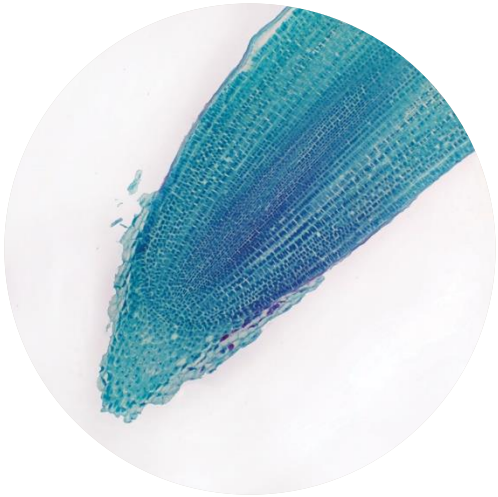
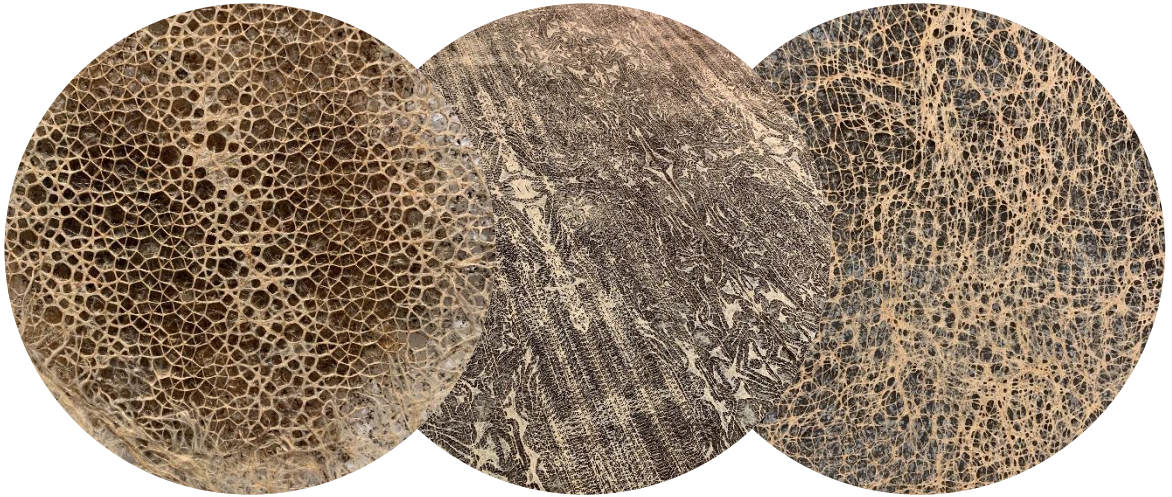
Dynamic crop growth and root development





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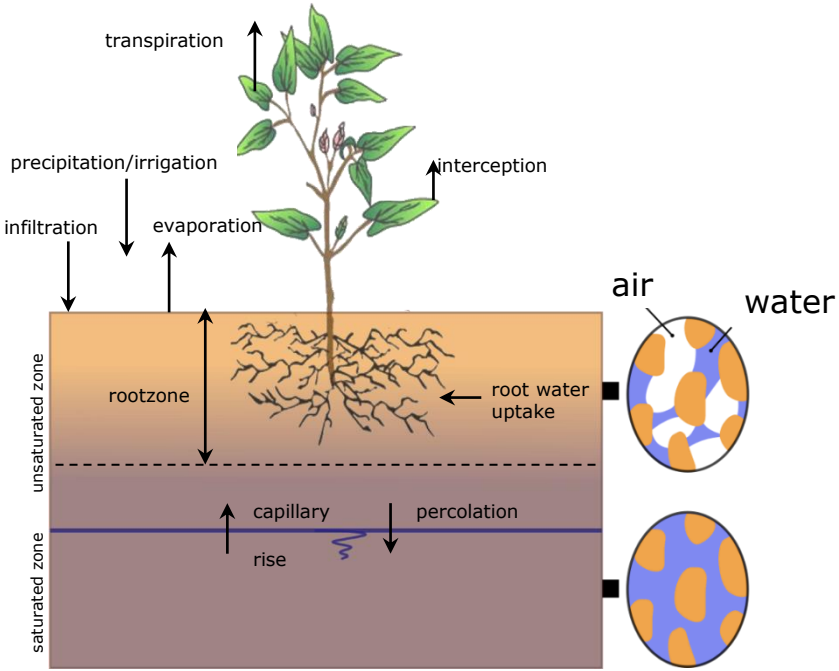
Content

