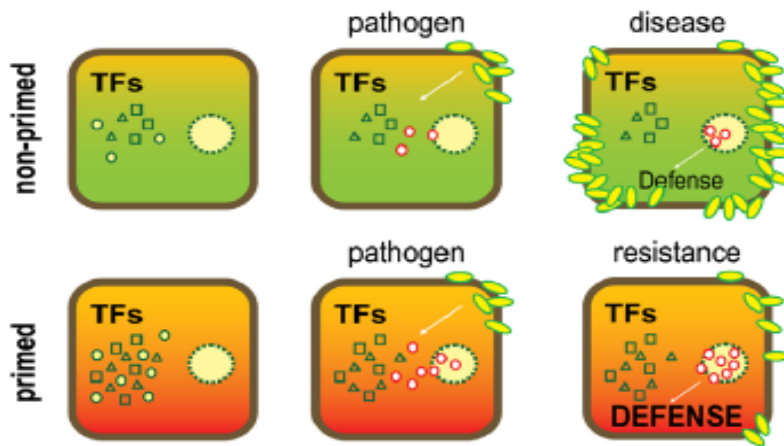


Multilevel analysis of the clubroot disease and its biological control by an endophytic fungus



Clubroot disease control is difficult

Can we exploit the induction of defense by endophytes to control the clubroot disease?

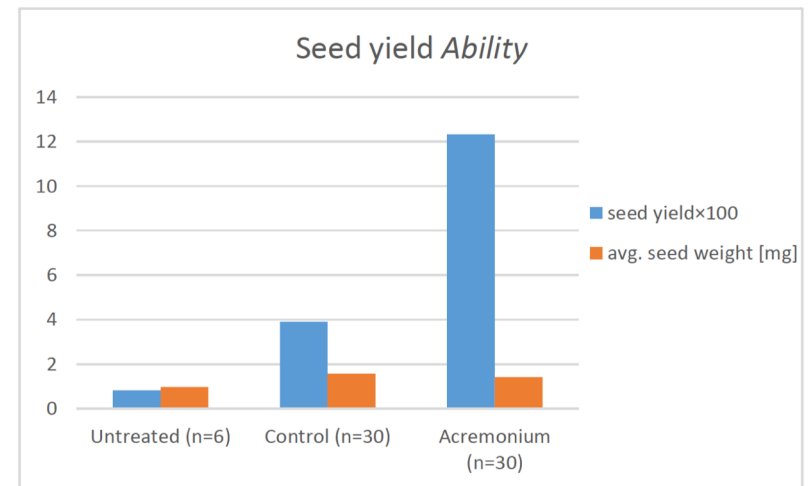
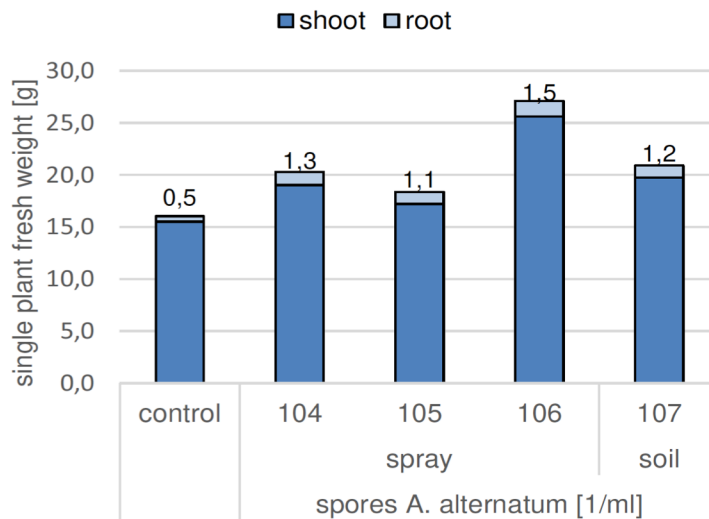
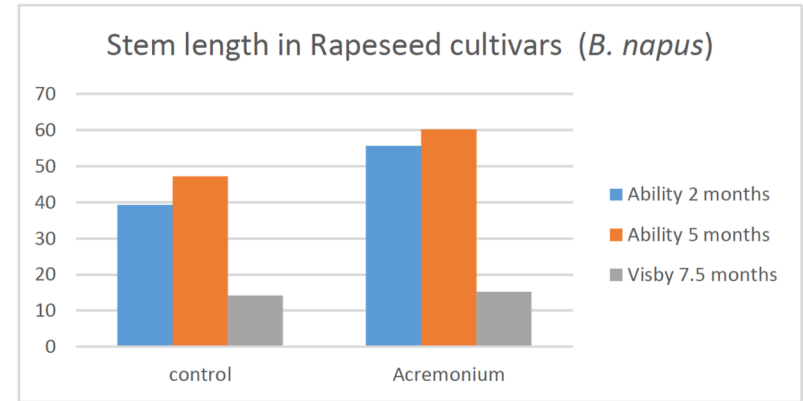
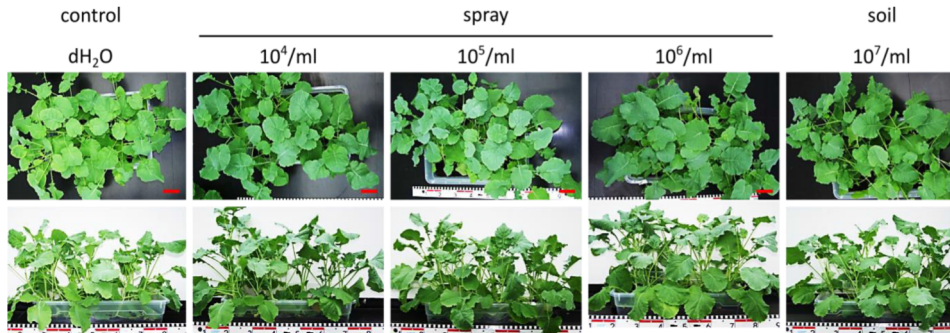


