

Molecular insights into an interaction of nematode resistant plant *Solanum torvum* and virulent/avirulent root-knot nematodes

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Time zone:
Japan (JST)



Background

- Plant parasitic nematodes are among the most devastating pests in agriculture: the global economic loss is estimated to be over \$80 billion.
- Root-knot nematodes (RKNs), in particular, infect a broad range of commercially important crops, including the Solanaceae, forming galls for development and reproduction.
- Solanum torvum* Sw. (Turkey berry) is a medicinal plant and has been used as a rootstock for eggplant cultivation because of its strong resistance to various nematodes.

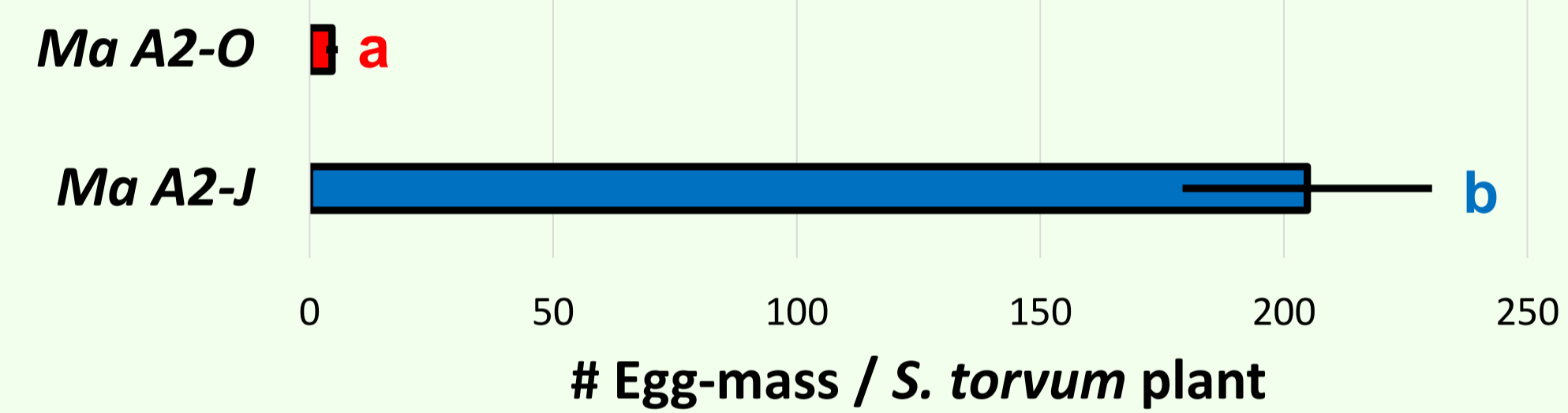


Root-knot nematode
U.S. Department of Agriculture - d2549-1

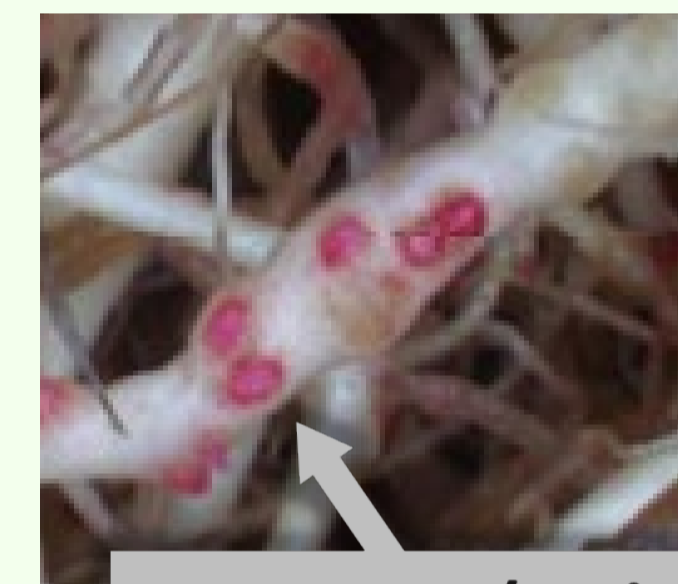
Eggplant (Susceptible)

S. torvum (Resistant)

- However, we have found that *Meloidogyne arenaria* (Ma) A2-J isolate is able to infect and propagate in *S. torvum*, while Ma A2-O isolate barely produce egg masses on *S. torvum* roots.



