

# Salicylic acid and heptanoyl salicylic acid induce distinct defence responses in a wheat-powdery mildew interaction

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# GENERAL INTRODUCTION

- *Blumeria graminis* f.sp. *tritici* is the causal agent of wheat (*Triticum aestivum*) powdery mildew
- great losses without the extensive use of conventional fungicides



Fungicides

- consequences on health and environment
- resistance in powdery mildew populations

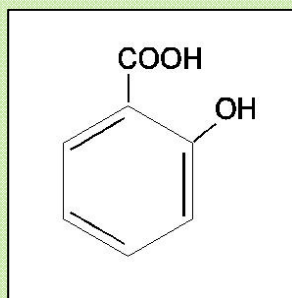
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**Resistance inducers**

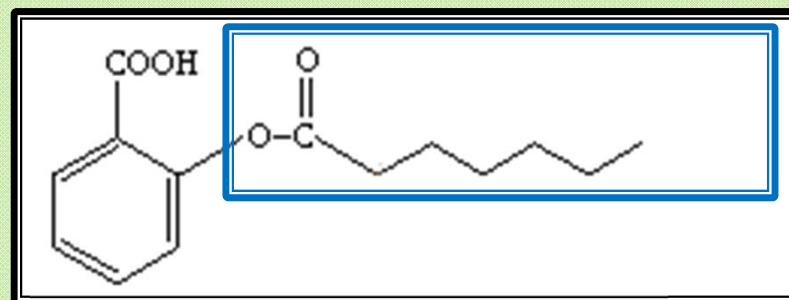
Activation of the plant defence responses

➤ Trehalose, Iodus 40®, Milsana®, OGAs-Ac, OGAs+Ac  
 (Reignault *et al.*, 2001; Randoux *et al.*, 2006; Renard-Merlier *et al.*, 2007; Randoux *et al.*, 2010)

➤ Salicylic Acid (SA)



Heptanoyl Salicylic Acid (HSA)



	SA	HSA
1 spraying	50%	95%
2 sprayings	65%	100%

(Muchembled *et al.*, 2006)  
 (Renard-Merlier *et al.*, 2007)

No direct effect on fungal germination *in vitro*



➤ Aim: compare, at the molecular and biochemical levels, physiological responses of wheat after treatment with SA and HSA.

# MATERIAL and METHODS

- Wheat cultivar Orvantis fully compatible with the MPEBgt1 powdery mildew isolate
- First leaf of 10-days-old wheat plant

Spraying :  
SA (1g/l)  
HSA (1g/l)

Inoculation  
with *Bgt*  
(500000sp/ml)



hpi

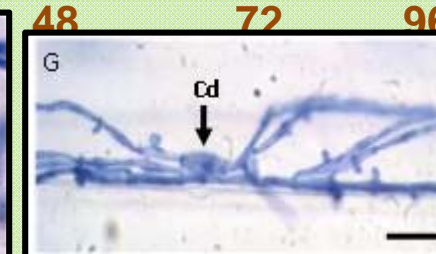
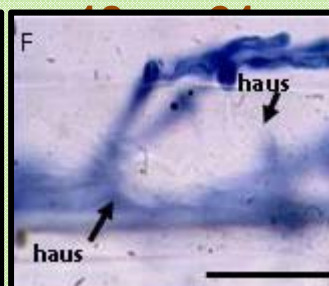
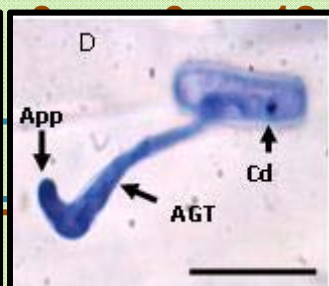
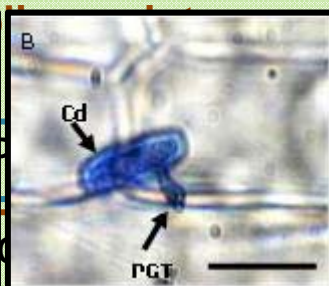
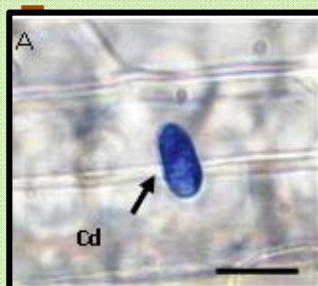
Genes sampling points