- SWAP-WOFOST
- Static concept root development
- Implementation of adaptive root development
- Effect in land evaluation studies

SWAP-WOFOST

Process based model



SWAP-WOFOST

SWAP

Soil, Water, Atmosphere and Plant

(Van Dam, 2000; Kroes et al., 2017)

WOFOST

World Food Studies

(Boogaard et al., 2014; de Wit et al., 2019)

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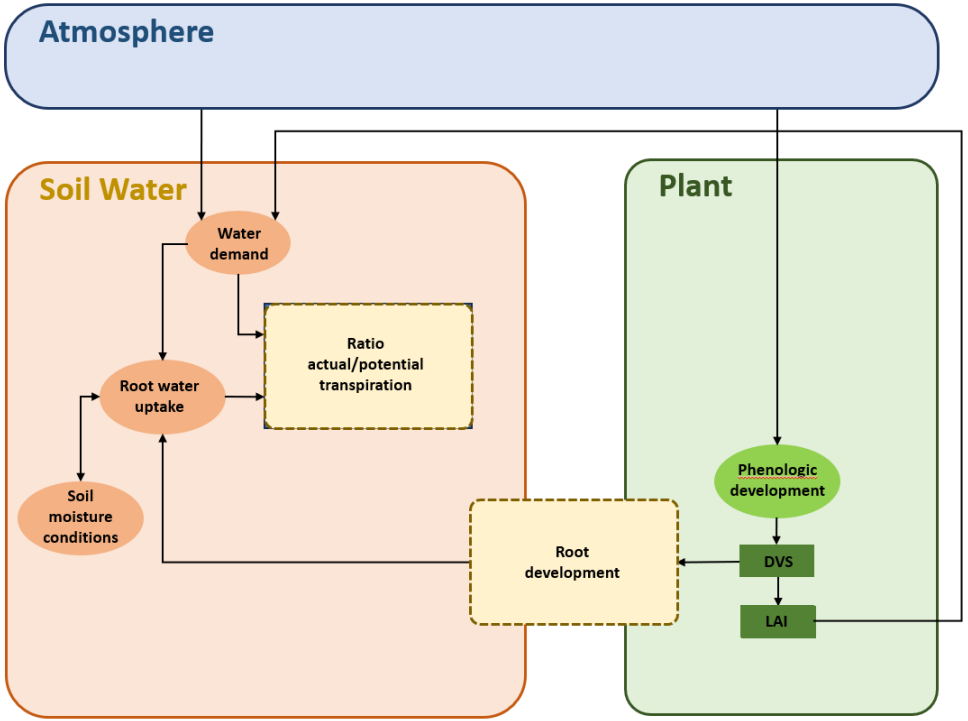
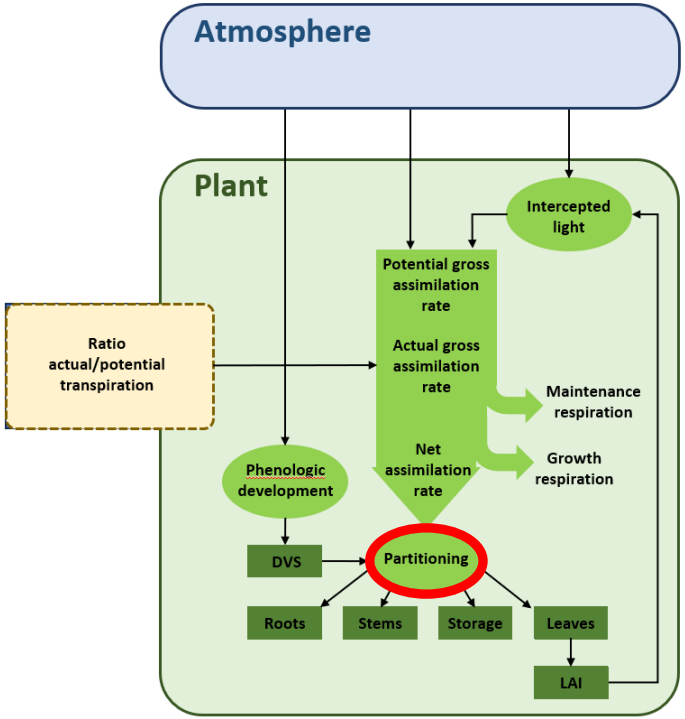
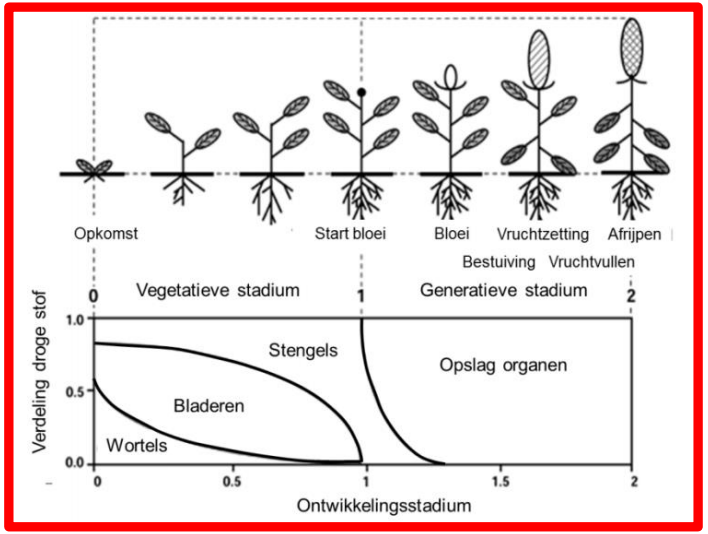
SWAP