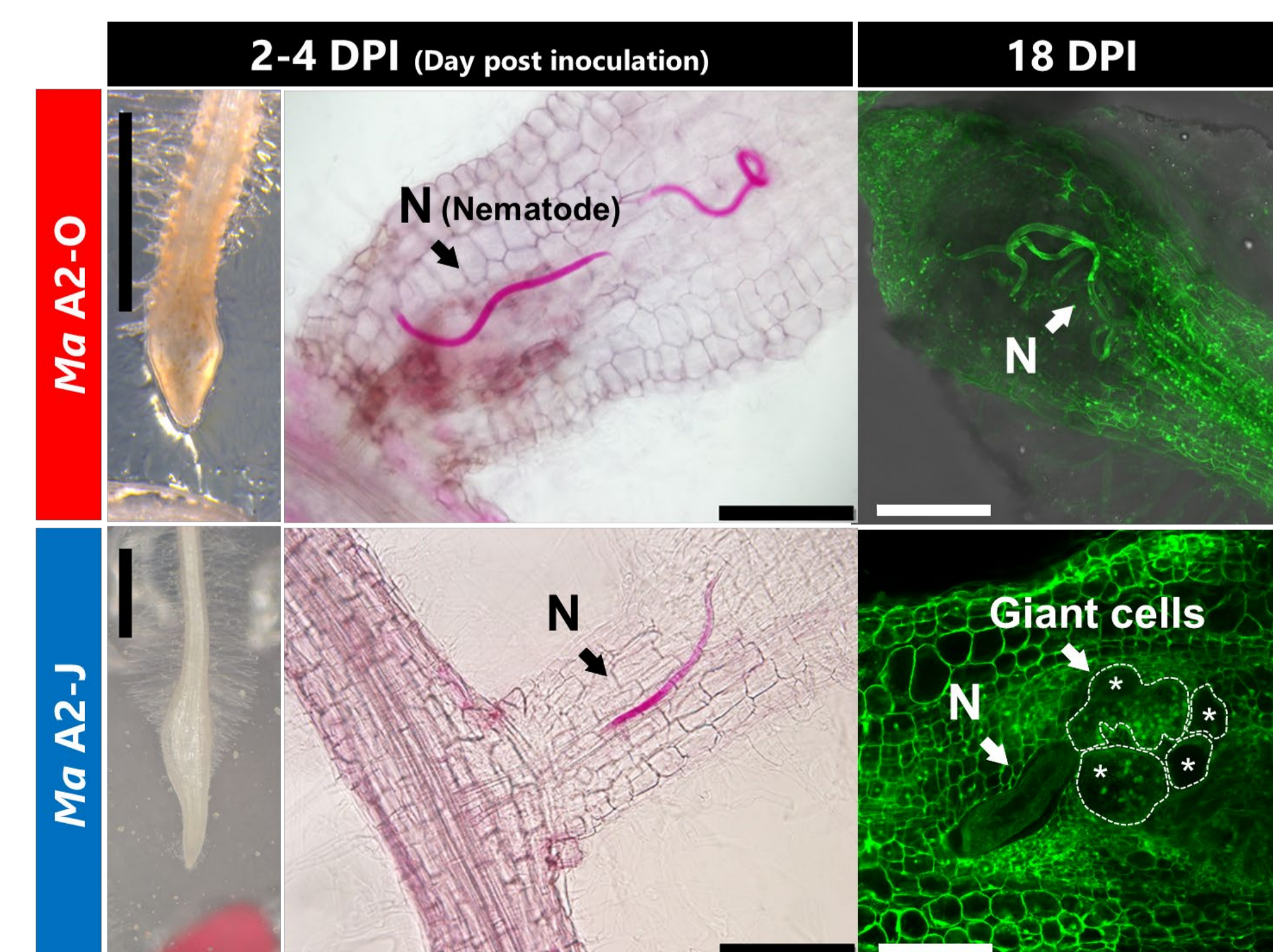
Different letters mean significant difference at P<0.05 (Tukey's HSD test), J. Phytopathol. 165(9), 575-579.