0 3 6 9 12 15 18 21 24

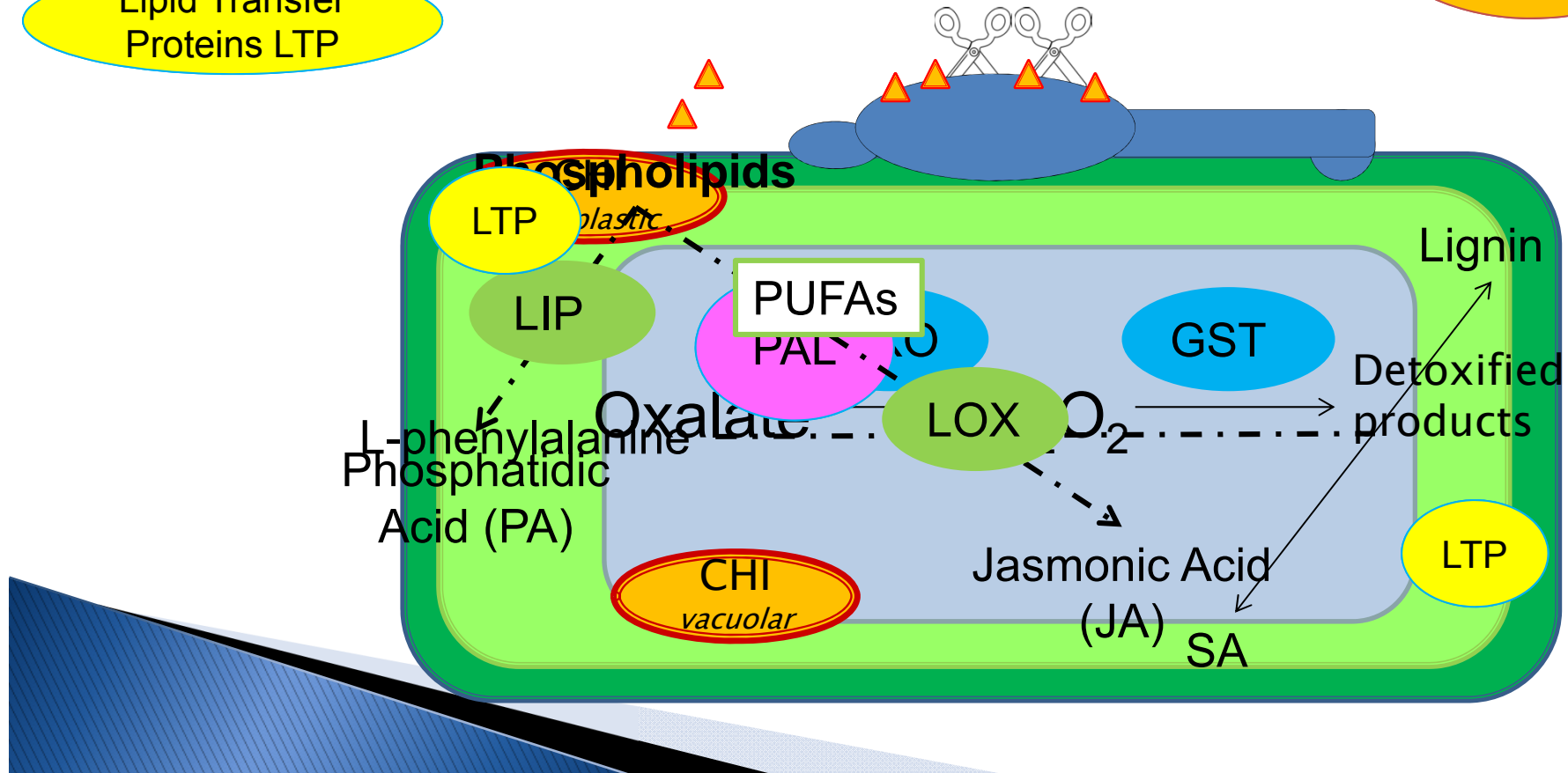
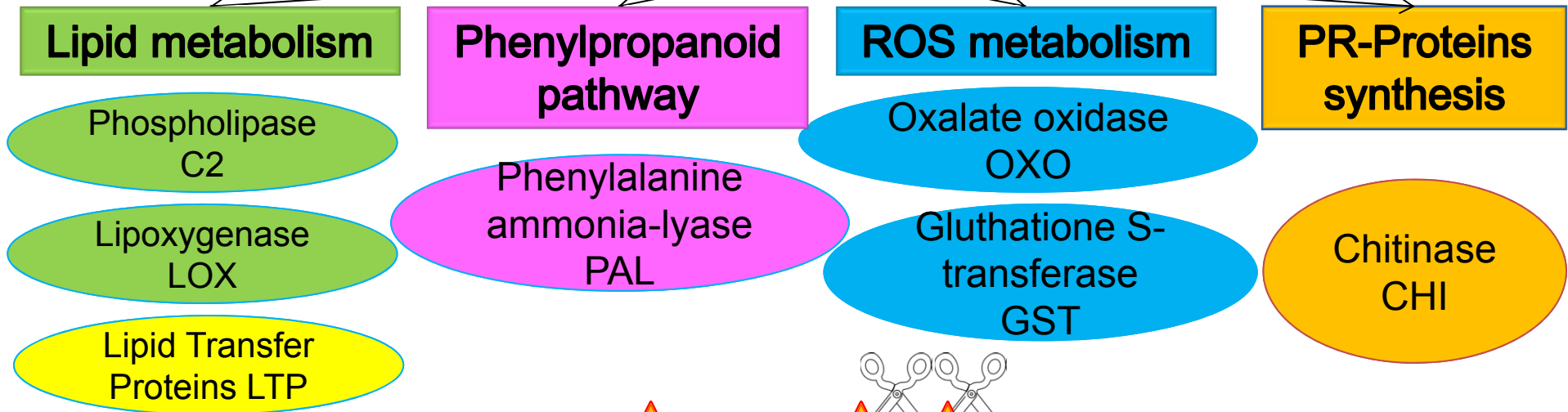
48

72

96



# Wheat defence responses



Lipid metabolism

Phenylpropanoid pathway

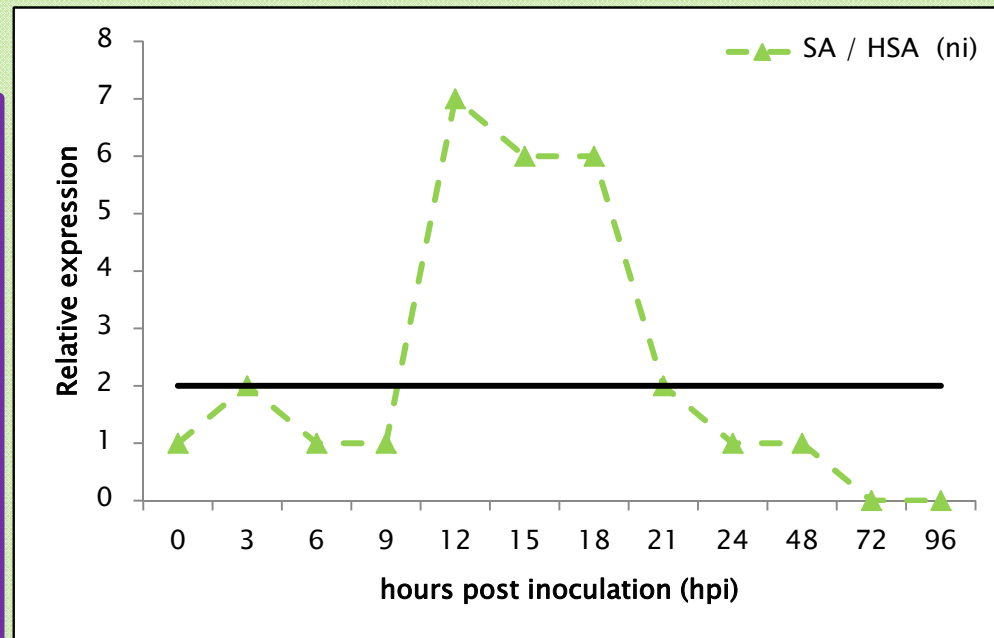
ROS metabolism

PR-Proteins synthesis

All gene expression data are calculated compared to non-inoculated (ni) control (H<sub>2</sub>O for SA, 30% Eth for HSA) and normalized to 2 housekeeping genes (actin and tubulin) in various (i) conditions

Elicitor effect  
Priming effect

- In (ni) context: no induction of genes expression
- In (i) context: higher up-regulation of genes expression compared to (i) reference

