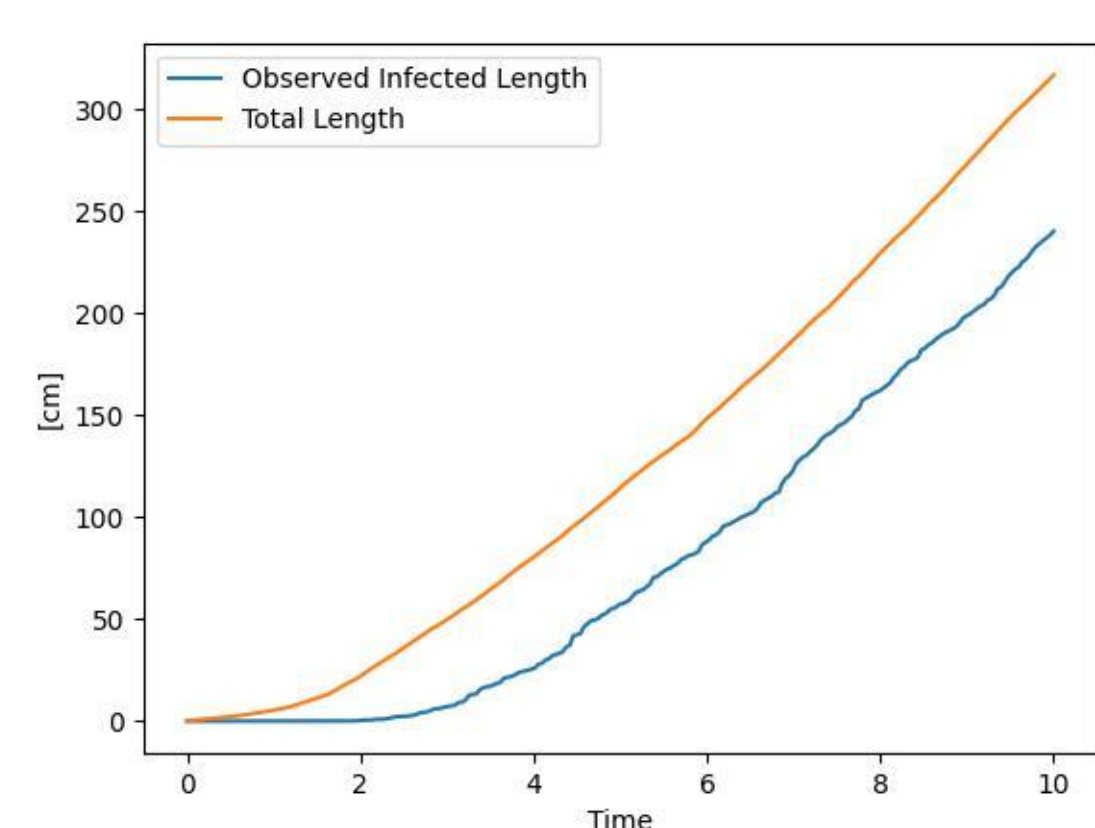


Fig 4: Left: Total root length plotted against infected root length. Right: Comparison of observed and model-predicted root length infected only by soil-borne spores (single run).

Future:

- Complete parametrization of AMF hyphae on tomato plants
- Modelling of drought tolerance of tomato plants
- Modelling of water and nutrient uptake and soil structure modulation by AMF presence