Atmosphere
Soil Water
Plant
Water demand
Ratio actual/potential transpiration
Root water uptake
Soil moisture conditions
Root development
Phenologic development
DVS
LAI

WOFOST





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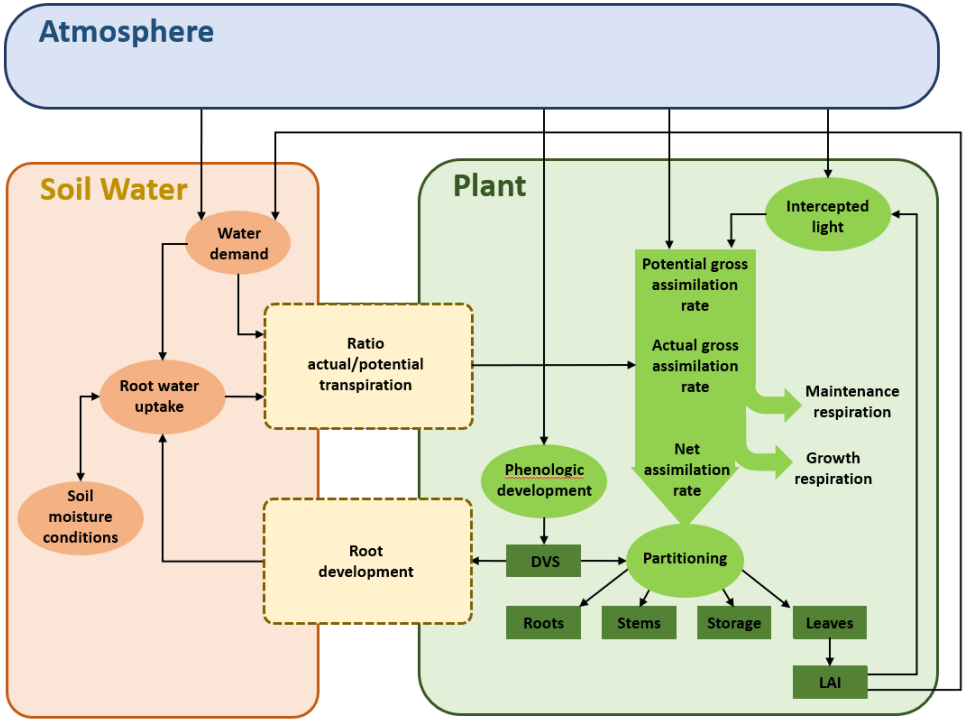
SWAP-WOFOST


Atmosphere
Soil Water
Water demand
Root water uptake
Soil moisture conditions
Ratio actual/potential transpiration
Root development
Plant
Intercepted light
Potential gross assimilation rate
Actual gross assimilation rate
Maintenance respiration
Net assimilation rate
Growth respiration
Phenologic development
DVS
Partitioning
Roots
Stems
Storage
Leaves
LAI