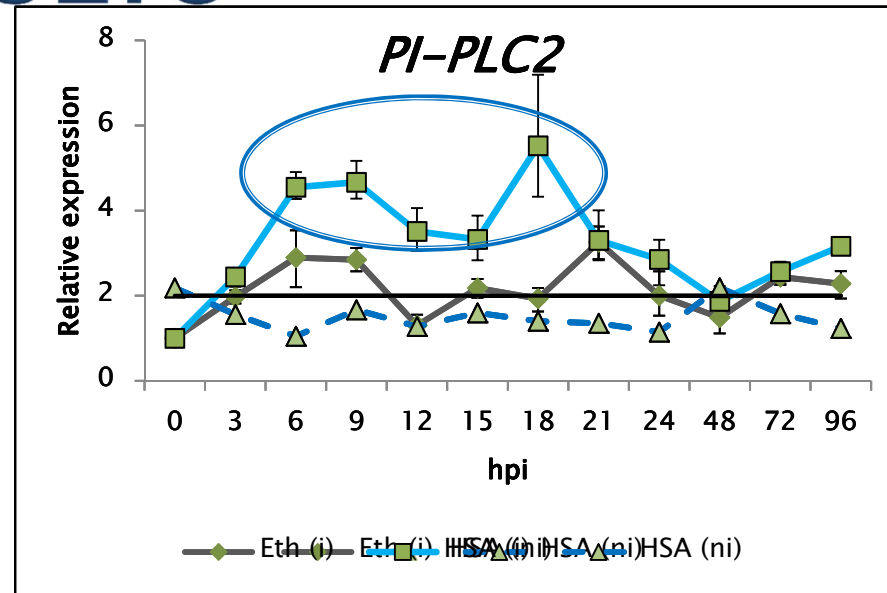
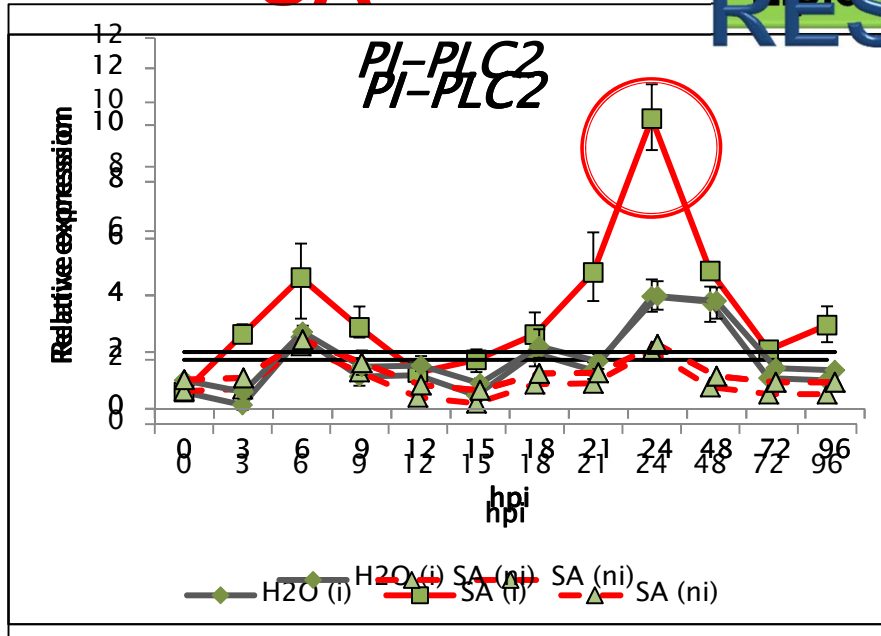


Defence and/or resistance markers specifically induced by SA and HSA

SA

# RESULTS

HSA



No up-regulation of *PI-PLC2* gene expression in (ni) conditions



No elicitor effect

More than 2-fold increase of *PI-PLC2* gene expression of SA-primed leaves at 24 hpi

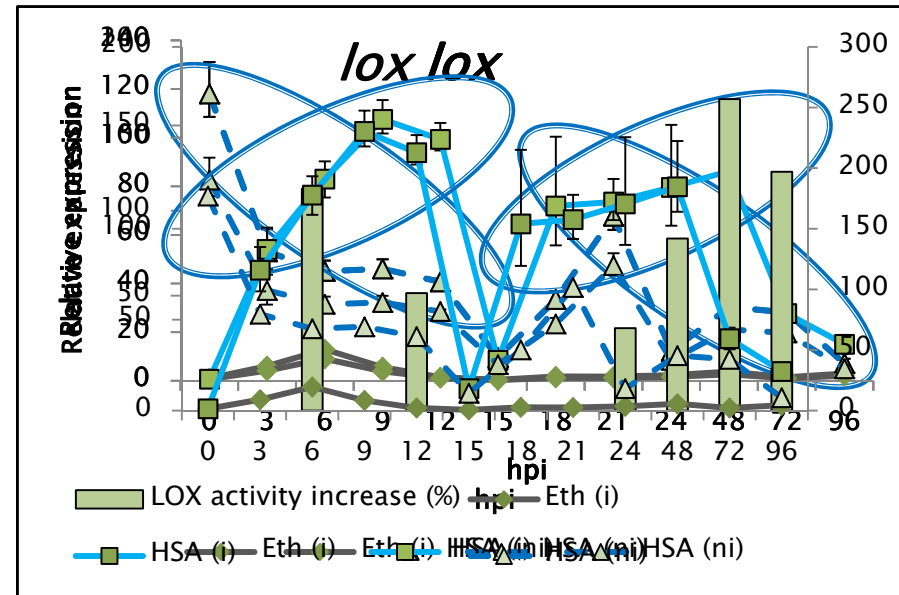
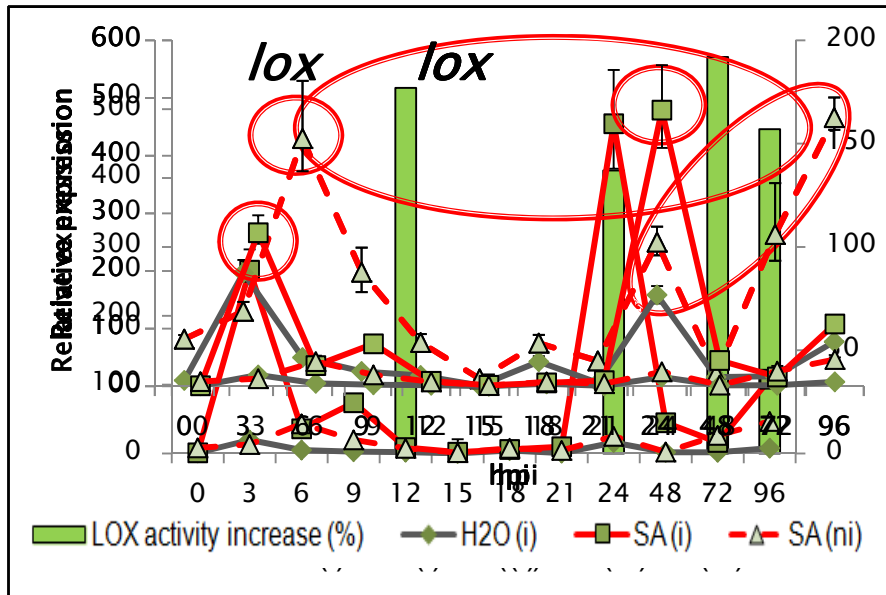


