

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

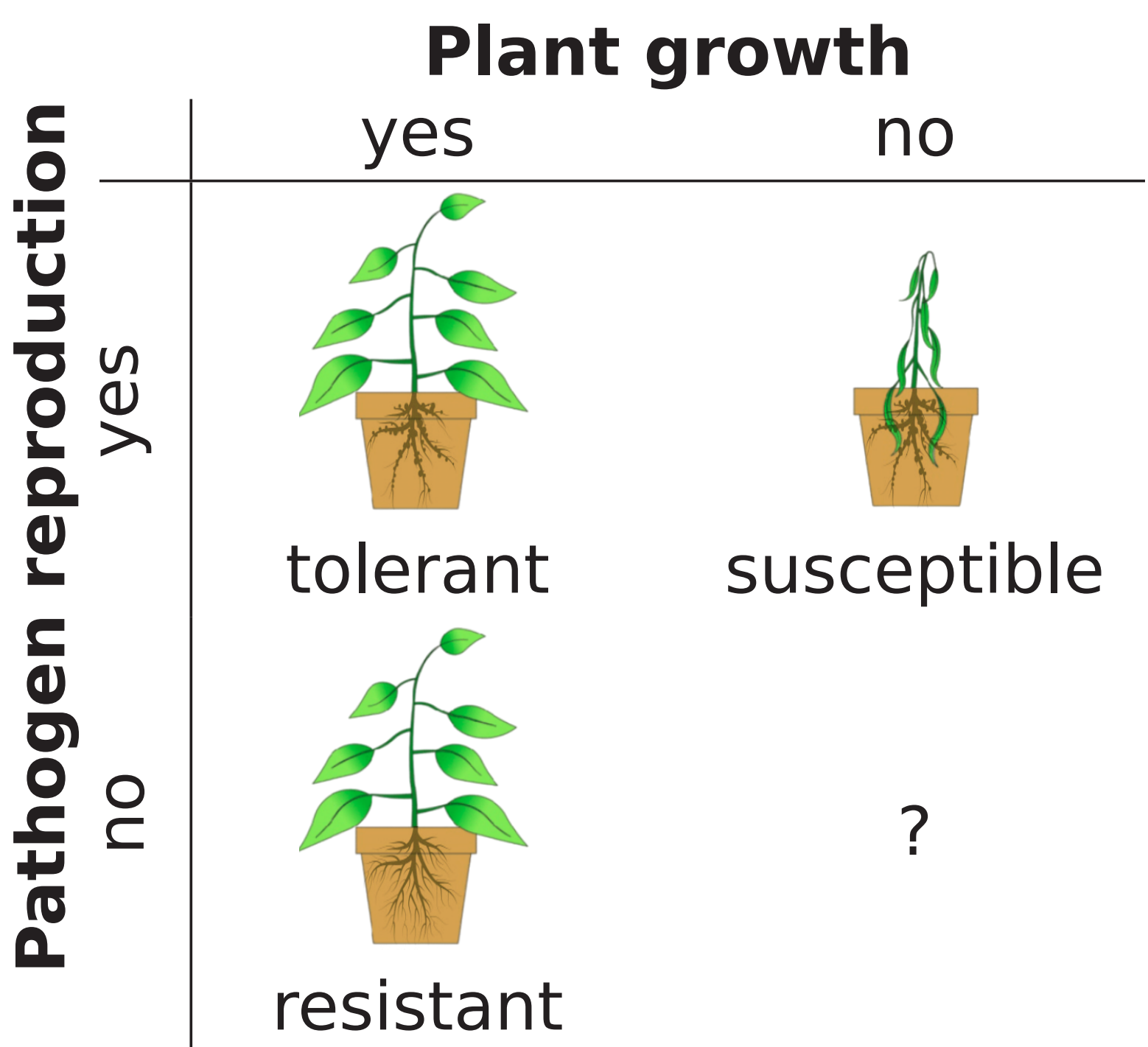


Symptoms

- 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



