Turnip Mosaic Virus impairs thermomorphogenetic responses in Arabidopsis plants amid genetic and hormonal disruption

Ignacio Lescano López(1); Anahí Yáñez Santos(1); María Florencia Realini(2); Hernán Ramiro Lascano(1); Sebastián Asurmendi(2); Carlos A. Manacorda(2)
(1) *Unidad de Estudios Agropecuarios (UDEA, CONICET-INTA), Córdoba*
(2) *Instituto de Biotecnología (IABIMO), CICVyA INTA. Dr. Nicolás Repetto y De Los Reseros S/Nº (B1686IGC). Hurlingham, Buenos Aires.*

BACKGROUND

- Plants rely on **thermomorphogenesis** (**TMG**) to adapt their growth and development in response to moderate temperature increases, a process mainly regulated by the **PIF4** (**Phytochrome Interacting Factor 4**) transcription factor and auxin signaling pathways under which **Expansins** (**EXPAs**) proteins act to enable cell expansion.
- **TuMV** (**Turnip Mosaic Virus**), a widespread plant pathogen that induces stress responses by disrupting hormonal and genetic regulatory networks, ultimately impairs host growth and development.
- EXPAs are altered by TuMV at 22ºC, however, how TuMV infection affects TMG and its key molecular determinants in Arabidopsis thaliana remains largely unexplored.

AIM OF THIS WORK

To analyze how TuMV infection affects TMG in *Arabidopsis thaliana*, focusing on the role of the PIF4 transcription factor.