Priming effect

SA

Lipid metabolism

HSA



High up-regulation of the *lox* gene in SA treated (i) experiment in (ni) conditions

High up-regulation of the *lox* gene in SA treated (i) conditions

Increase of LOX activity



Strong elicitor effect



Priming effect at 3 hpi  
No priming effect

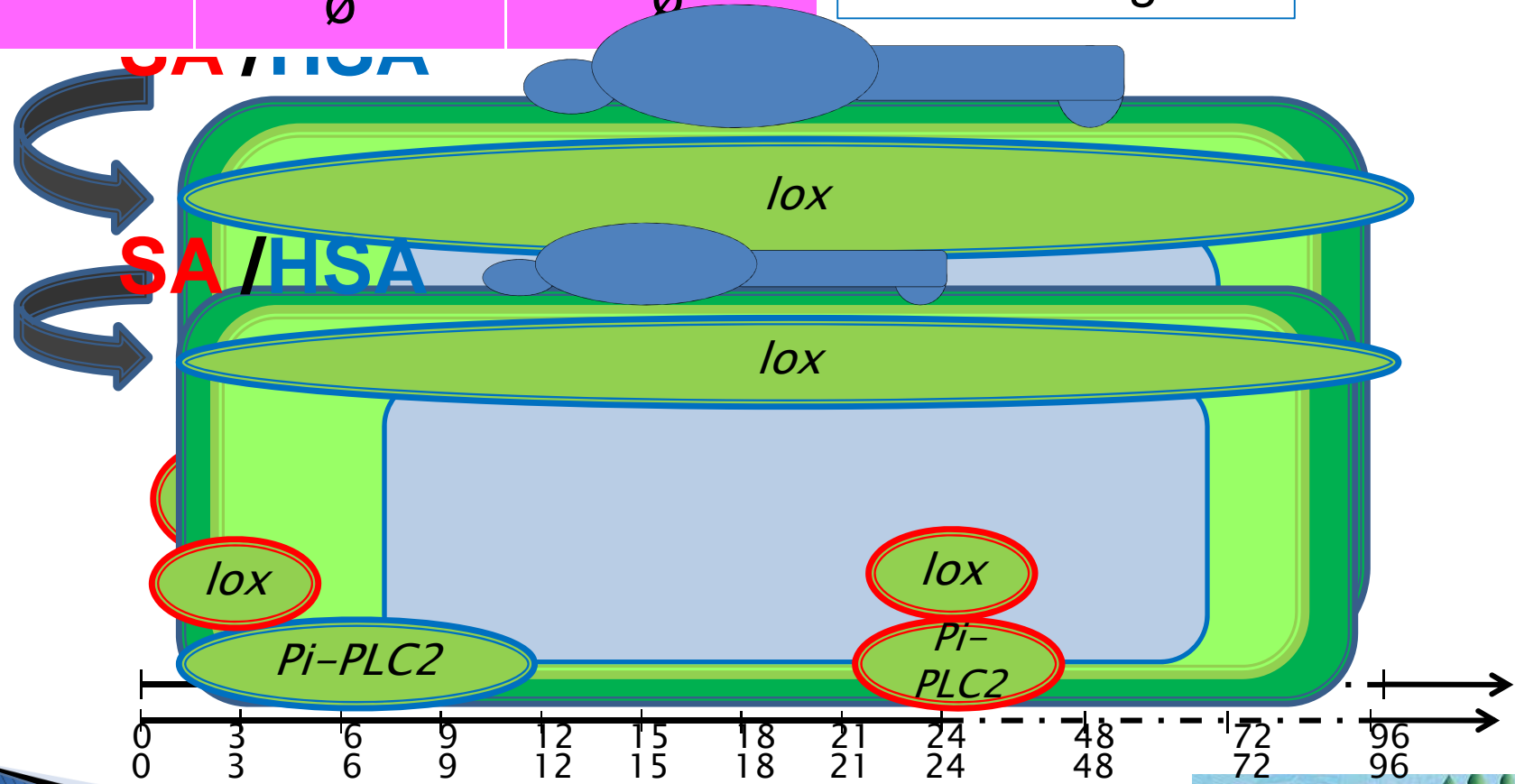


	SA	HSA
<i>lox</i>	✓	✓
<i>Pi-PLC2</i>	✓	✓
<i>ltp</i>	∅	∅
<i>pal</i>	∅	∅

Longer activation of *lox* gene and LOX activity

