Ecophysiological modelling of plant-nematode interactions to understand plant tolerance

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1. Context

Root-knot nematodes (RKN), *Meloidogyne spp.*

- small soil worms, obligate root endoparasites
- clonal reproduction
- ubiquitous polyphagous pest
- 14% of global crop losses worldwide[1]

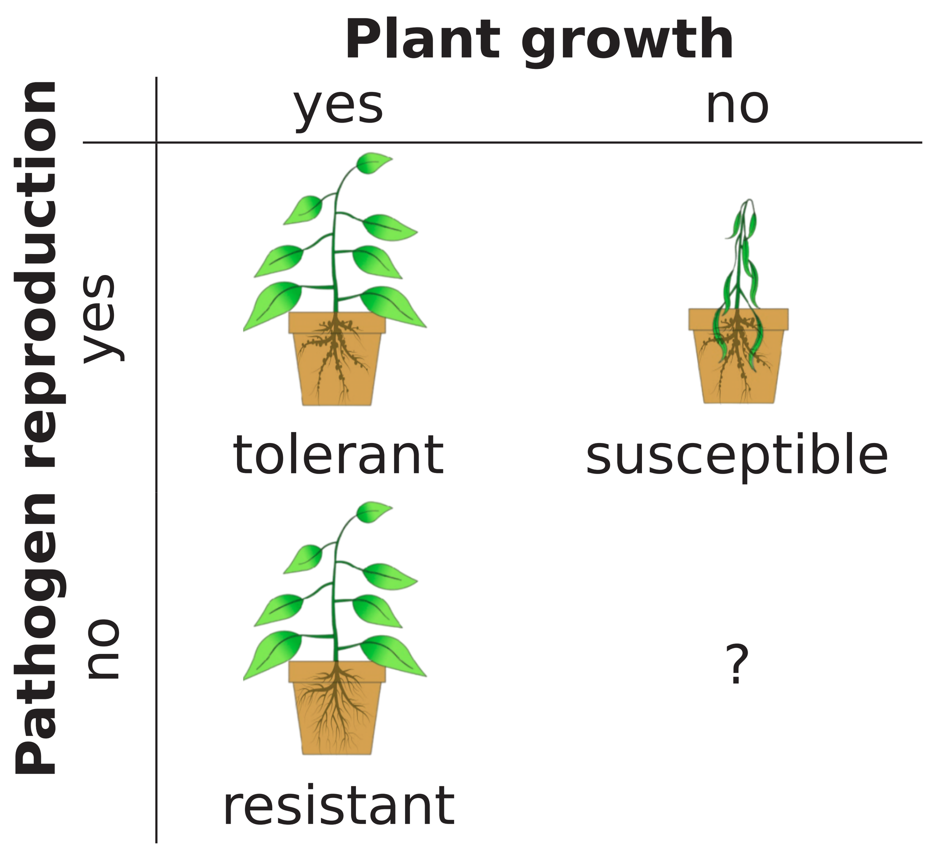
[1] Djian-Caporalino, *EPPO Bulletin*, 2012

Symptoms

- wilting and root deformation (galls)
- stunted growth
- reduced water and nutrient uptake
- hijacking of plant resources (carbon)

2. Research question

Strong variability in plant response to RKN parasitism among species & cultivars



Which mechanisms underlie plant tolerance?