A. alternatum growing out of tomato leaf

Acremonium alternatum

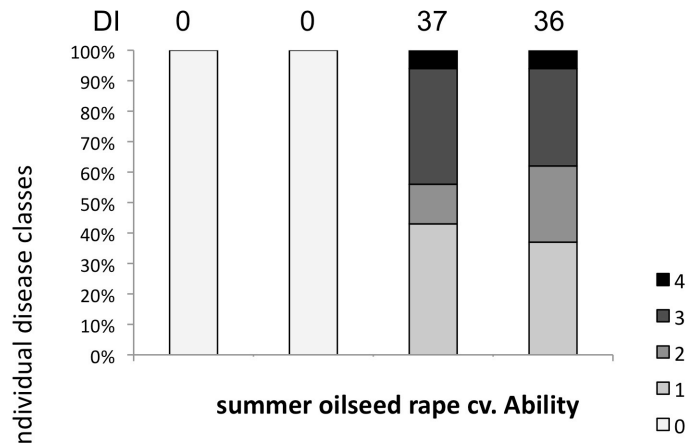
Reprinted from Van der Ent, S., Van Wees, S.C.M., and Pieterse, C.M.J. (2009). Jasmonate signaling in plant interactions with resistance-inducing beneficial microbes. *Phytochemistry* 70: [1581-1588](#) with permission from Elsevier.

Acremonium alternatum – an endophytic fungus - can induce growth and yield of *Brassica napus*