Static concept root development

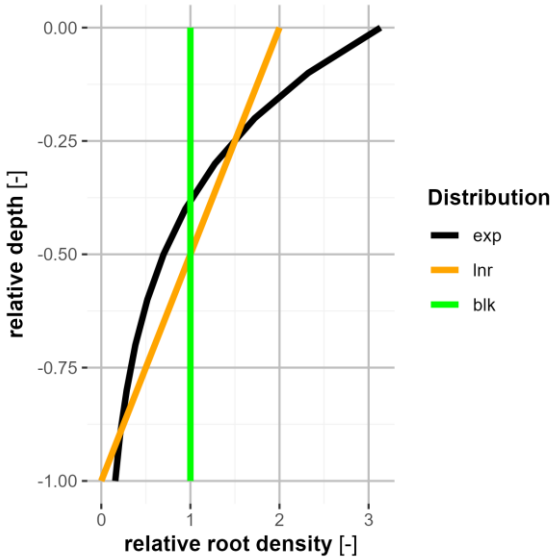
Static root development

Root extension:

- Initial depth
- Maximum daily increase
- Maximum depth
- Stop at anaerobic conditions

Root distribution:

- As function of relative depth
- Constant in time



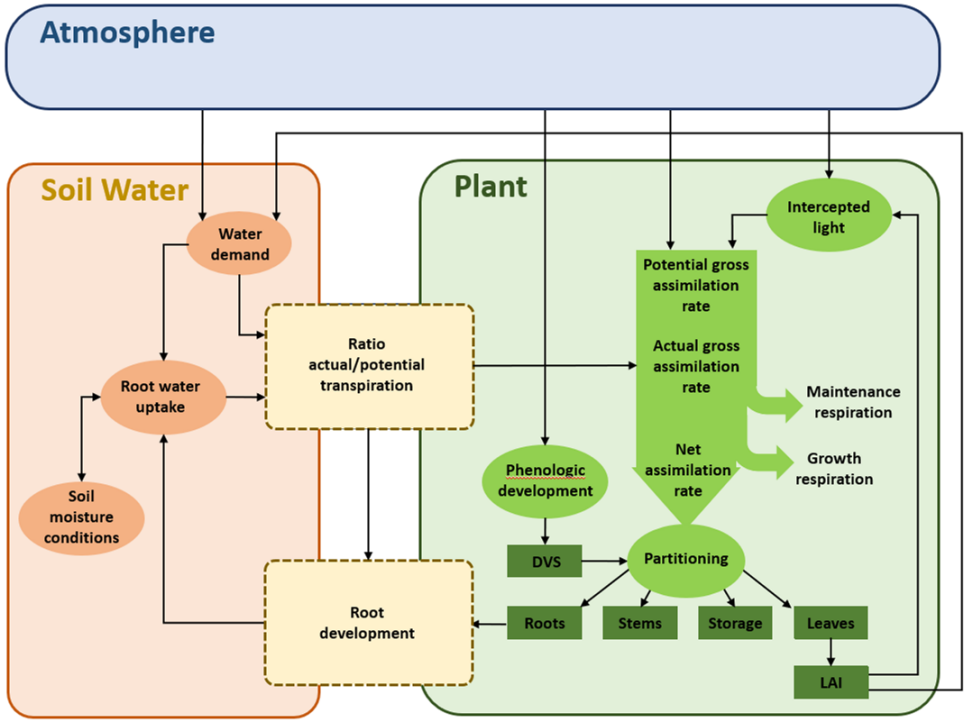
Experiences so far

- Some non-realistic crop yield effects due to drought and oxygen stress in land evaluation studies
- Soil water is very dynamic, but root development is not
- Literature: root growth influenced by conditions in soil

- A process-based root water uptake model was implemented in SWAP
- **This requires more detailed information on root growth and root distribution**