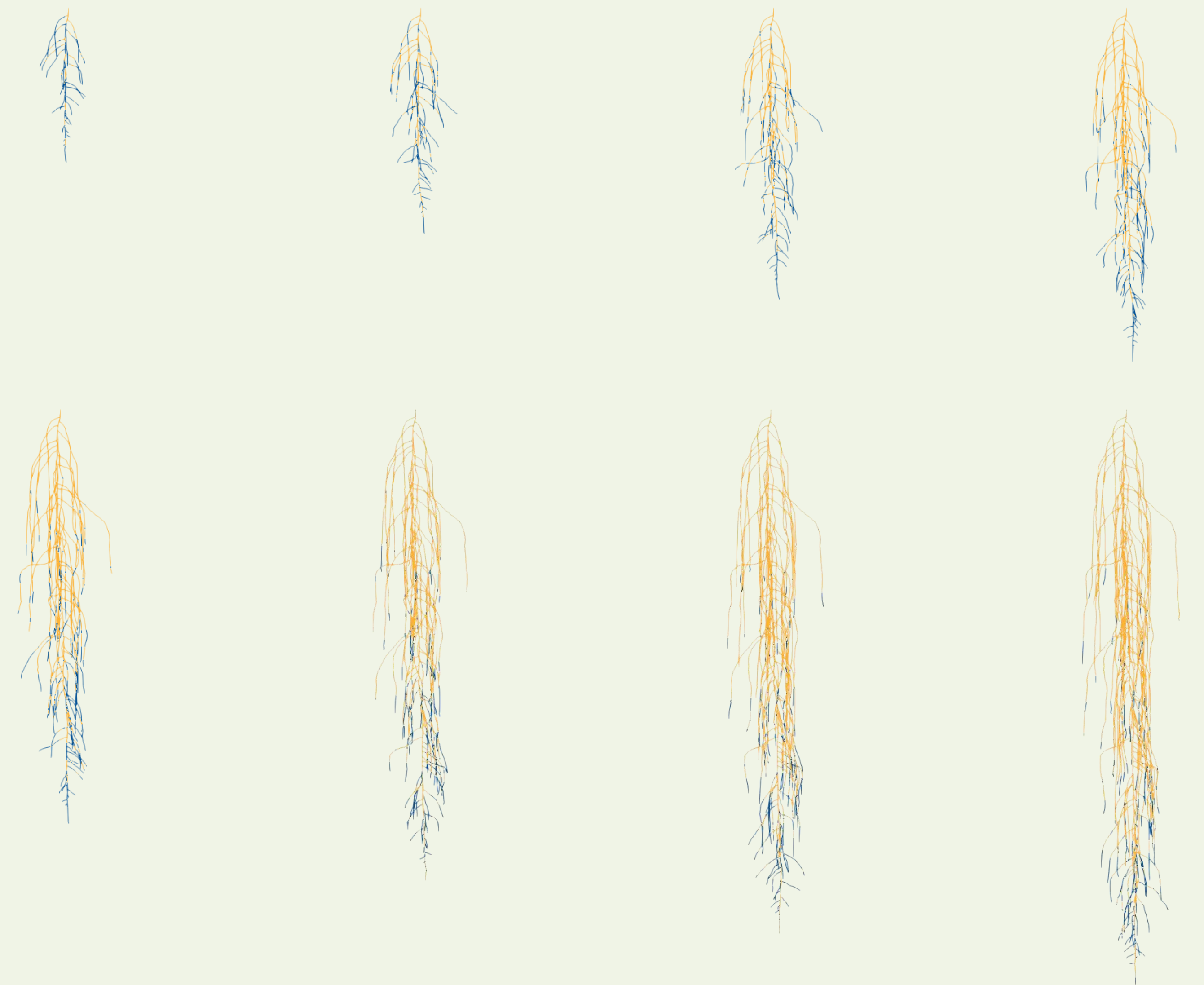


Fig 1: Simulation of root growth and AMF infection of soy plants, as an exemplary dicot, where spores were evenly dispersed throughout the soil everywhere. Growth shown from day 4 to day 20 in 2-day intervals. The yellow-colored roots are infected with AMF the blue roots not. AMF hyphae not pictured.