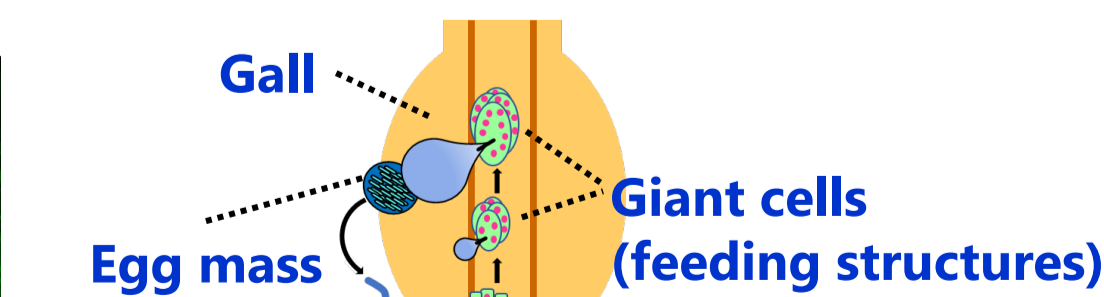
Egg mass (stained)

What is the difference between resistant and susceptible responses to RKNs in plants?

I. A2-O induces a browning response, and A2-J induces the formation of giant cells (feeding structures) in *S. torvum*

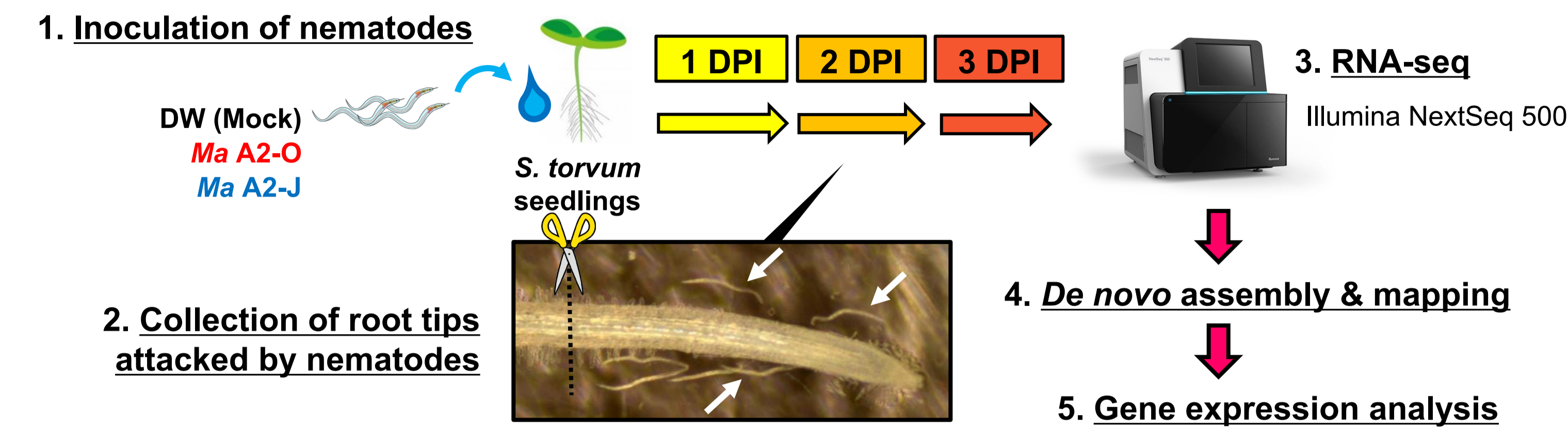


- Root browning
- Inhibition of nematode growing



- Feeding structure formation
- Nematode growing

II. Transcriptomic analysis of *S. torvum* during A2-J or A2-O infection



Infection with A2-J induces genes related to cell wall modification and transmembrane transport

Gene expression (log₂FC)

In the heatmap, grey boxes indicate no statistically significant differences at |log₂FC| ≥ 1 and FDR ≤ 0.01.