RESULTS

1. TuMV infection impaired TMG responses, but were partially restored by PIF4 overexpression

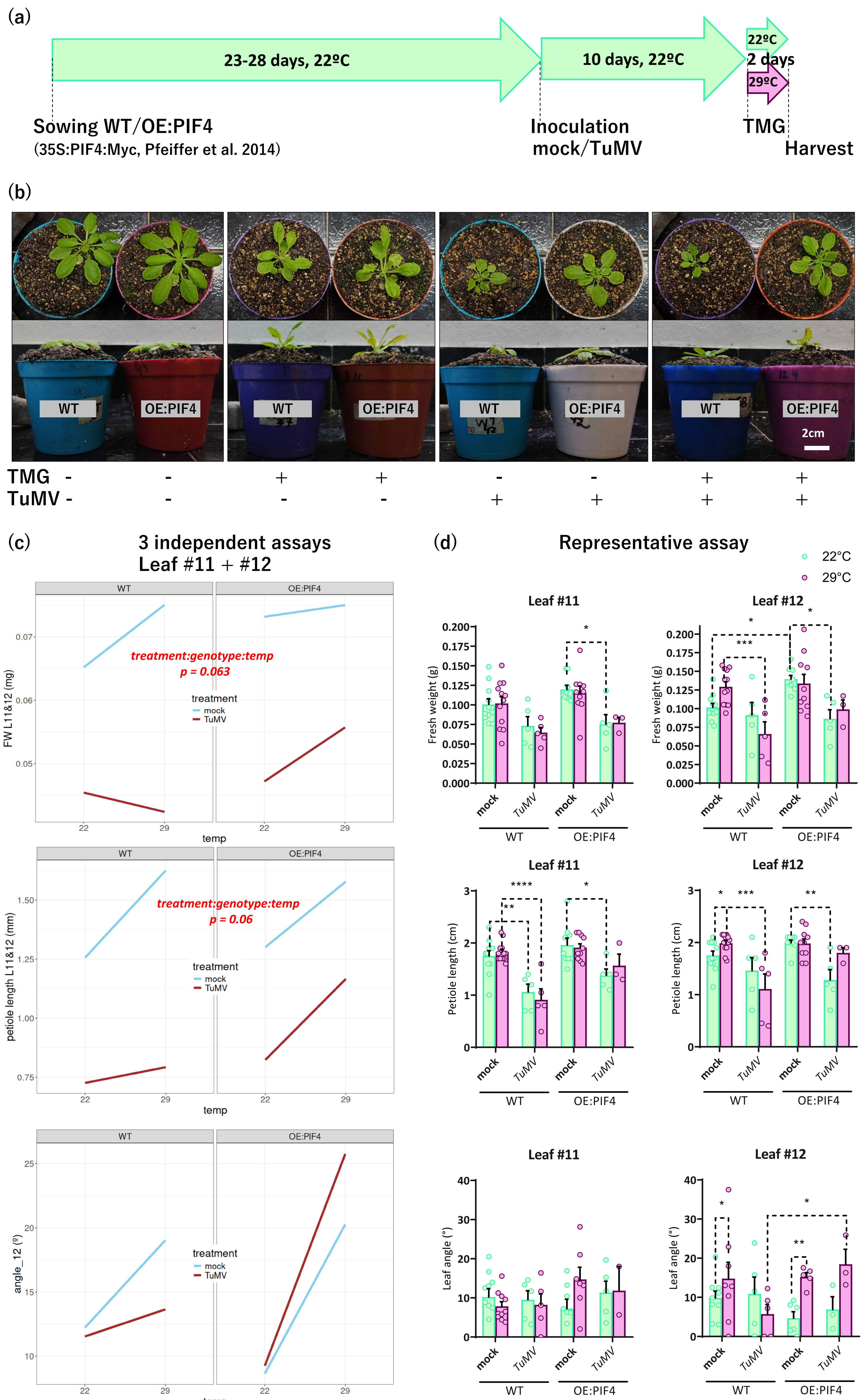


Figure 1 TuMV-impaired TMG responses in WT Arabidopsis were partially rescued by PIF4 overexpressing lines. (a) Experimental Setting. Plants were inoculated with either buffer (mock) or TuMV extract. At 10-days post inoculation (DPI) plants were incubated at 22° C (control) or 29° C (TMG) conditions. (b) Representative pictures after 2-day TMG treatment. TMG responses analysis of (c) three experiments together using mixed linear models (LMM) or (d) a representative experiment using ANOVA followed by multiple comparison tests. Asterisks indicate significant differences between treatments (*p < 0.033, **<0.002, ***<0.001, ****<0.0001).