Implementation of adaptive root development

Adaptive root development



Root development

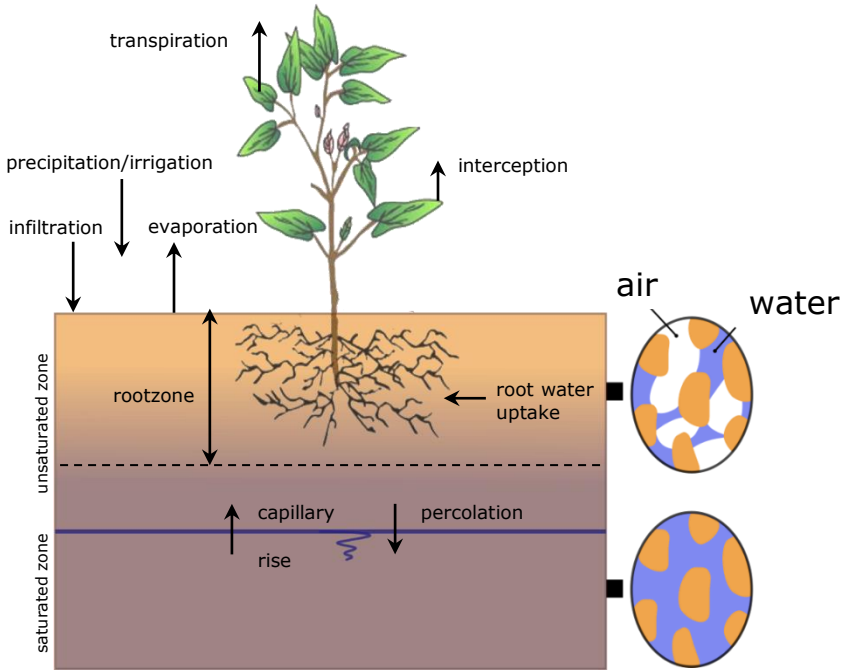
Adaptive approach:

Soil hydrological information (SWAP)

- (un)favorable conditions
  - each soil compartment

Crop development information (WOFOST)

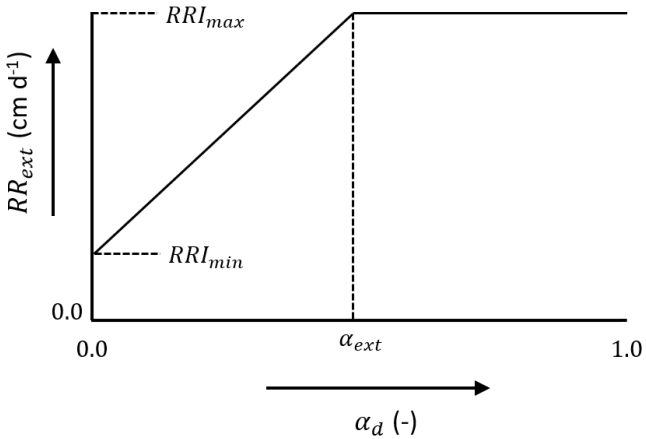
- Change in root biomass
  - growth/death rate



Adaptive root development

Root extension:

- Extension rate as function of drought stress
  - Daily maximum increase (RRI_{max})
  - Daily minimum increase (RRI_{min})
- Maximum depth
- Stop at anaerobic conditions



Adaptive root development

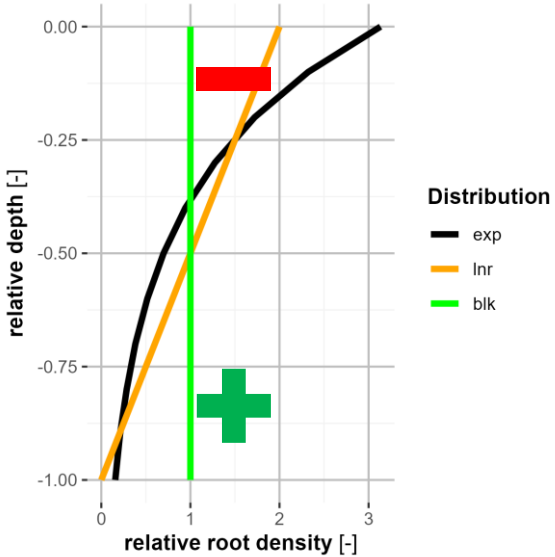
Root distribution:

- Growth at favorable compartments

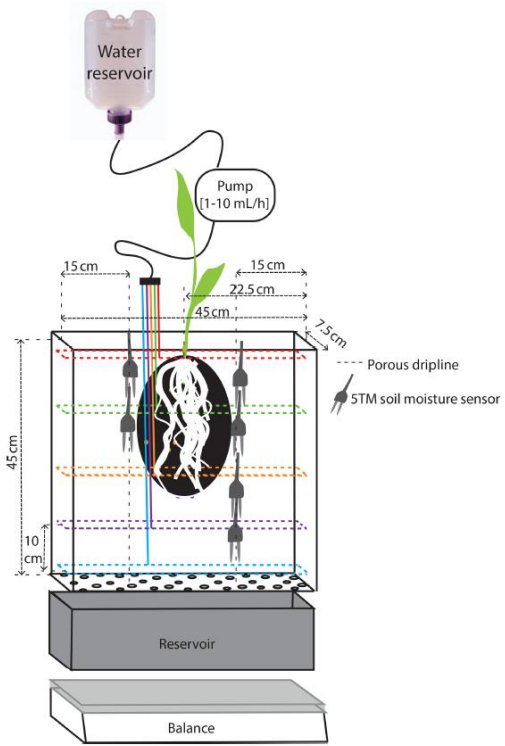
$$G_{j,t} = (1 - f_1) \frac{W_{j,t}}{\sum W_{j,t}} G_t \, \Delta t + f_1 \frac{S_{a,j,t}}{\sum S_{a,j,t}} G_t \, \Delta t$$