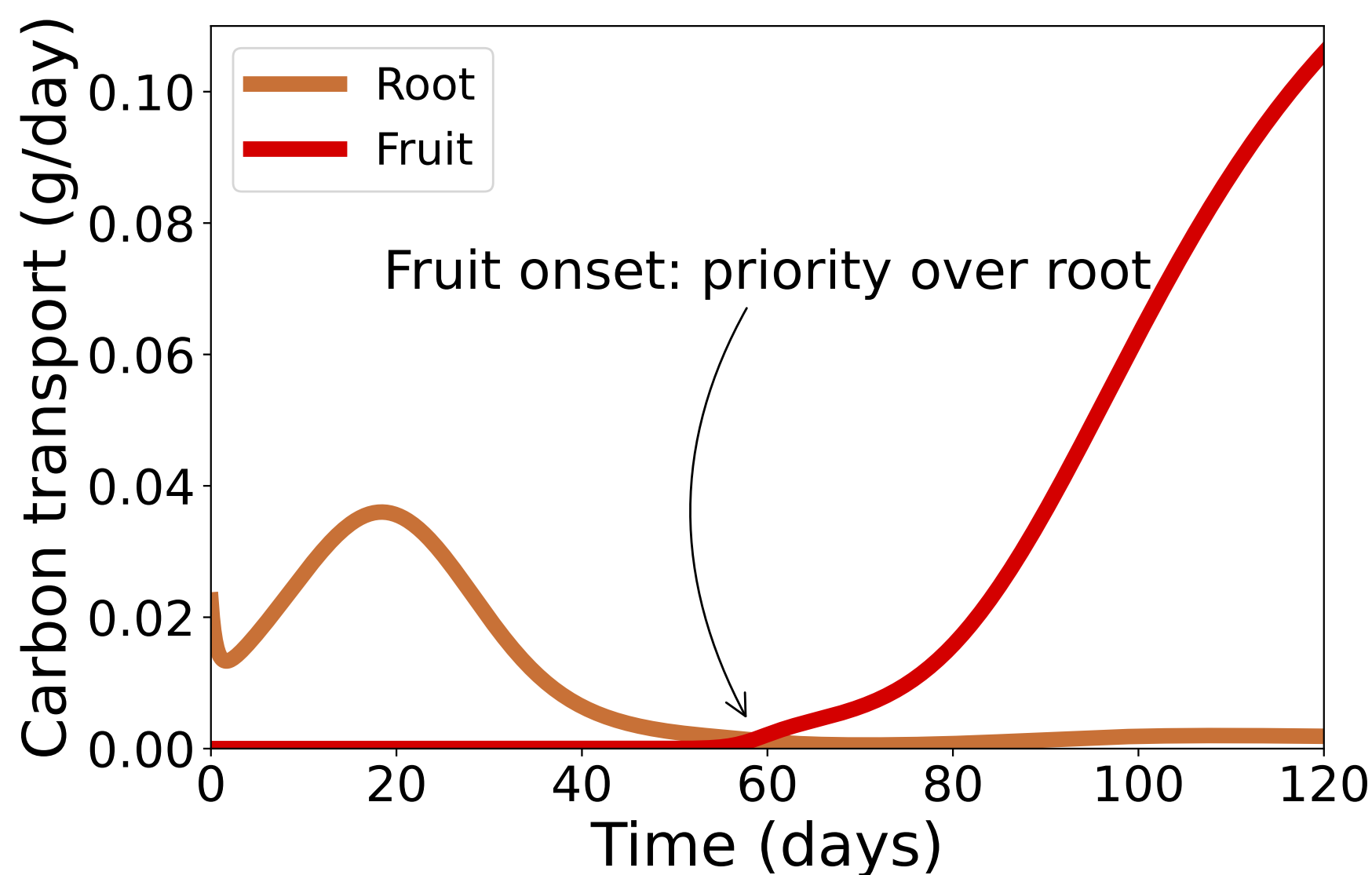
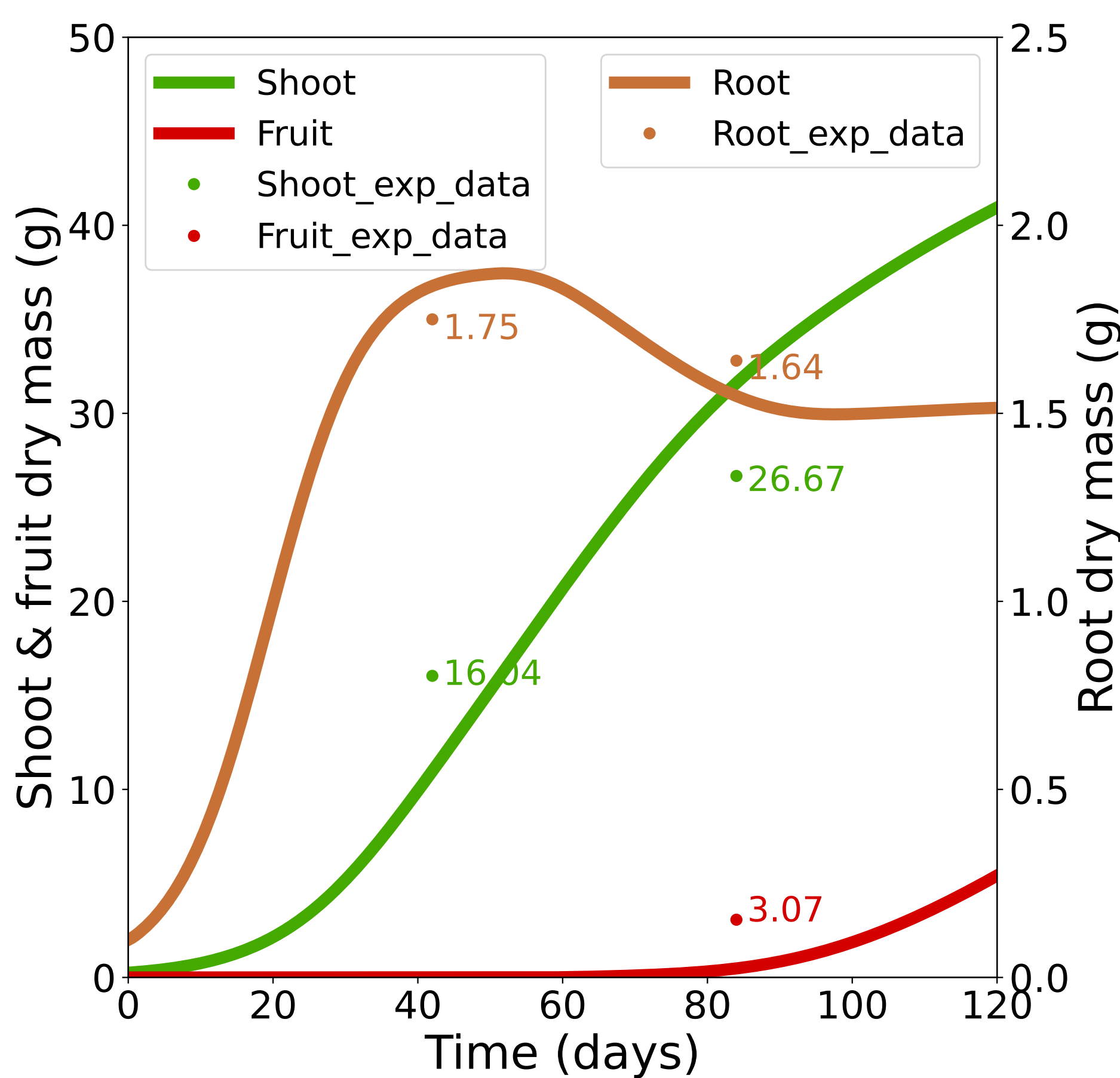
Which mechanisms underlie plant tolerance?