2. TuMV infection impacted TMG-related gene expression

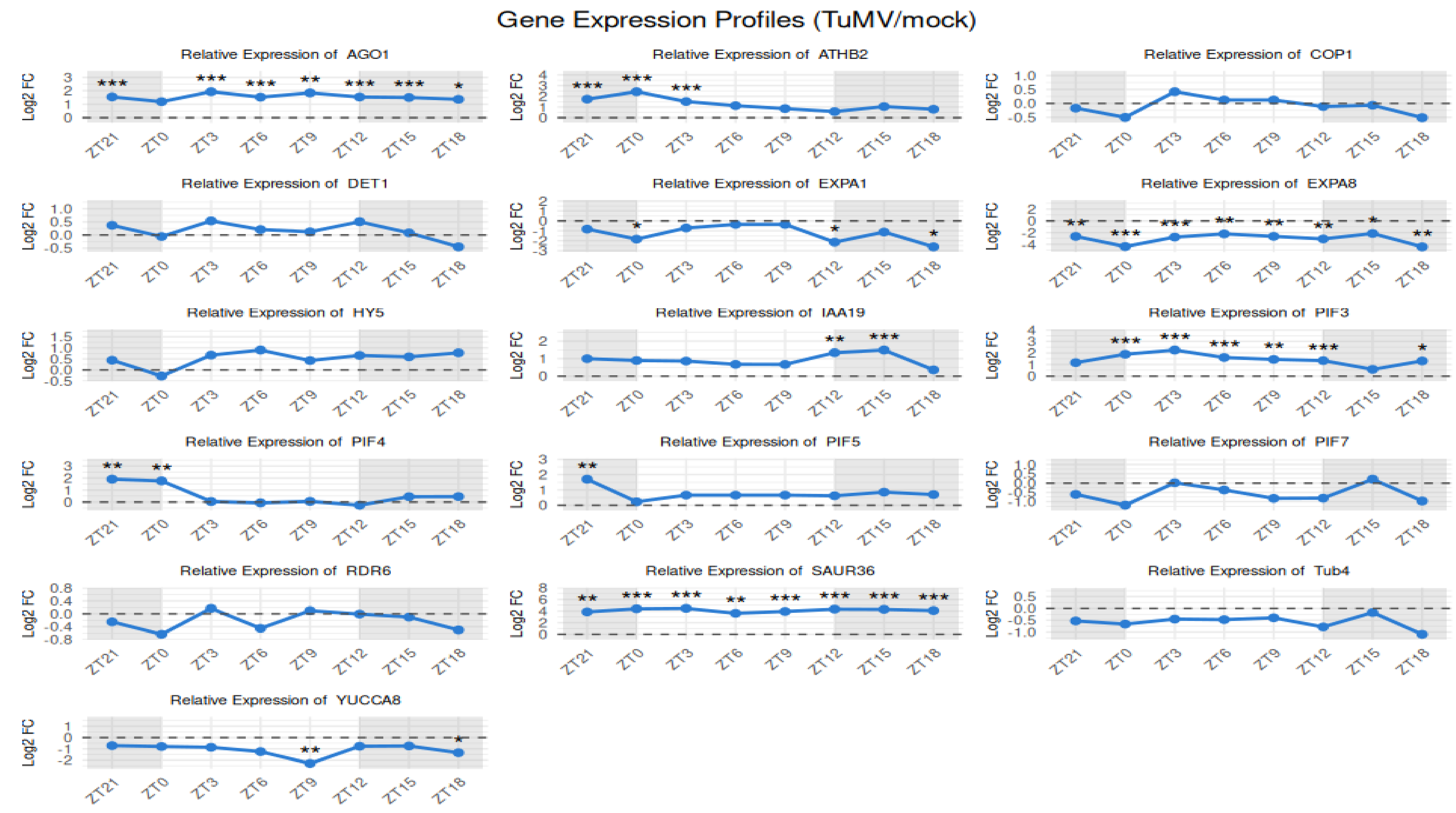
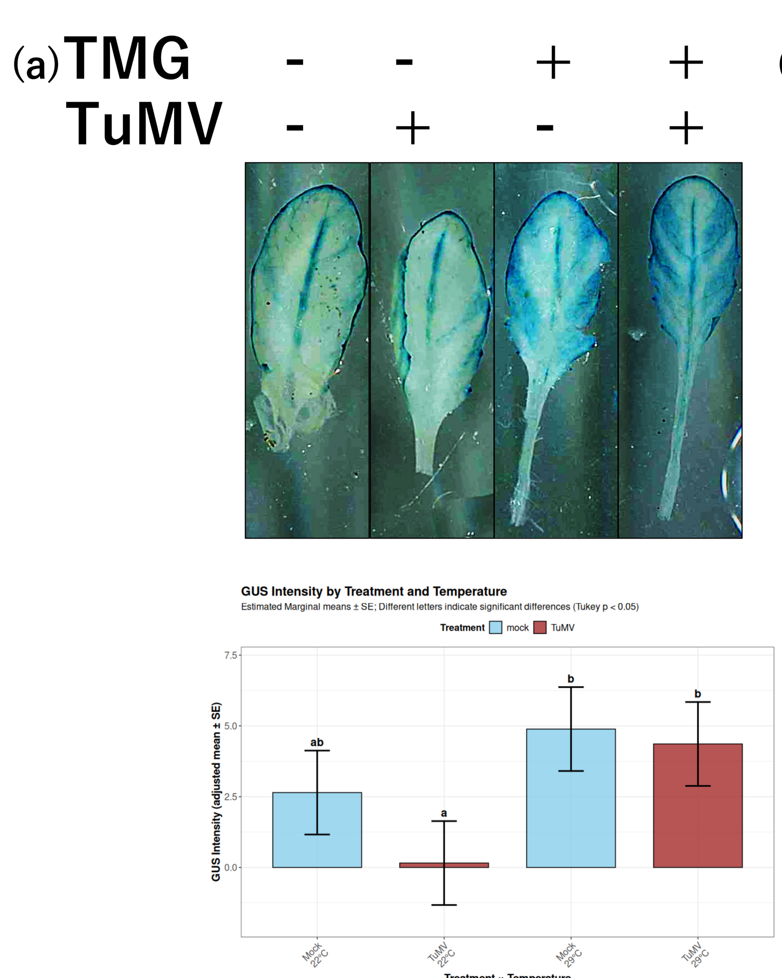


Figure 2 Circadian relative expression (TuMV/mock) of TMG-related genes. Samples were taken every 3h during 12-13 DPI. White boxes: daylight; grey boxes: nighttime. Relative expression change induced by TuMV is indicated as Log2-Fold change where 0 = no change. ZT = Zeitgeber Time. Asterisks denote significant changes (* = p< 0.05; ** = p <0.01; *** = p <0.001.

3. Auxin perception and signalling are altered by TuMV



(b) Log2 relative gene expression

(29° C/22° C), mock

AGO1	0.7
EXPA8	1.94
ATHB2	0.18
PIF3	-0.0042
PIF4	0.56
SAUR36	-0.96

(29° C/22° C), TuMV

AGO1	-0.75
EXPA8	2.56
ATHB2	-0.24
PIF3	-0.04
PIF4	1.52
SAUR36	-0.68

(TuMV/mock), 22° C

AGO1	1.73
EXPA8	-2.71
ATHB2	0.89
PIF3	1.18
PIF4	-0.64
SAUR36	0.66

(TuMV/mock), 29° C

AGO1	0.28
EXPA8	-2.09
ATHB2	0.47
PIF3	1.14
PIF4	0.32
SAUR36	0.94

Figure 3 **TuMV's alteration of auxin perception and TMG-and-defense-related gene expression is temperature-dependent.** (a) DR5 promoter activity. Letters denote significant differences between treatments (ANOVA followed by Tukey test, p <0.05). (b) Col-0 plants were subjected to TMG and infection treatments and gene expression analysis were performed. The effect of temperature within treatments (above panels) and the effect of treatments within temperatures (below panels) are shown.