Approach

- experimental data (tomato, cucurbit, pepper) with and without RKN
- model coupling plant ecophysiology and pest population dynamics

3. Integrated plant-pest model

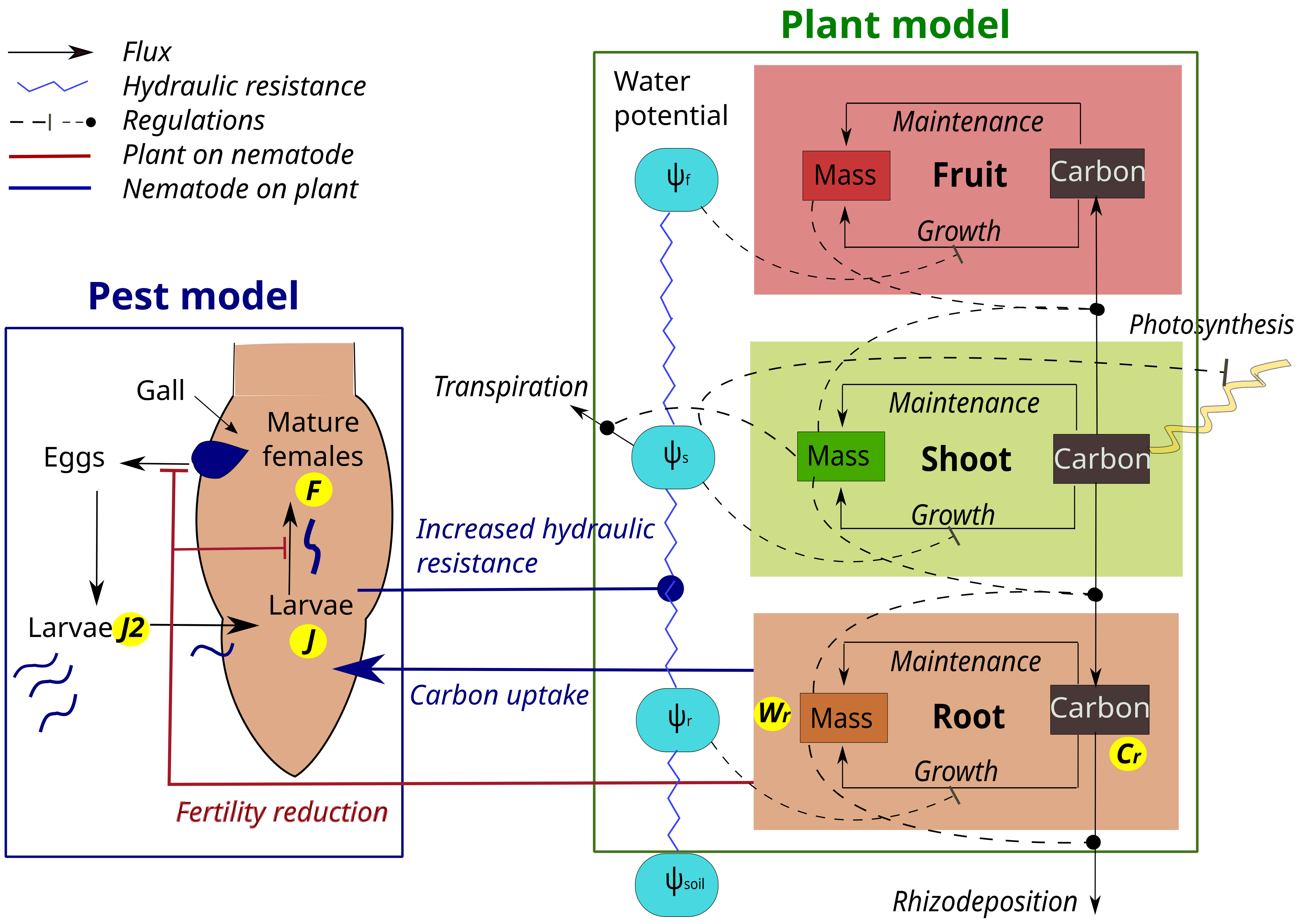
Pest

- RKN stages:
  - eggs
  - free-living larvae J2
  - within-root larvae
  - mature females
- RKN demography

Plant

- Plant compartments: fruit, shoot, root
- Vegetative and reproductive phases
- Plant resources: carbon and water
- Resource uptake and transport