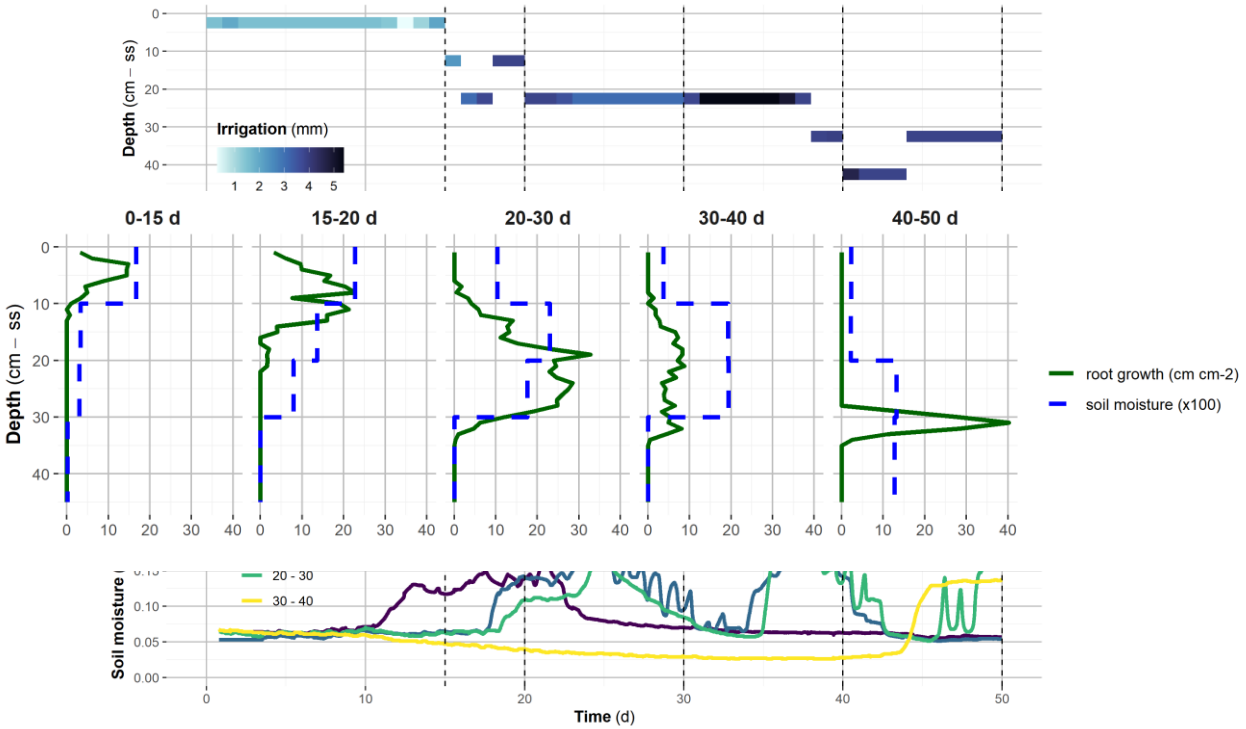
- Death at unfavorable compartments

$$D_{j,t} = (1 - f_2) \frac{W_{j,t}}{\sum W_{j,t}} D_t \, \Delta t + f_1 \frac{S_{r,j,t}}{\sum S_{r,j,t}} D_t \, \Delta t$$



