

# Modelling P acquisition from the sub-soil for different crops with specific consideration of bio-pores

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## Aims

The main objective of this research is to develop a cropping systems model which describes P mobilization, fluxes and uptake from the sub-soil by crop roots considering soil P pools, bio-pore density, crop P demand and shoot/root interactions. The development of the model will follow a three step approach:

- Development of a detailed 3D-model including root development, water uptake and selected processes of P flux and P uptake based on experiments with large soil cores
- Development of simplified algorithms with effective parameters to catch the root development and the P uptake processes as affected by bio-pores
- Integration of the results from the 3D-model into a field-scale cropping systems model with consideration of shoot C supply and P demand and model testing based on measurements from field experiments (Figure 1)

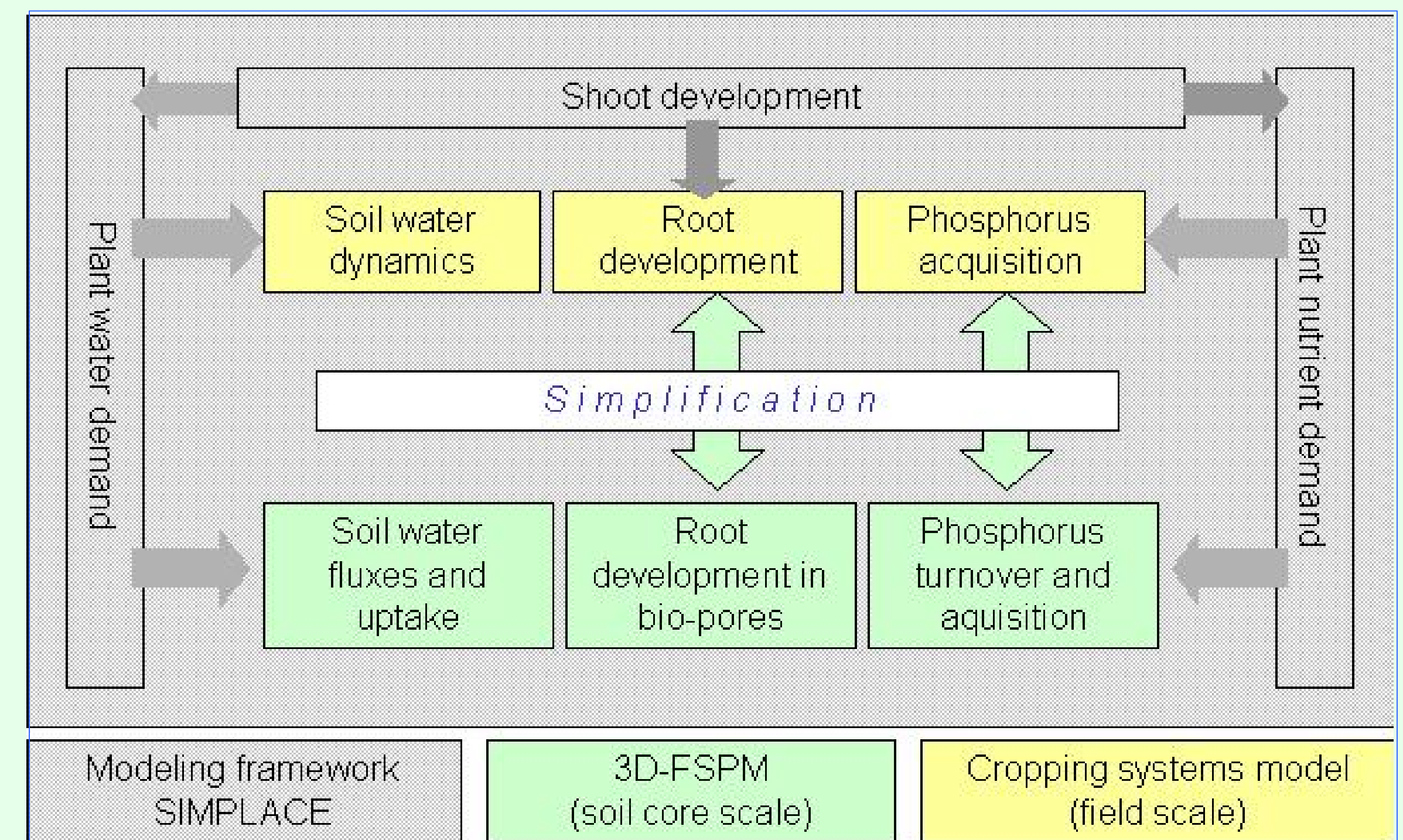


Figure 1: Linking field scale cropping system models with a 3D-FSPM model within the modeling framework SIMPLACE