Annotation	A2-J			A2-O		
	1 DPI	2 DPI	3 DPI	1 DPI	2 DPI	3 DPI
Cell wall modification						
cellulose synthase like	0.6	1.6	2.3	0.7	1.0	1.6
COBRA-like protein	0.1	0.6	1.0	0.1	-0.1	0.6
xyloglucan endotransglucosylase / hydrolase protein	-0.4	0.9	2.1	0.1	-0.4	0.4
pectin lyase-like superfamily protein	-0.2	0.3	1.0	-0.2	-0.2	-0.3
non-catalytic subunit of the polygalacturonase isozyme	-0.1	0.2	1.4	0.3	0.0	0.5
expansin	0.2	1.4	1.3	0.5	0.6	0.7
Transmembrane transport						
MATE efflux family protein	0.6	0.5	2.7	0.2	-0.3	1.1
Organic cation/carnitine transporter	0.1	-0.2	2.0	0.6	0.1	0.8
ABC transporter family G member 5	-0.2	0.3	1.2	0.0	-0.3	0.4
sugar transporter ERD6-like	0.3	0.8	1.0	0.0	0.0	0.1
auxin efflux carrier component 1	0.2	0.0	0.9	0.2	0.0	0.4
zinc transporter	0.1	0.0	1.5	-0.3	0.1	0.6
Flavonoid biosynthesis						
chalcone synthase	-0.8	1.7	4.1	1.8	-0.1	-0.2

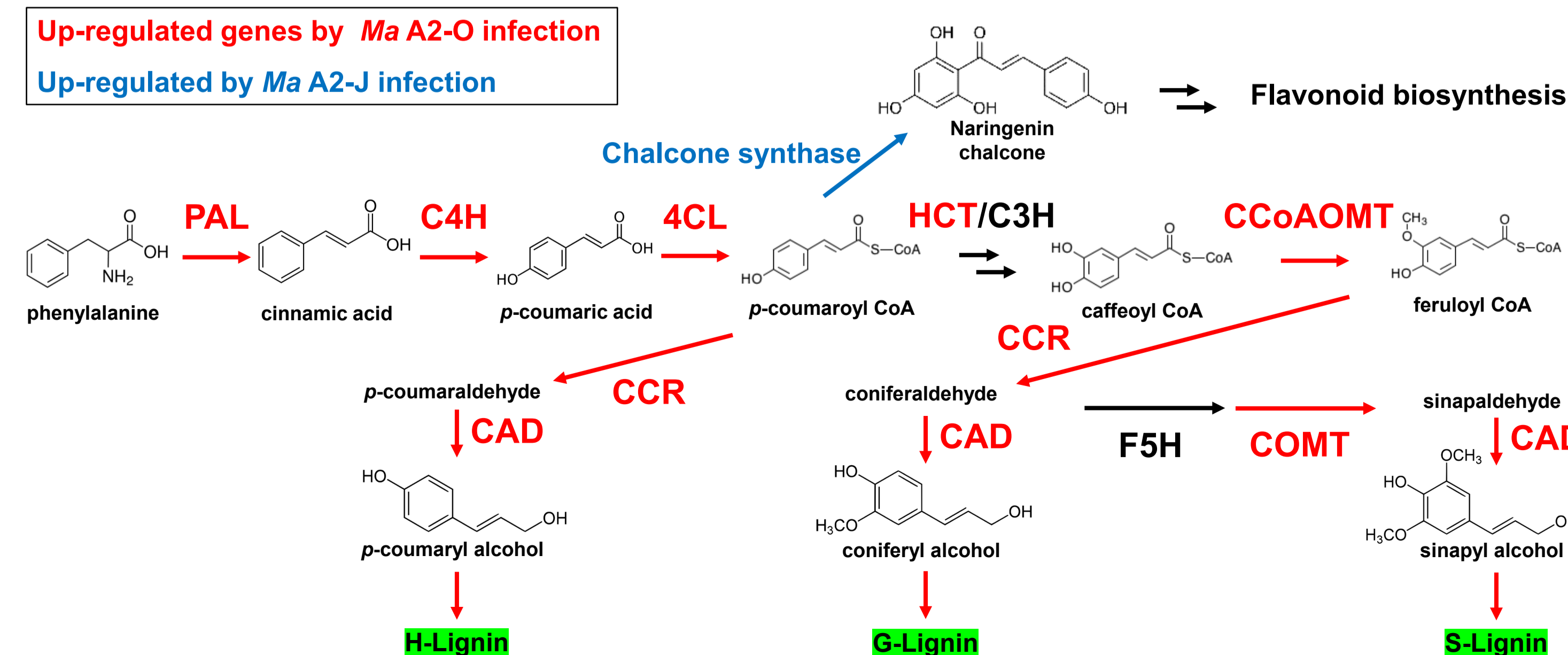
Infection with A2-O induces the expression of defense-related genes

Gene expression (log₂FC)