Approach

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

4. Model calibration

Experimental tomato data (ongoing)



3. Integrated plant-pest model

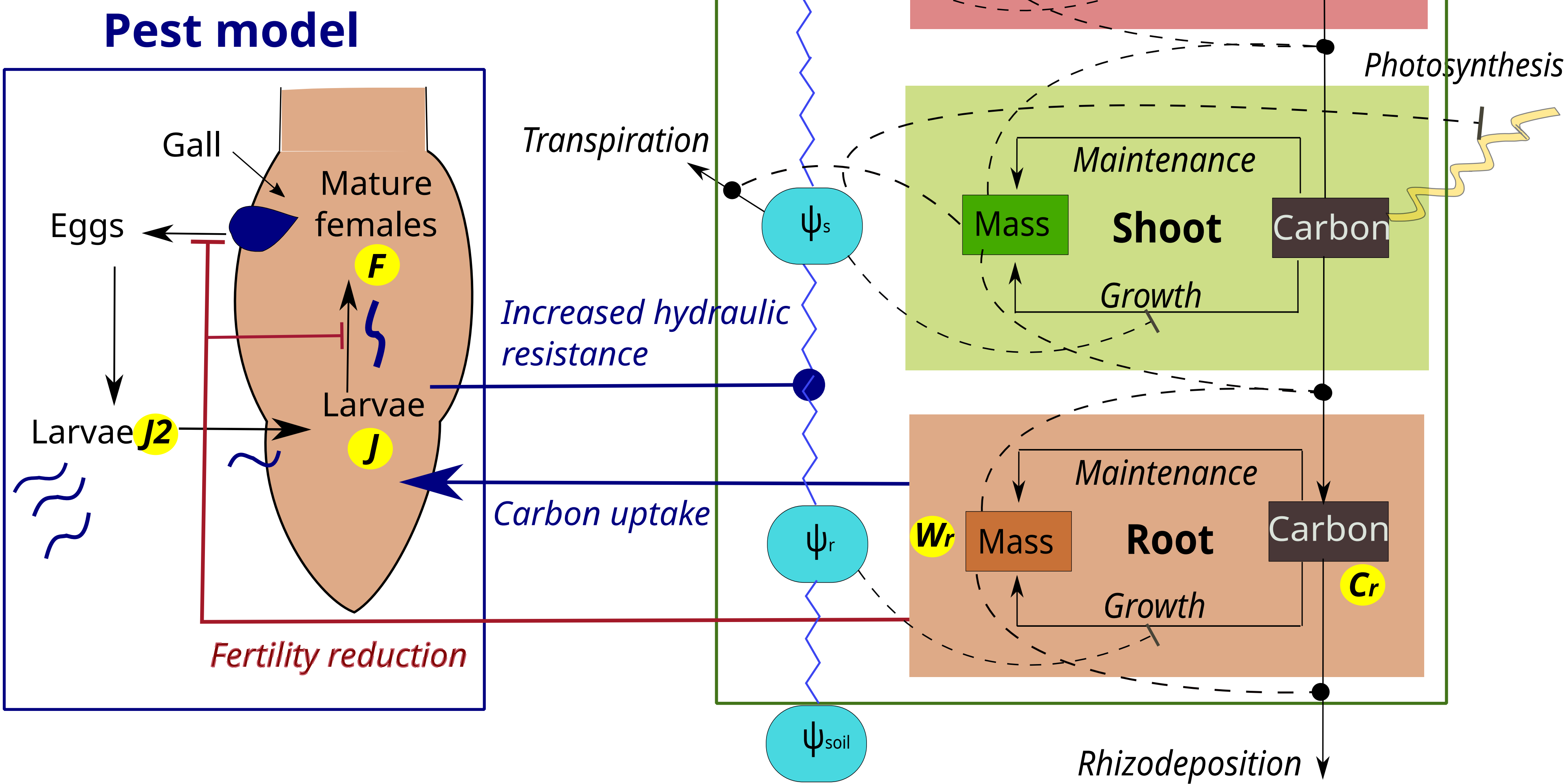
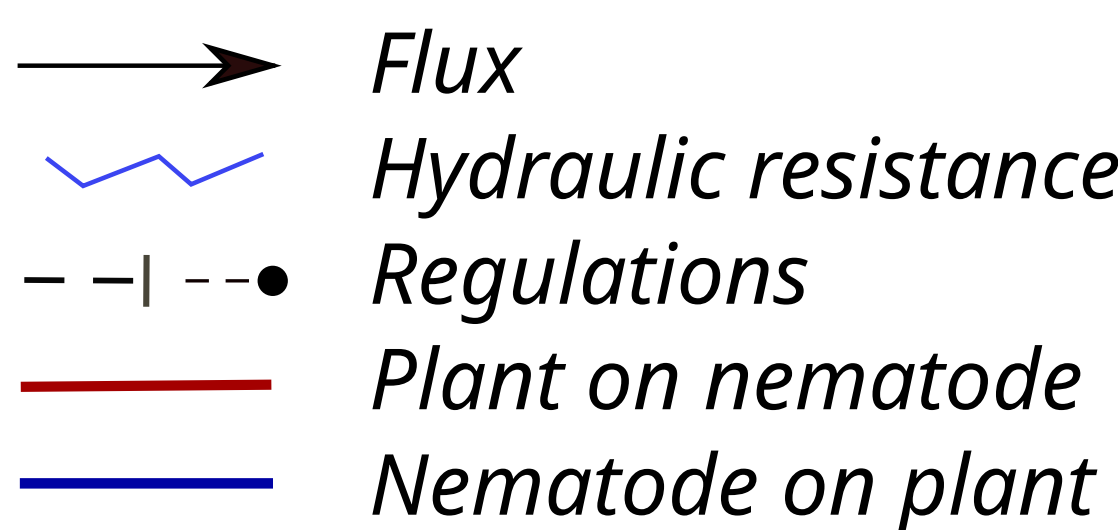
Pest

- 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



$$\begin{aligned} \text{Root} \quad & \begin{cases} \frac{dW_r}{dt} = \underbrace{G_r(C_r)W_r}_{\text{Growth}} - \underbrace{\gamma_r W_r}_{\text{Mortality}} - \underbrace{\epsilon\beta J_2 W_r}_{\text{Infected roots}} \\ \frac{dC_r}{dt} = \underbrace{T_r(W_r)}_{\text{Transport}} - \underbrace{G_r(C_r)W_r}_{\text{Growth}} - \underbrace{r_m W_r}_{\text{Respiration}} - \underbrace{C_{rh}C_r}_{\text{Rhizodeposition}} - \underbrace{\gamma F}_{\text{RKN feeding}} - \underbrace{k\epsilon\beta J_2 W_r}_{\text{Gall formation}} \end{cases} \\ \text{RKN} \quad & \begin{cases} \frac{dJ}{dt} = \underbrace{\Omega(C_r)\beta J_2 W_r}_{\text{RKN entry}} - \underbrace{\eta J}_{\text{Maturation}} - \underbrace{(\mu_j + \mu_r)J}_{\text{Mortality}} \\ \frac{dF}{dt} = \underbrace{\theta(C_r)\eta J}_{\text{Maturation}} - \underbrace{(\mu_F + \mu_r)F}_{\text{Mortality}} \end{cases} \end{aligned}$$

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