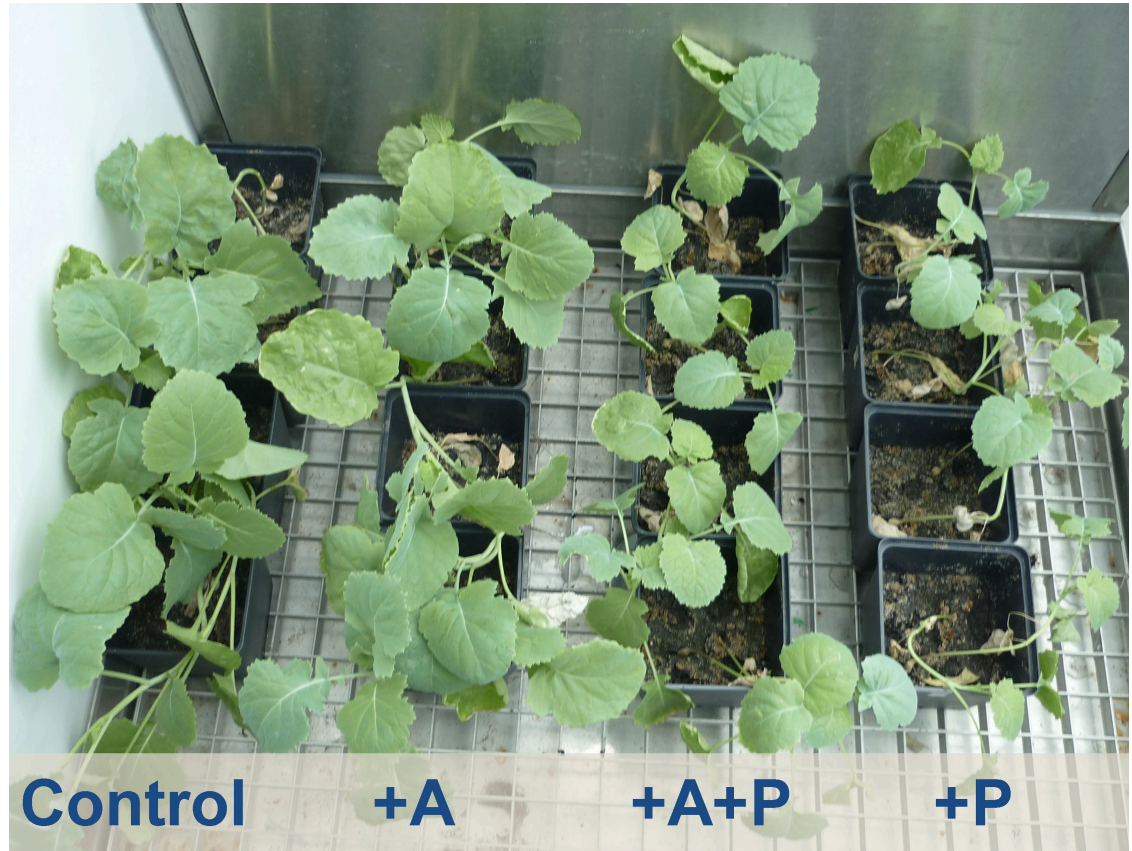
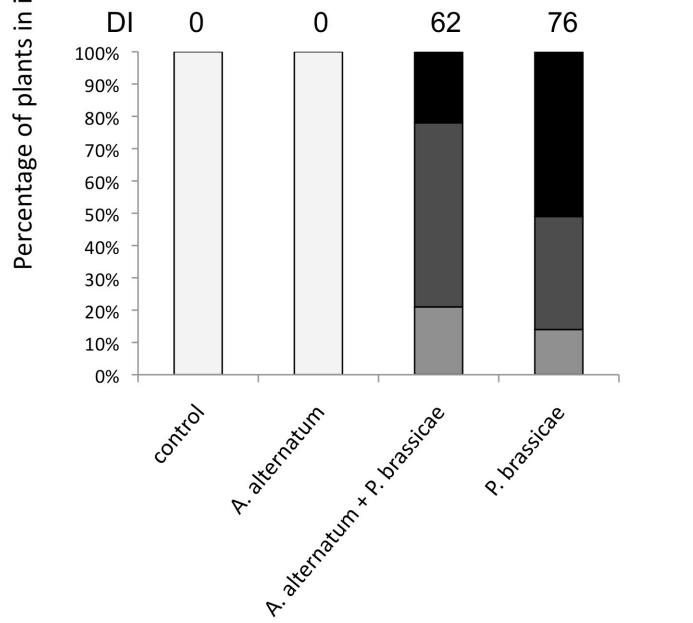