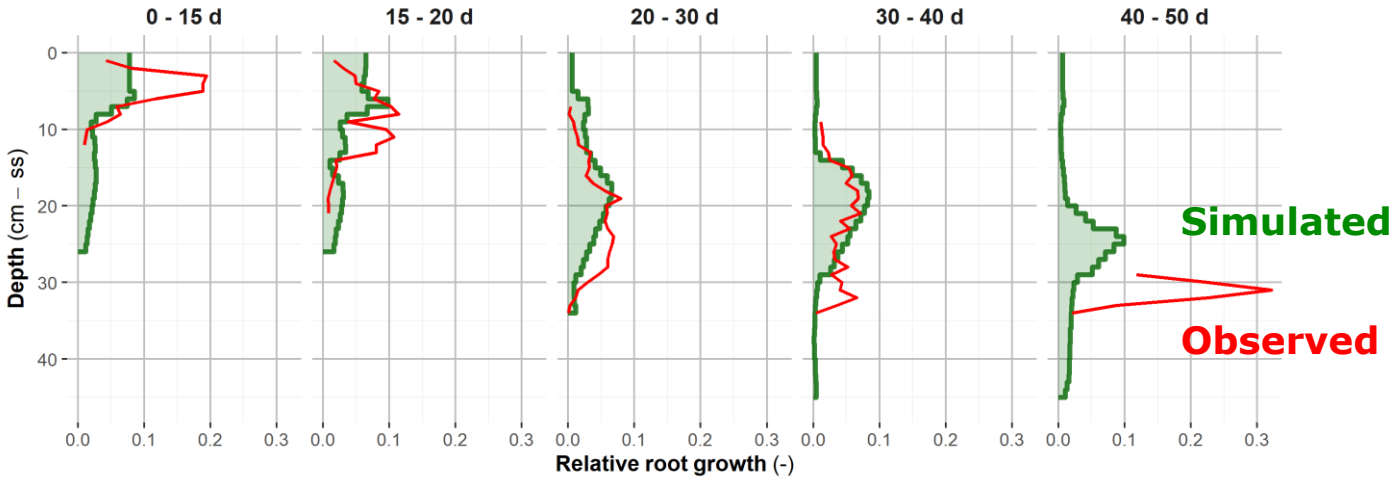
Rhizobox experiment





Rhizobox experiment by Maan et al., 2023

Rhizobox experiment



Effect in land evaluation studies

(static vs adaptive approach)