Earlier activation of *PI-PLC2* gene

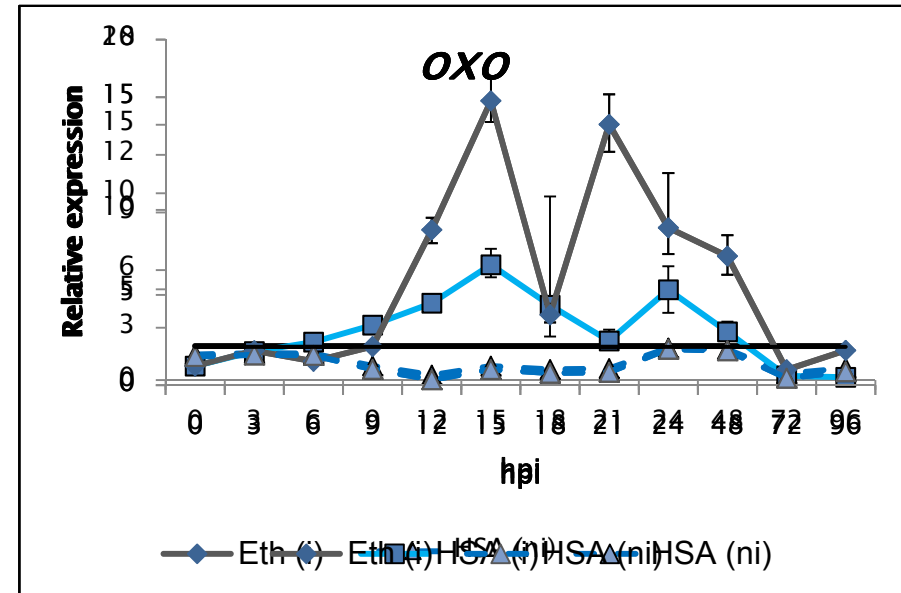
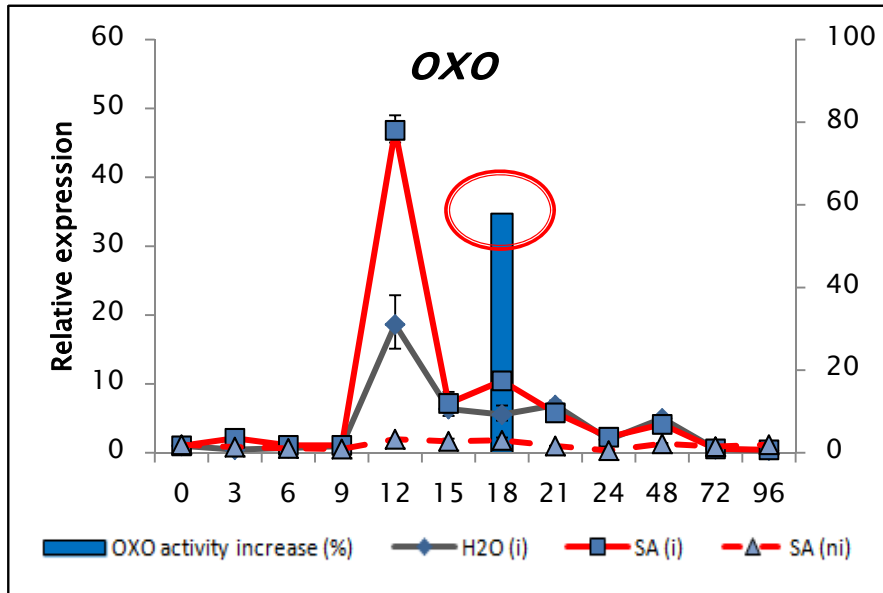
HSA efficiency



# SA

# ROS metabolism

# HSA



No up-regulation of oxo

gene expression

No up-regulation of oxo gene

or OXO activity upon HSA

treatment in both (ni) and (i)

conditions

OXO activity stimulation

No elicitor effect

No elicitor or

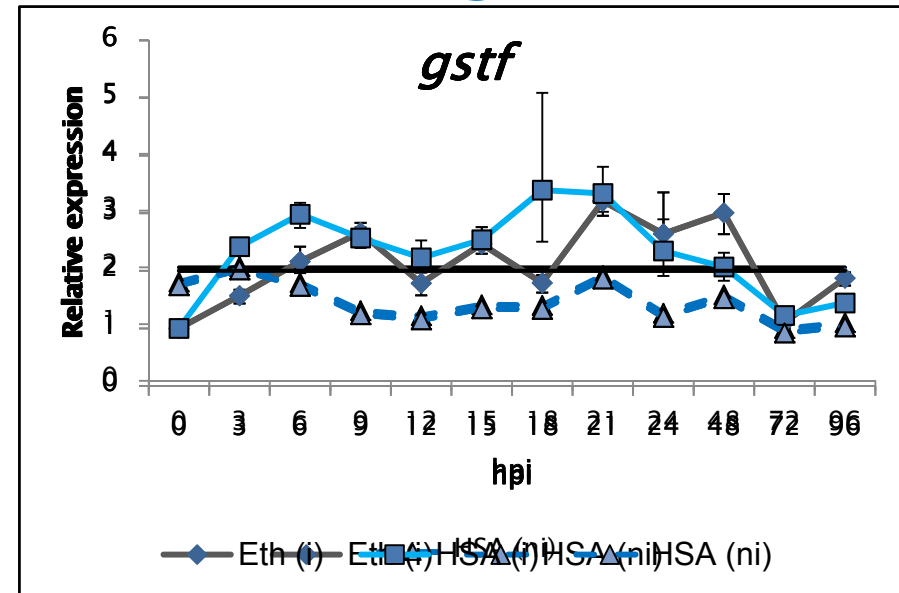
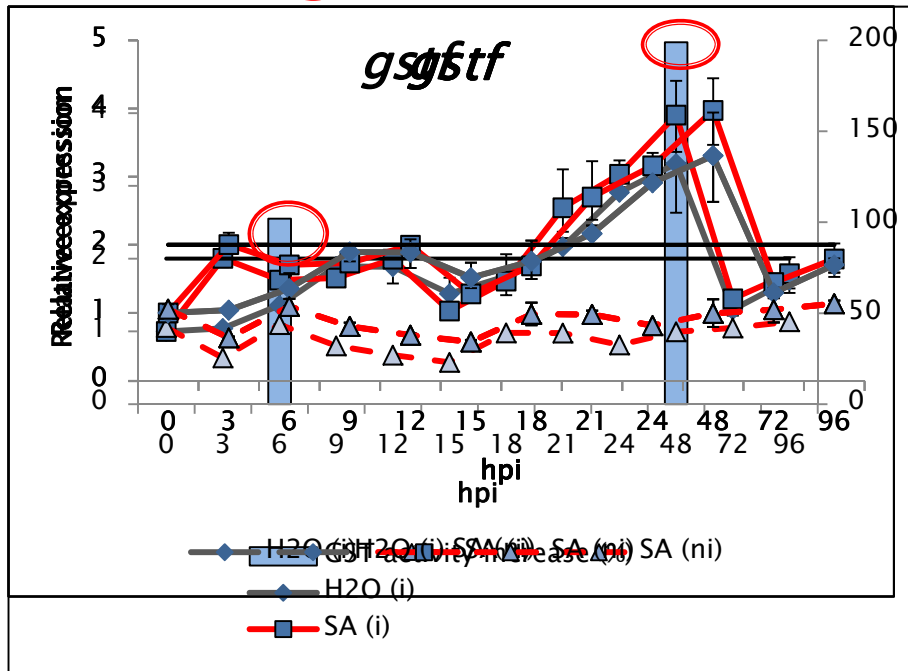
priming effect