Tolerance against clubroot is induced in *Brassica napus* (oilseed rape) plants

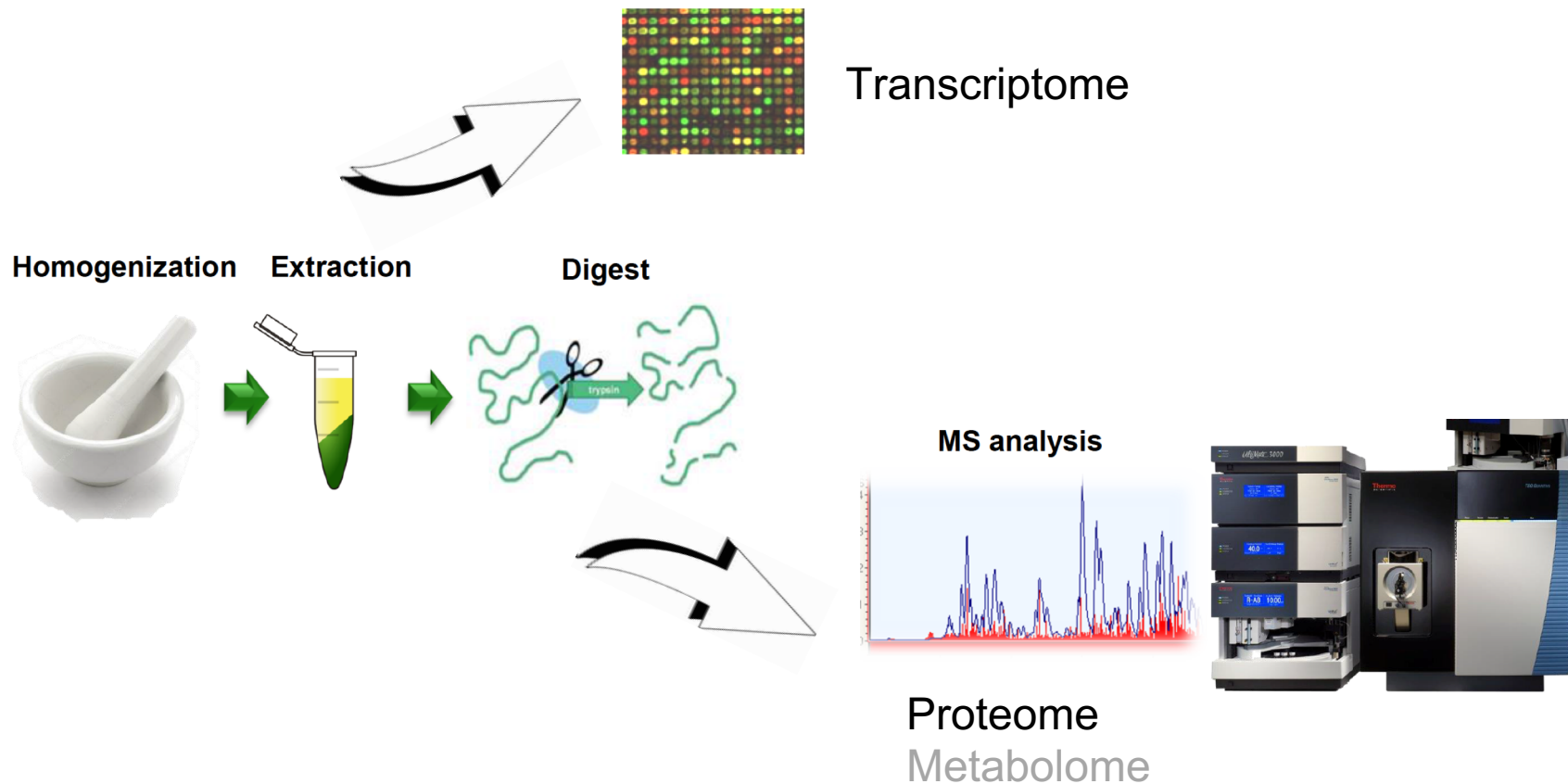
winter oilseed rape cv. Visby



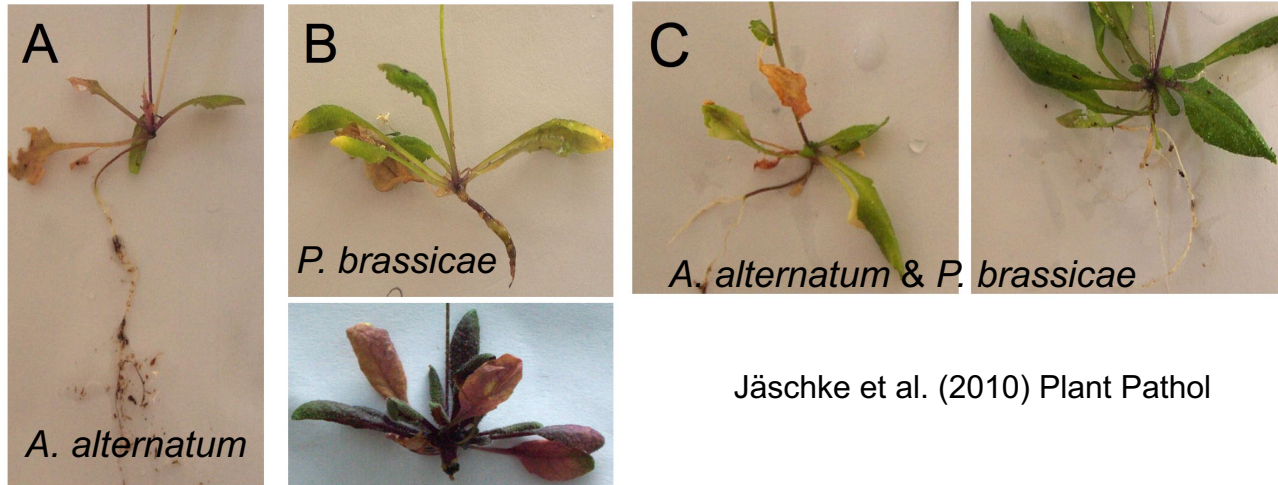