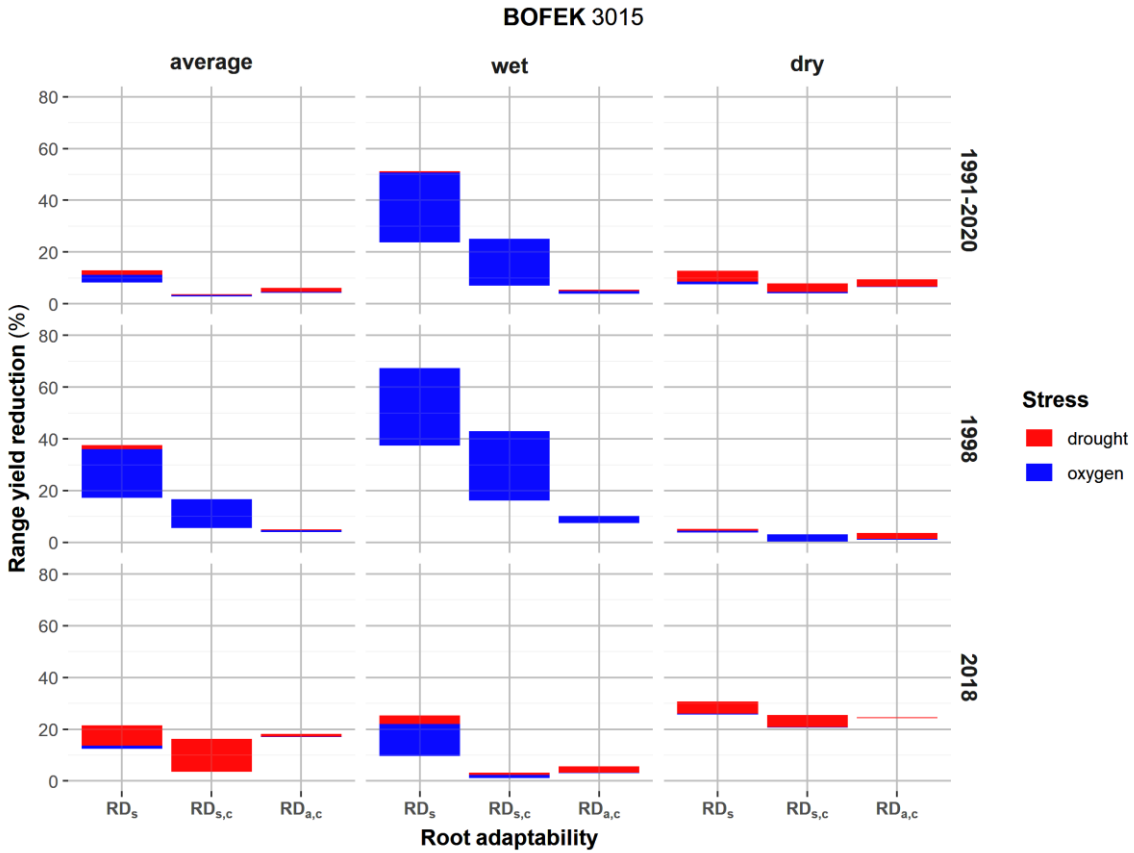
Root development scenario’s

Hydrological conditions:
Aaverage, wet and dry

Period:
Average, 1998 (wet) and 2018 (dry)

Root adaptability:
Static (s) or adaptive (a)

Initial root distribution:
Exponential (exp), linear (lnr)
or homogeneous (hom)



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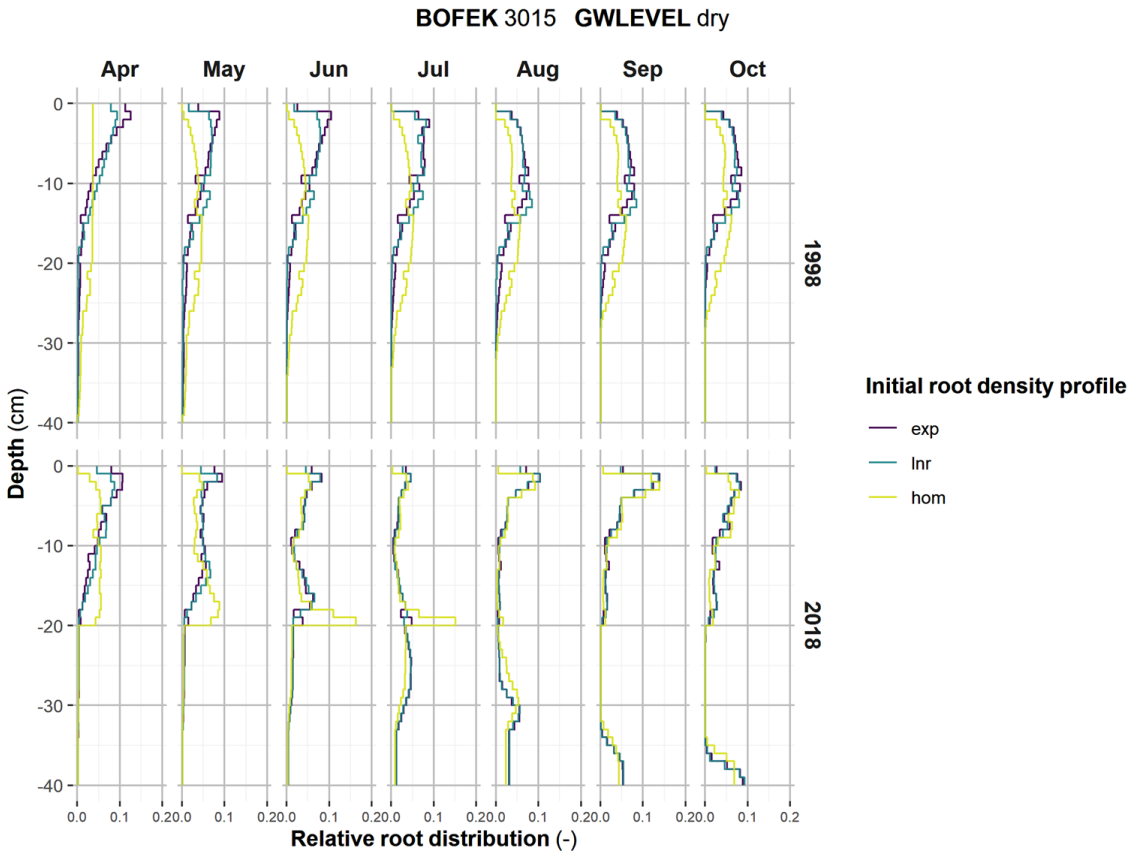
Adaptive root development



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Conclusions

Adaptive root development:

- Root growth will respond to simulated soil-hydrologic conditions
  - Model results are less influenced by initial settings
- Link between assimilates assigned to roots and root development and root water uptake

Improvements:

- Effect of other stressors: salinity, nutrients, etc.
- Adaptive partitioning of assimilates?

Thank you

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