4. Exogenous Auxin treatment could not revert TuMV symptoms

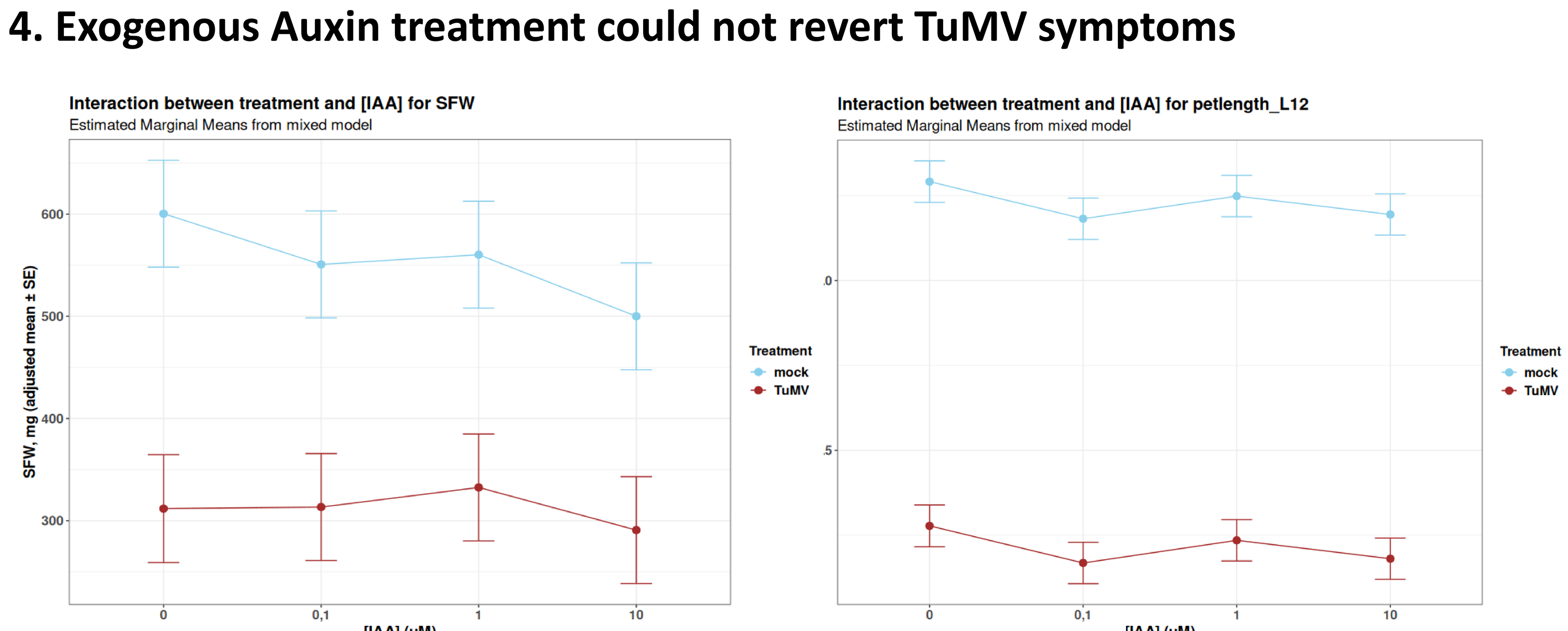


Figure 4 IAA does not rescue TuMV-induced phenotypes. Different [IAA] were sprayed for 6 consecutive days from 3 to 10 DPI and Shoot Fresh Weight **(a)** and petiole lengths **(b)** were recorded at 12 DPI.

CONCLUSIONS AND PERSPECTIVES

- TuMV infection interfere with plant architectural responses to moderate temperature increases, crucial for plant fitness under combined stresses.
- Key genes related to auxin metabolism and response were altered by TuMV throughout the day, including *PIFs* and expansin genes which are crucial for plant TMG phenotypes and growth.
- *PIFs* induction alongside *EXPA1/8* downregulation suggested functional uncoupling between thermomorphogenic signaling and TMG programme execution under viral infection and T increase.
- The research highlights PIF4's central role in mediating these complex interactions, offering insights relevant to climate change challenges and informing breeding strategies for crops resilient to combined stresses.

Financial support
INTA PD i083 and i084
PICT 2020 01852

CONICET INTA IABIMO CONICET INTA UDEA