summer oilseed rape cv. Ability



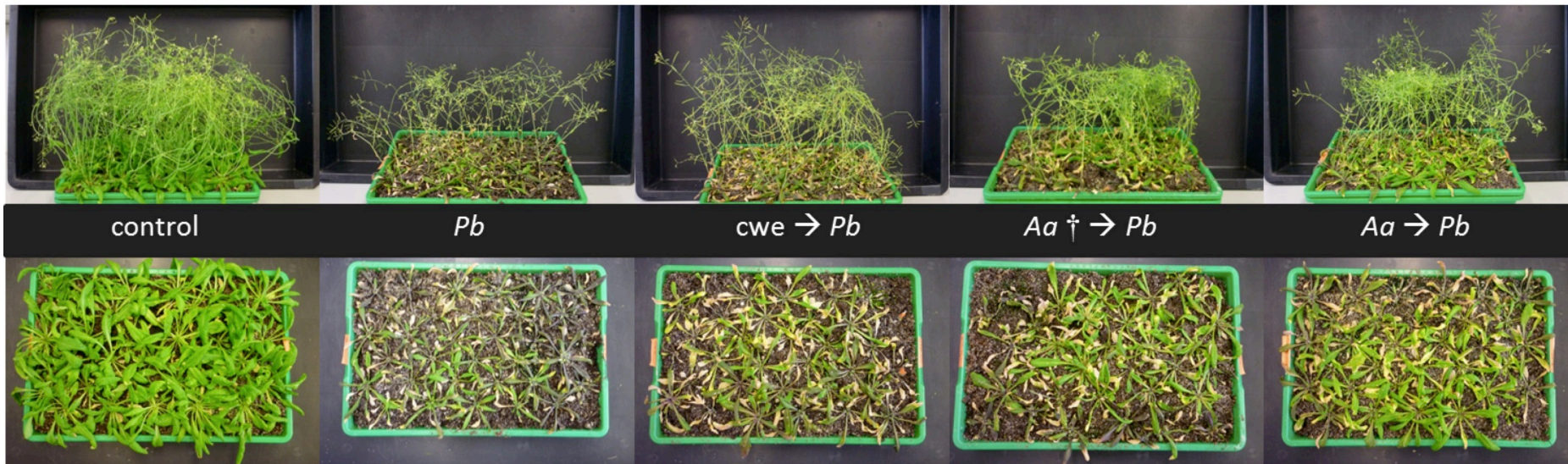
-omics analyses to study early events during the clubroot disease and the interaction with *A. alternatum*