## Methods

### Soil core scale:

- 3D simulation considering the effect of biopores on root growth and water fluxes (Figure 2)
- 3D-spatially explicit simulation of the effect of root growth and soil water content on nutrient (P) uptake by the roots with special emphasis on biopores
- Selection and evaluation of different modelling approaches
- Assessing the influence of water and nutrient distribution on the parameterization of process based models that do not explicitly account for the 3-D heterogeneous distribution of water and nutrients
- Development of effective modeling approaches and model parameterizations for integration into the field scale model (Figure 1)

### Field scale:

- Estimating the biophysical behavior of crops in response to the interaction of weather, soil and agro-technical management
- Using the modular framework SIMPLACE (Scientific Impact Assessment and Modelling Platform for Advanced Crop and Ecosystem management) with flexibility to exchange model components
- Incorporation of a P turnover module considering pools and fluxes in biopores and soil matrix (Figure 3)
- Expanding the modelling framework with new components (P turnover, root development, P acquisition) derived from the soil core scale simulations
- Validation with independent data sets from field trials including 100 years long-term fertilization experiment at Bonn-Dikopshof

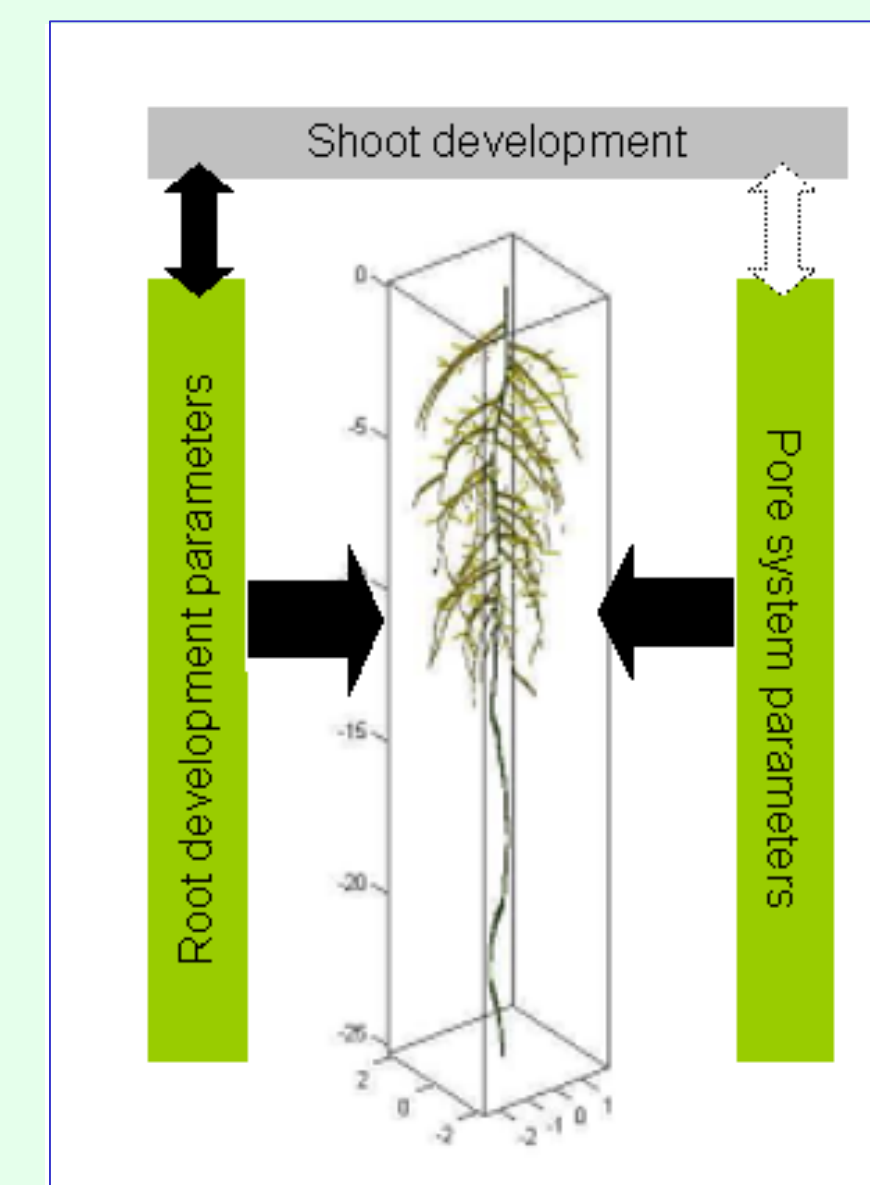


Figure 2: 3D-Simulation of root growth as affected by biopore geometries derived from computer tomography

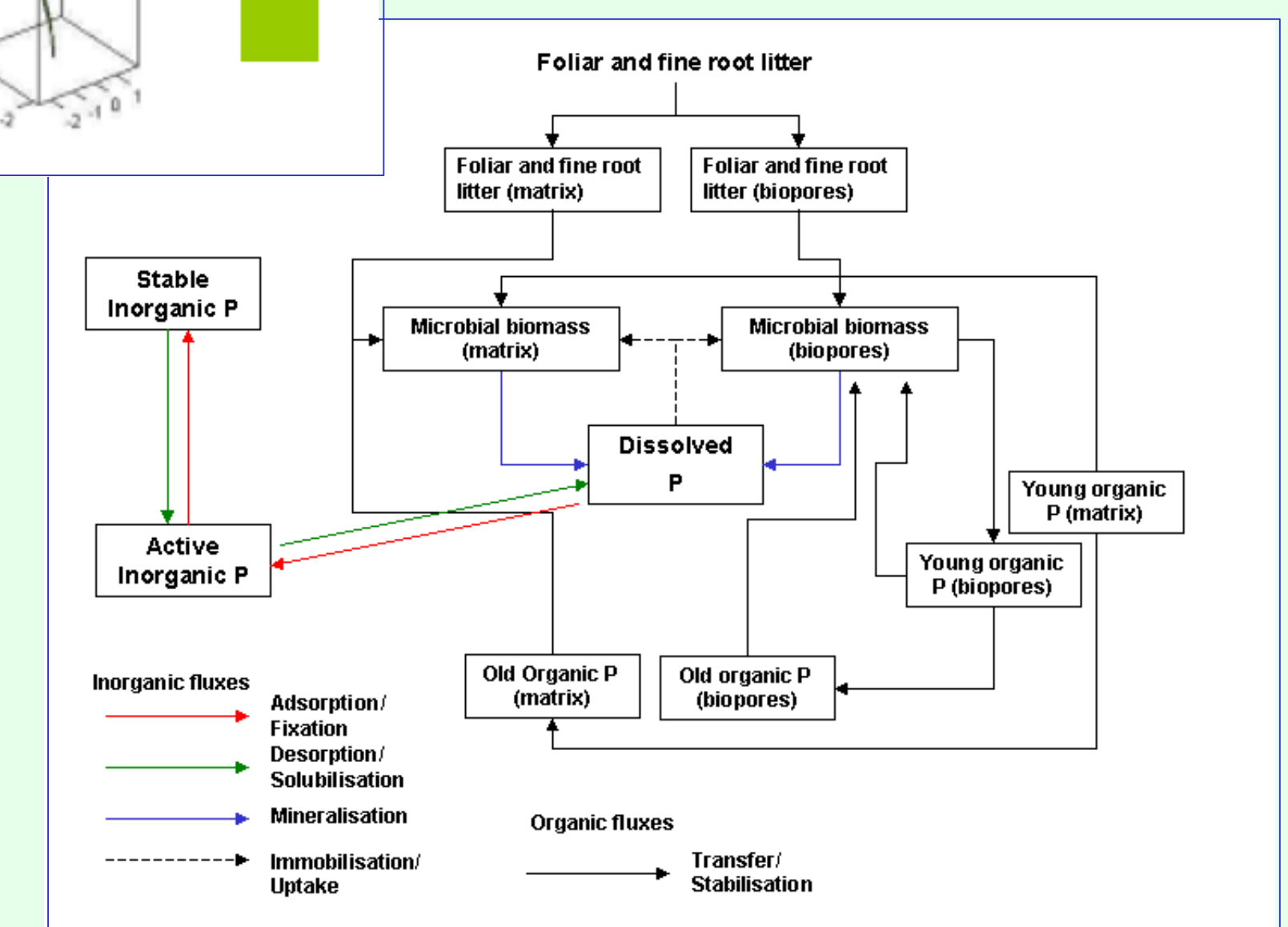


Figure 3: P turnover in field scale model considering organic P accumulation in biopores