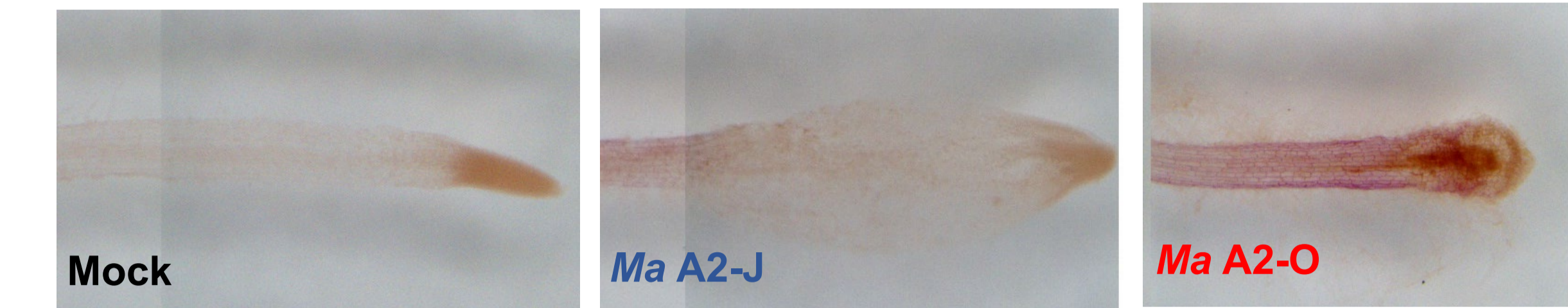
In the heatmap, grey boxes indicate no statistically significant differences at |log₂FC| ≥ 1 and FDR ≤ 0.01.

Annotation	A2-J			A2-O		
	1 DPI	2 DPI	3 DPI	1 DPI	2 DPI	3 DPI
Salicylic acid / Jasmonic acid / Ethylene marker genes						
PR1	2.4	4.8	5.9	4.0	7.8	9.3
PR2	5.4	8.0	8.7	5.3	10.7	12.4
LoxD	0.1	-0.2	0.6	1.7	1.8	3.0
PHI	-0.4	3.9	2.6	3.9	8.5	7.2
ACO	2.5	4.5	6.1	5.3	6.3	9.1
ACS	0.8	1.2	0.3	1.8	1.7	1.3
Positive regulation of immunity						
SIWRKY31	0.5	0.4	0.5	1.2	1.5	1.8
SIWRKY33	0.4	0.0	0.3	1.2	1.1	1.6
SIWRKY39	0.8	1.1	1.1	3.0	2.5	2.2
Sesquiterpene synthesis						
germacrene C synthase-like	2.2	5.6	4.8	5.7	8.4	8.2
viridiflorene synthase	2.1	3.2	3.4	5.0	5.4	6.0
viridiflorene synthase	-0.6	4.8	3.3	5.1	7.8	6.4
vetispiradiene synthase	1.1	2.9	2.5	3.8	5.2	5.2
vetispiradiene synthase	0.9	2.8	3.3	3.4	5.0	5.7
premnaspirodiene oxygenase	4.3	4.4	3.7	7.2	6.8	6.6
cytochrome P450 71D7-like	2.4	4.3	5.8	2.3	8.1	10.0
Fatty acid modification						
FAD2-7 in tomato	2.7	4.0	2.9	5.7	6.1	5.5
FAD2-9 in tomato	2.4	6.0	2.2	7.5	8.8	5.4
ACETYLASE1a/b in tomato	1.7	3.2	3.2	5.1	5.7	5.7
ACETYLASE1a/b in tomato	3.9	4.5	4.0	7.0	6.6	6.2

Infection with A2-O induces the expression of lignin biosynthetic genes, while infection with A2-J induces the expression of chalcone synthase gene