Plant-RKN interactions



Root

$$\frac{dW_r}{dt} = \underbrace{G_r(C_r)\,W_r}_{\text{Growth}} - \underbrace{\gamma_r\,W_r}_{\text{Mortality}} - \underbrace{\epsilon\beta J_2\,W_r}_{\text{Infected roots}}$$

$$\frac{dC_r}{dt} = \underbrace{T_r(W_r)}_{\text{Transport}} - \underbrace{G_r(C_r)\,W_r}_{\text{Growth}} - \underbrace{r_m\,W_r}_{\text{Respiration}} - \underbrace{c_{rh}\,C_r}_{\text{Rhizodeposition}} - \underbrace{\gamma F}_{\text{RKN feeding}} - \underbrace{\kappa\epsilon\beta J_2\,W_r}_{\text{Gall formation}}$$

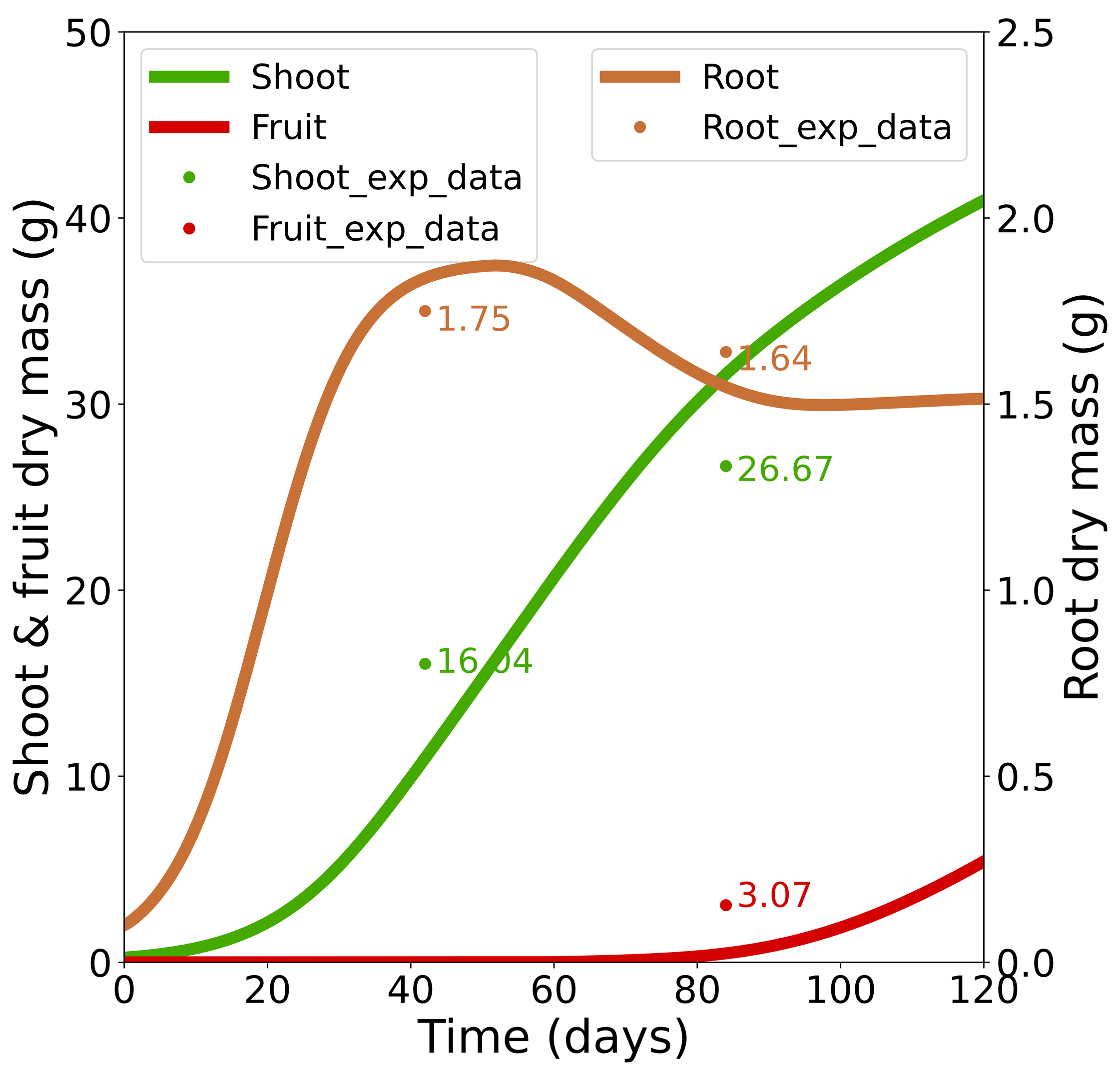
RKN

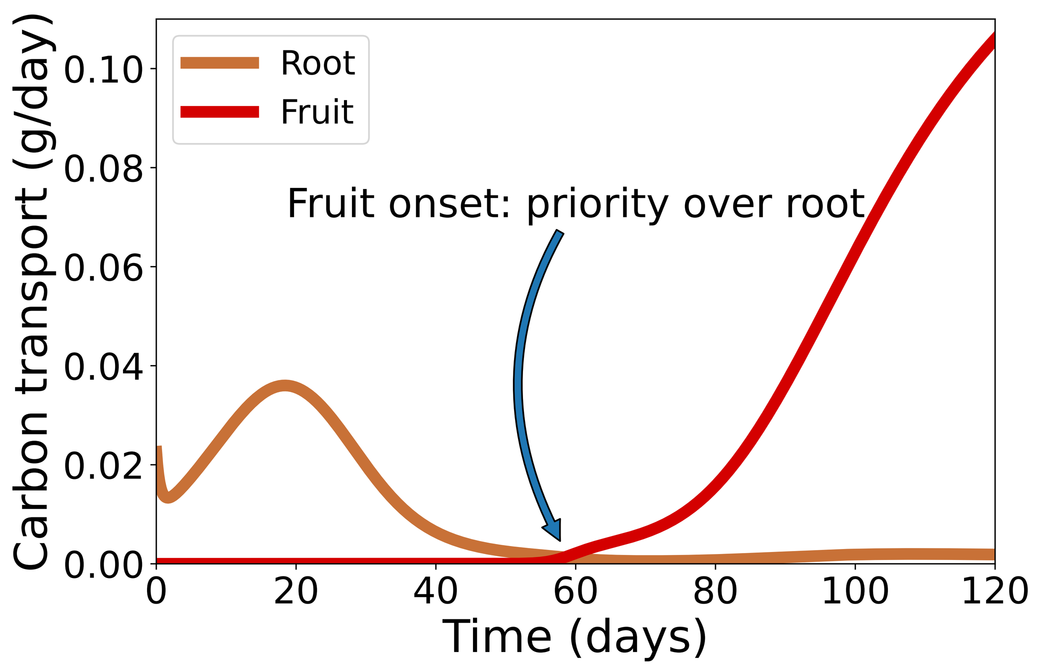
$$\frac{dJ}{dt} = \underbrace{\Omega\beta J_2 W_r}_{\text{RKN entry}} - \underbrace{\eta J}_{\text{Larvae maturation}} \underbrace{-(\mu_j+\mu_r)J}_{\text{Mortality}}$$

$$\frac{dF}{dt} = \theta\eta J - (\mu_F + \mu_r)F$$

4. Model calibration

Experimental tomato data (ongoing)





5. Perspectives

- Identify **key physiological and architectural traits** underlying plant tolerance to guide the selection of new tolerant cultivars
- **Long-term dynamics**: effect of plant tolerance, cultural practices (rotations, etc.) and abiotic conditions on soil infestation and crop damages[2]

[2] Nilusmas et al., *Evolutionary Applications*, 2020