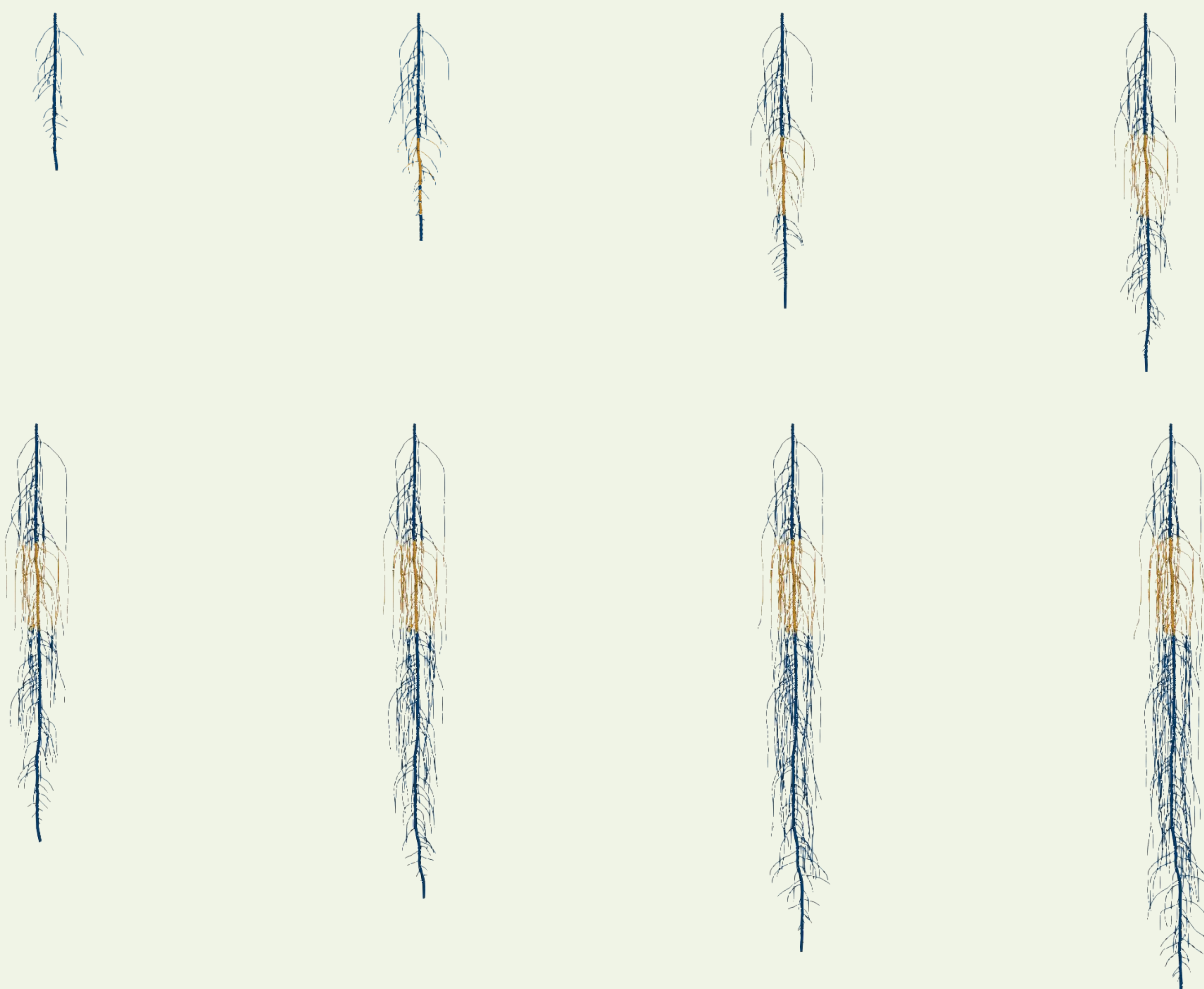


Fig 2: Simulation of root growth and AMF infection of soy plants, as an exemplary dicot, where spores were only present in the soil between a depth of 10 cm and 20 cm. Growth shown from day 4 to day 20 in 2-day intervals. The yellow-colored roots are infected with AMF the blue roots not. AMF hyphae not pictured.