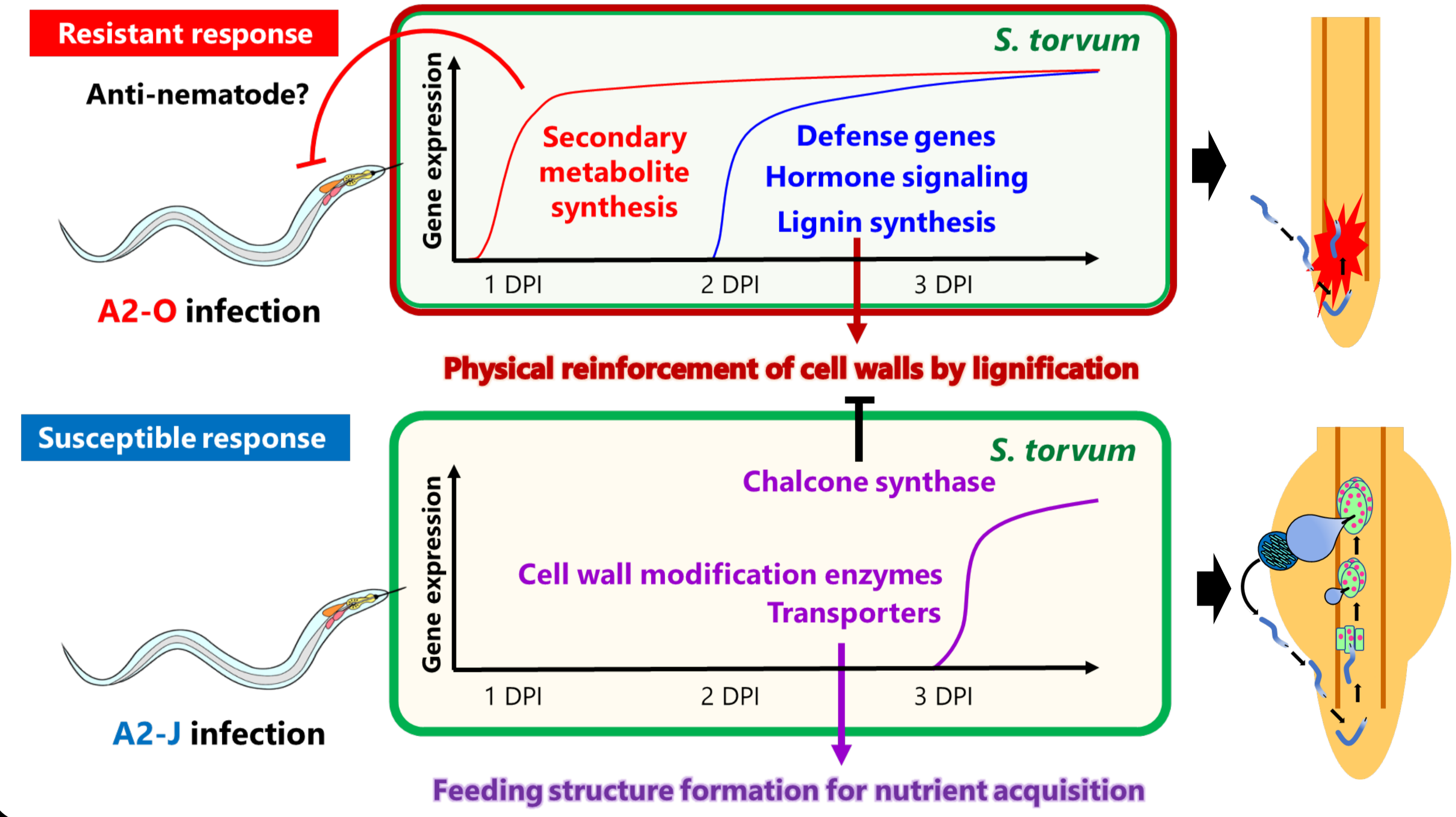
III. Infection with A2-O, but not A2-J, induces lignin accumulation in *S. torvum*



Lignin in Ma-infected roots was stained in red with phloroglucinol (3 DPI)

Summary

- In vitro* infection assays showed that *S. torvum* induced the accumulation of brown pigments during avirulent pathotype A2-O infection, but not during virulent A2-J infection.
- Infection with A2-J specifically induced the expression of genes related to cell wall modification and transmembrane transport.
- Infection with A2-O rapidly induced sesquiterpene synthases, and fatty acid desaturases at 1 DPI, followed by genes involved in defense and lignin biosynthesis at 3 DPI.
- Histochemical analysis revealed that A2-O, but not A2-J, induced lignin accumulation at the root tip, suggesting that physical reinforcement of cell walls with lignin is an important defense response against nematodes.



Future perspective

- We have sequenced the genomes of A2-J and A2-O to identify virulence factors and are currently sequencing the genome of *S. torvum*.
- We have also started metabolome analyses to identify anti-nematode metabolites synthesized by *S. torvum* during A2-O infection.

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