Priming effect

# SA

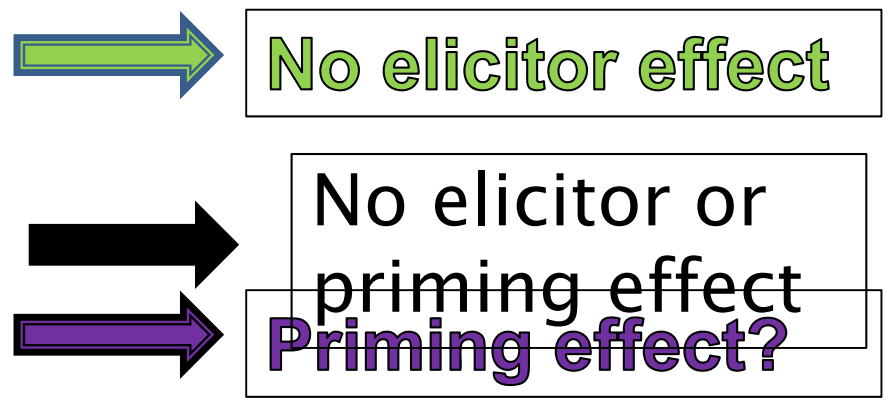
## ROS metabolism

# HSA



No up-regulation of *gstf* gene expression upon SA treatment in (ni) conditions or GST activity upon HSA treatment in both (ni) and (i) conditions

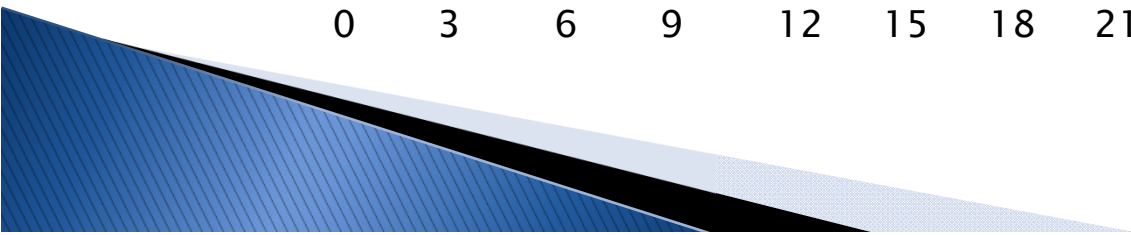
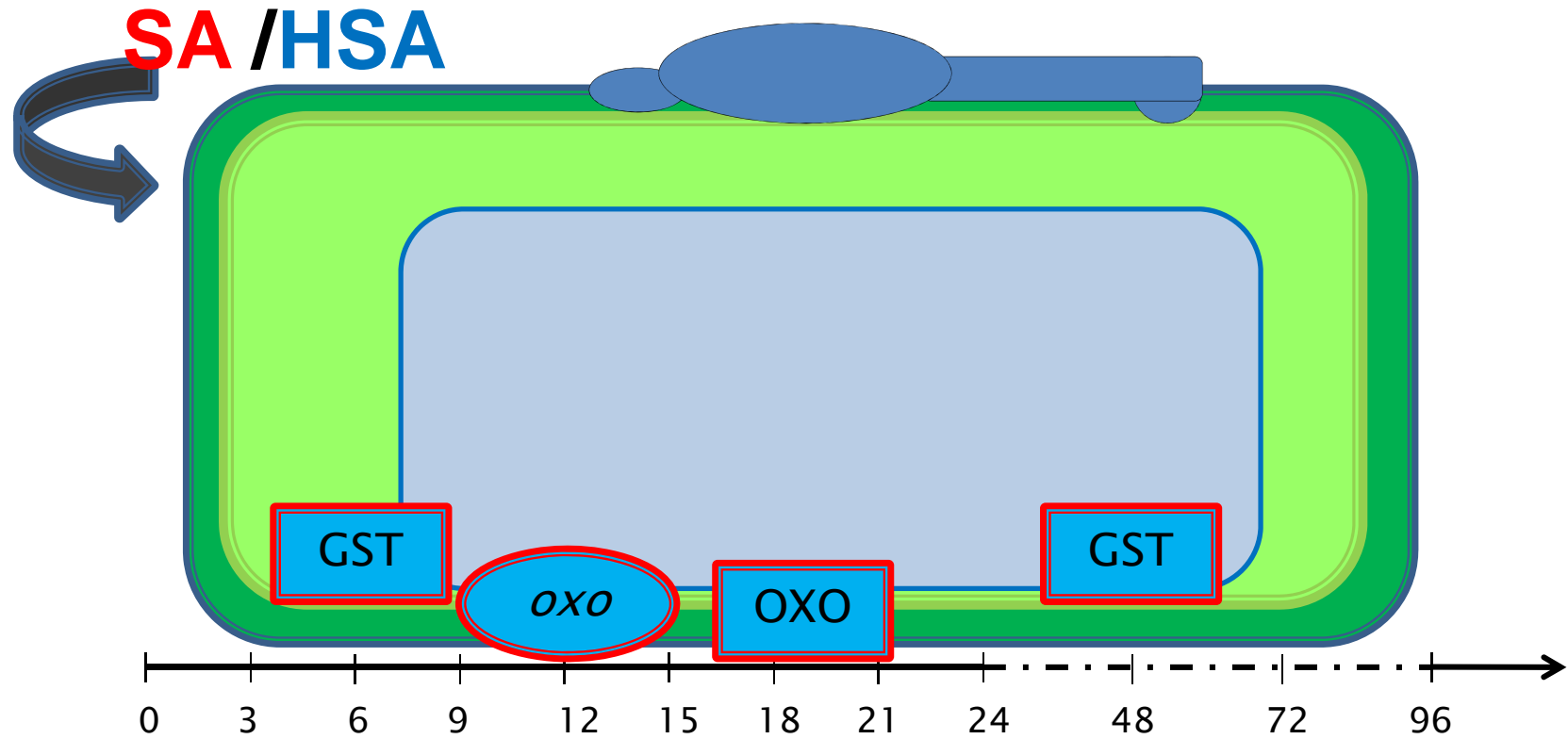
High increases in GST activity at 6 and 48 hpi