## First results

Figures 4 and 5 demonstrate the importance of root/shoot interactions. Figure 4 shows that root growth and distribution is strongly related to soil strength. When soil strength threshold decreases, root length density in the subsoil decreases also. The reduction in subsoil root length density causes drought stress to the crop and a reduction in above ground dry matter production (Figure 5). This has pronounced effects on P uptake as well as on P demand.

Figure 4: Vertical root length density distribution of spring wheat at flowering as affected by the soil strength threshold

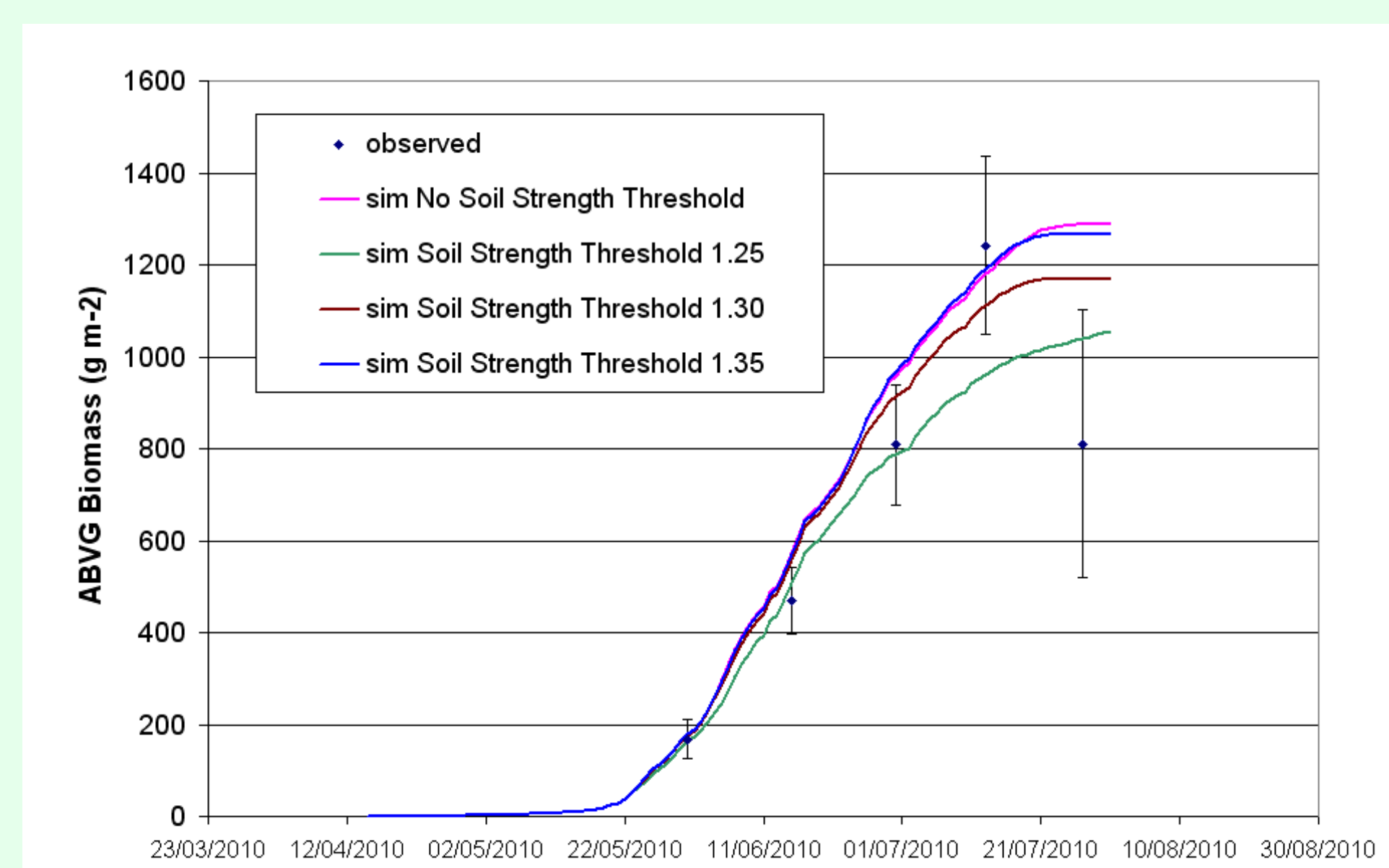
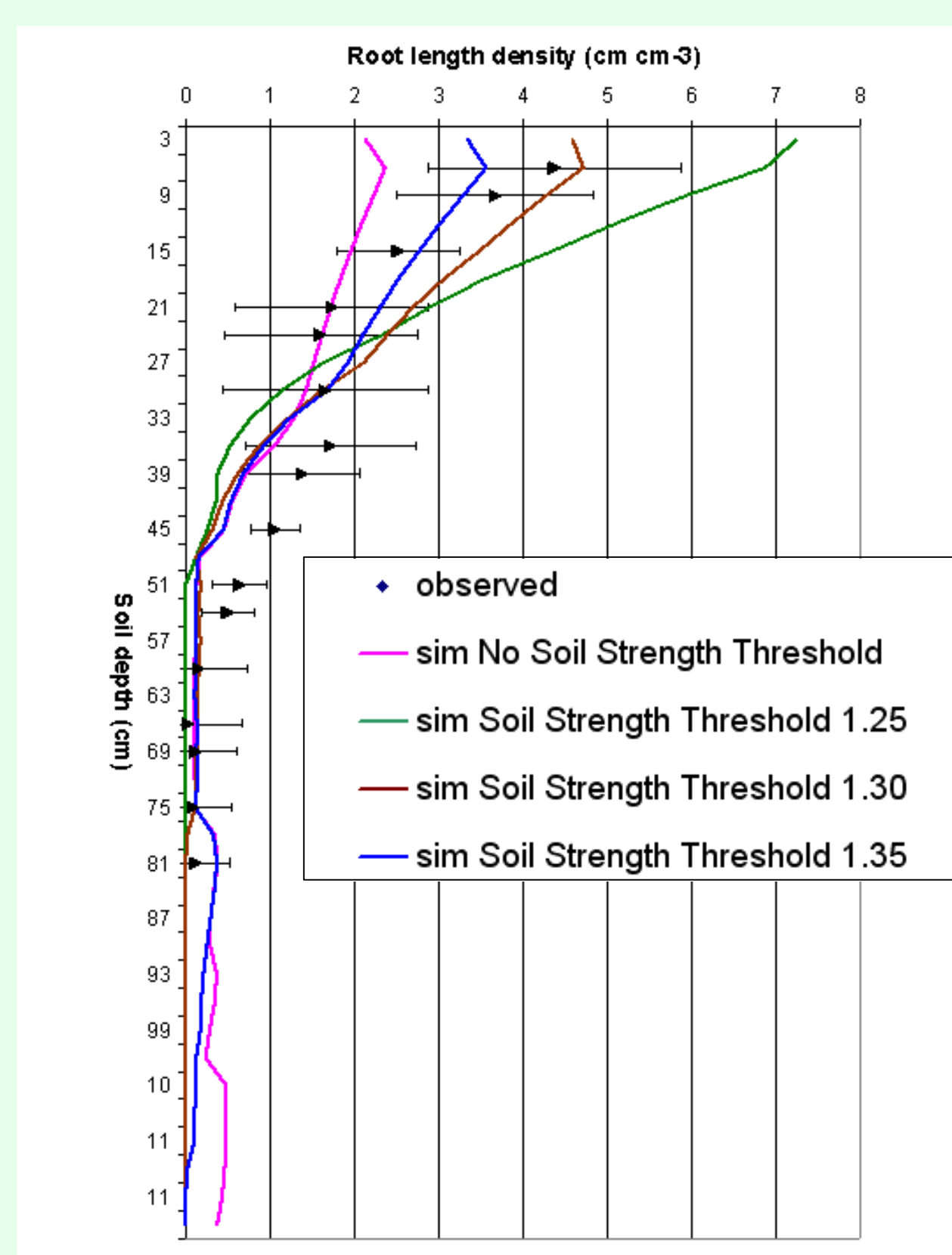


Figure 5: Response of shoot dry matter production of spring wheat on reduced root length density in the subsoil caused by increasing model sensitivity to soil strength



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