	SA	HSA
<i>oxo</i>	✓	∅
<i>gstf</i>	∅	∅

Balance of ROS metabolism upon SA treatment

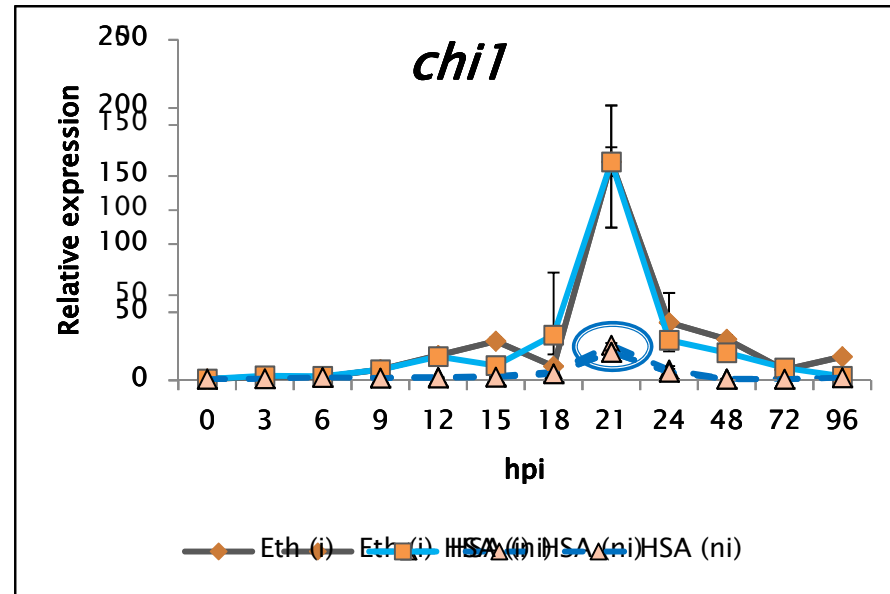
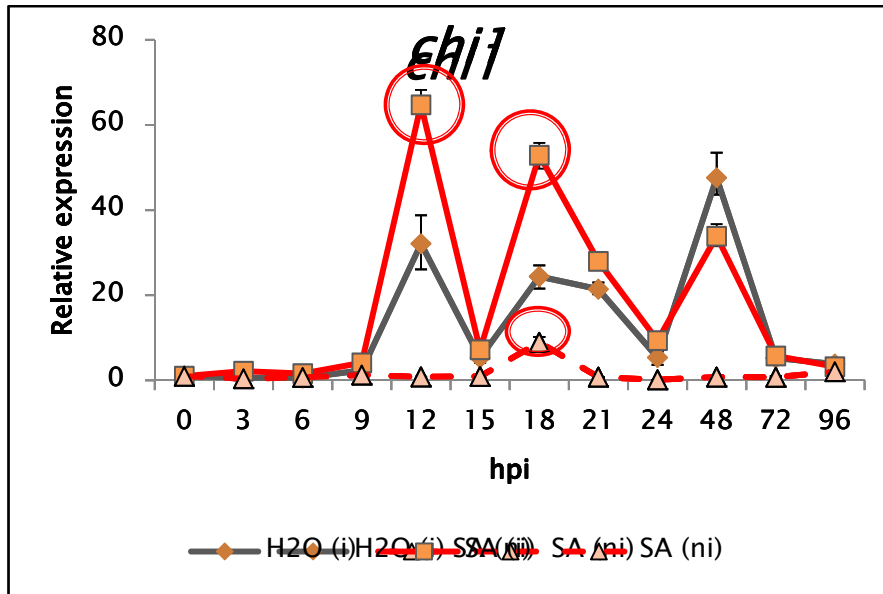
Global GST activity ≠ GST **phi**-encoding gene



# SA

## PR-Proteins synthesis

# HSA



Single up-regulation of *chi1* gene expression in (ni) conditions

No up-regulation of *chi1* gene upon HSA treatment in (i) conditions especially 12 hpi



Elicitor effect

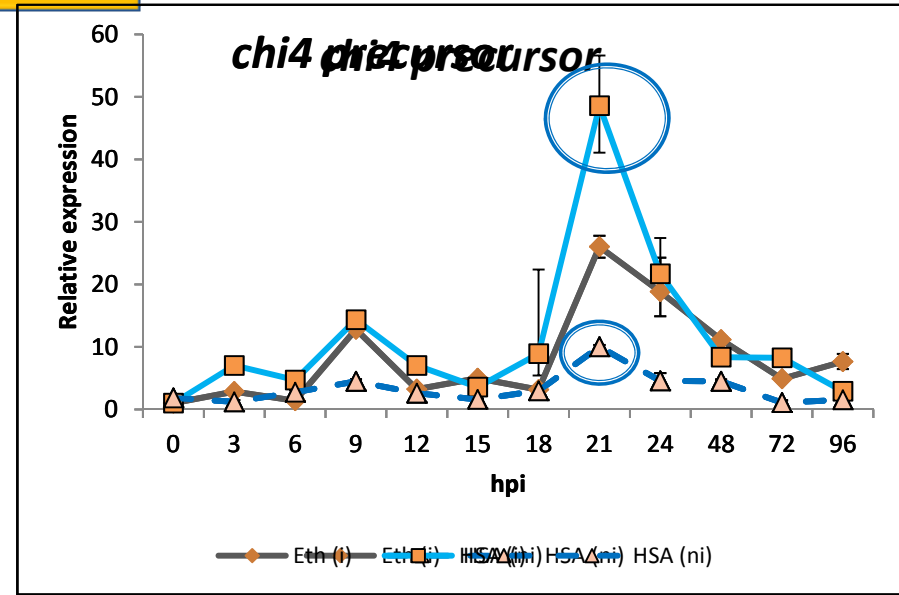
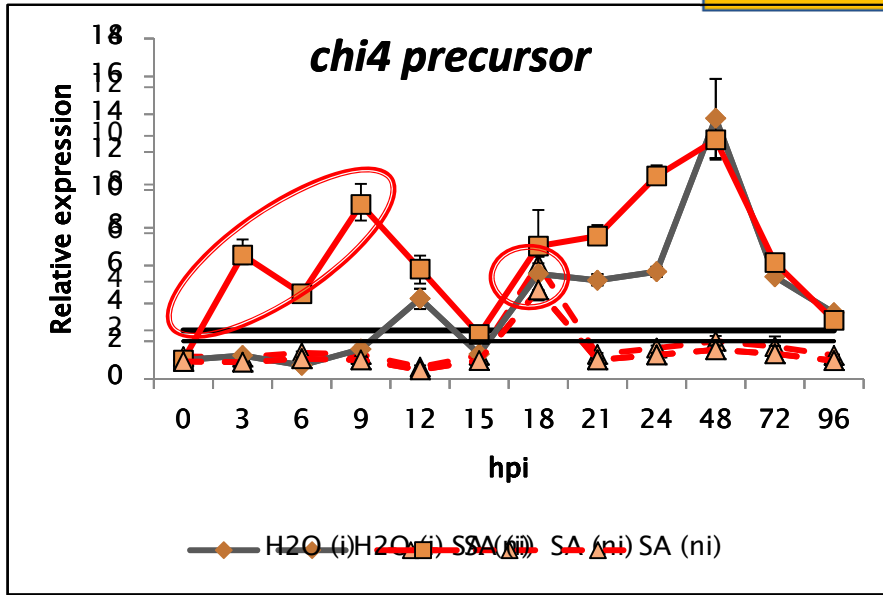


No priming effect at 12 hpi

SA

PR-Proteins synthesis

HSA



Up-regulation of *chi4* precursor gene expression in (ni) conditions

Up-regulation of *chi4* precursor gene expression at the same time as (i) context the first (hpi)



Elicitor effect

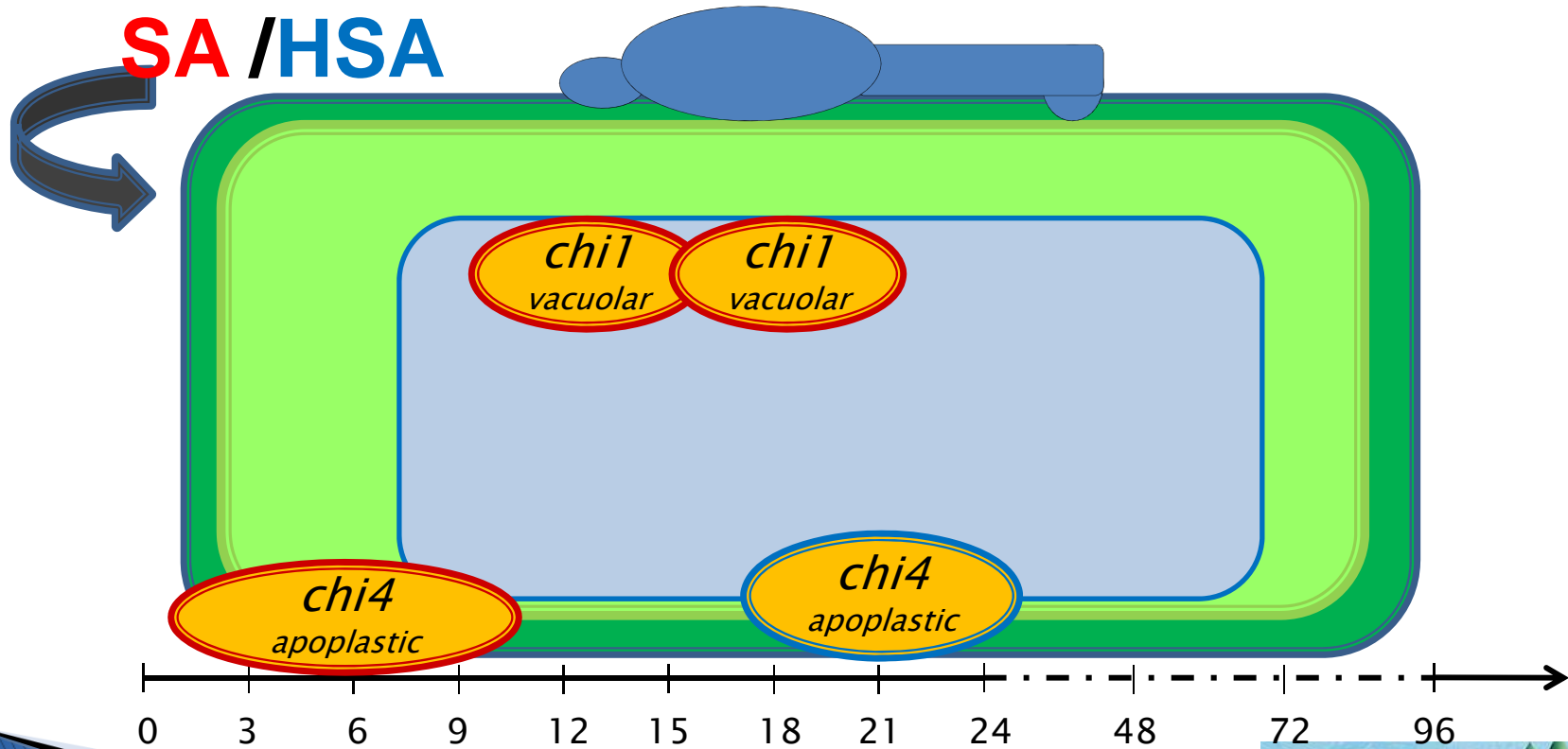


Priming effect

	SA	HSA
<i>chi</i>	∅	∅
<i>chi1</i>	✓	∅
<i>chi4 precursor</i>	✓	✓

*chi* gene  $\rightarrow$  Marker as in wheat-septoria interaction (Shetty *et al.*, 2009)

Chitinases profile upon SA treatment recalls the chronology described by Kasprezwska (2003)



# CONCLUSION

	SA	HSA
<i>chi</i>	∅	∅
<i>chi1</i>	✓	∅
<i>chi4 precursor</i>	✓	✓
<i>oxo</i>	✓	∅
<i>gstf</i>	∅	∅
<i>lox</i>	✓	✓
<i>PI-PLC2</i>	✓	✓
<i>ltp</i>	∅	∅
<i>pal</i>	∅	∅

Protection level	50%	95%
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SA

more numerous changes in the genes expression profiles

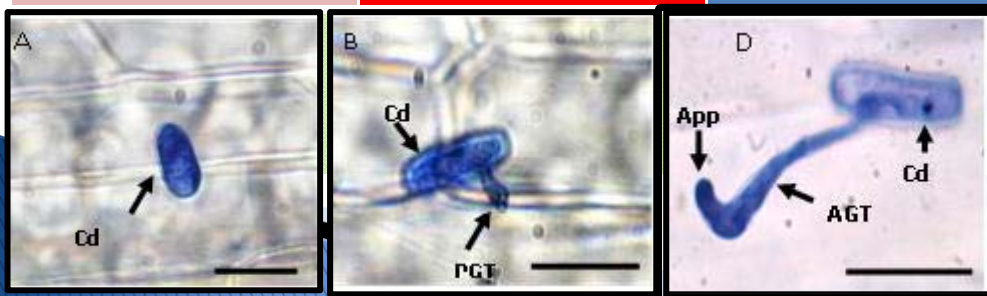
less efficiency in protection level

HSA

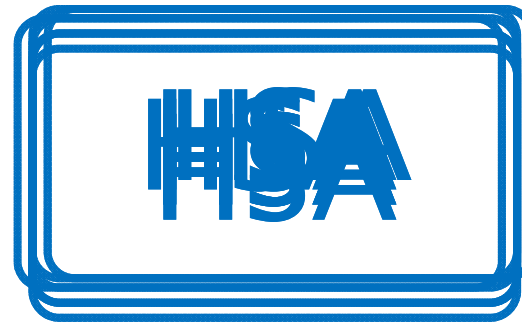
Other triggered defence pathways?

Elicitor property

Physiological cost?







Hi High cost in (i) conditions

Less cost in (i) conditions

5 50% protection

9 95% protection

Less cost in (ni) conditions

High cost in (ni) conditions



- UCEiV
- French Ministry of Higher Education and Research
- INTERREG IV- PHYTOBIO



Thank you for your attention