To elucidate the mechanism(s) working with model plants is necessary

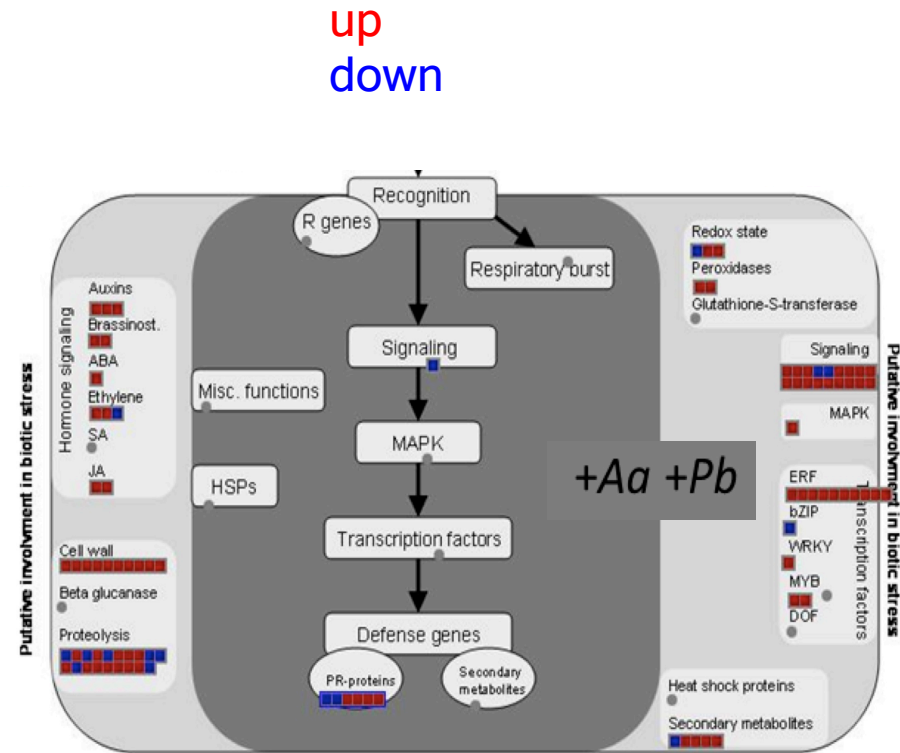
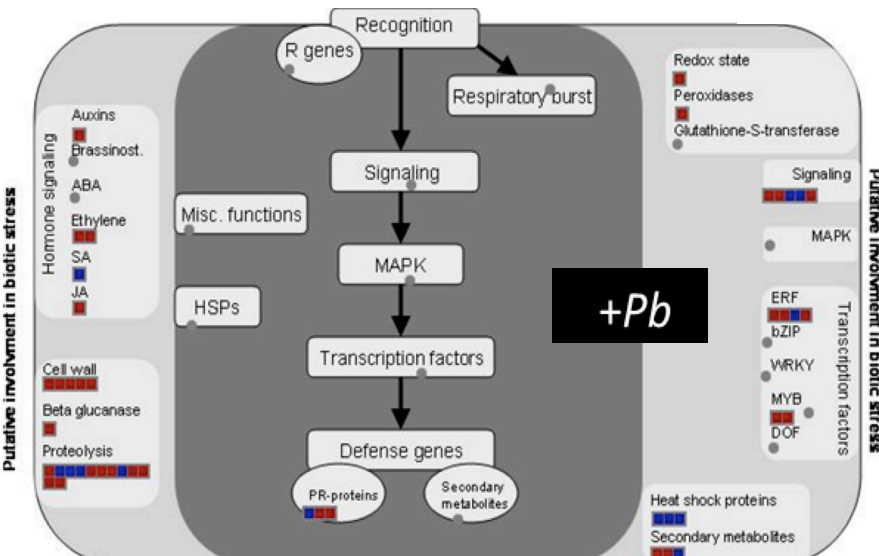
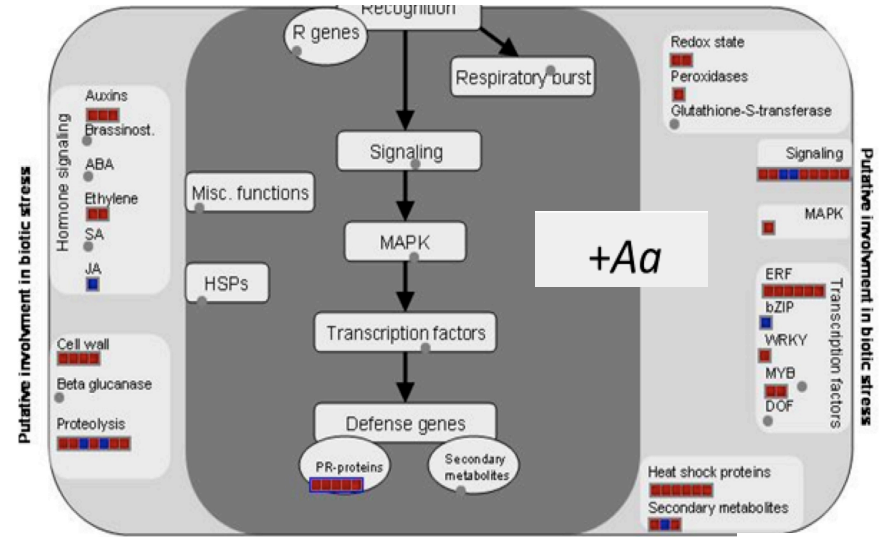


Jäschke et al. (2010) Plant Pathol

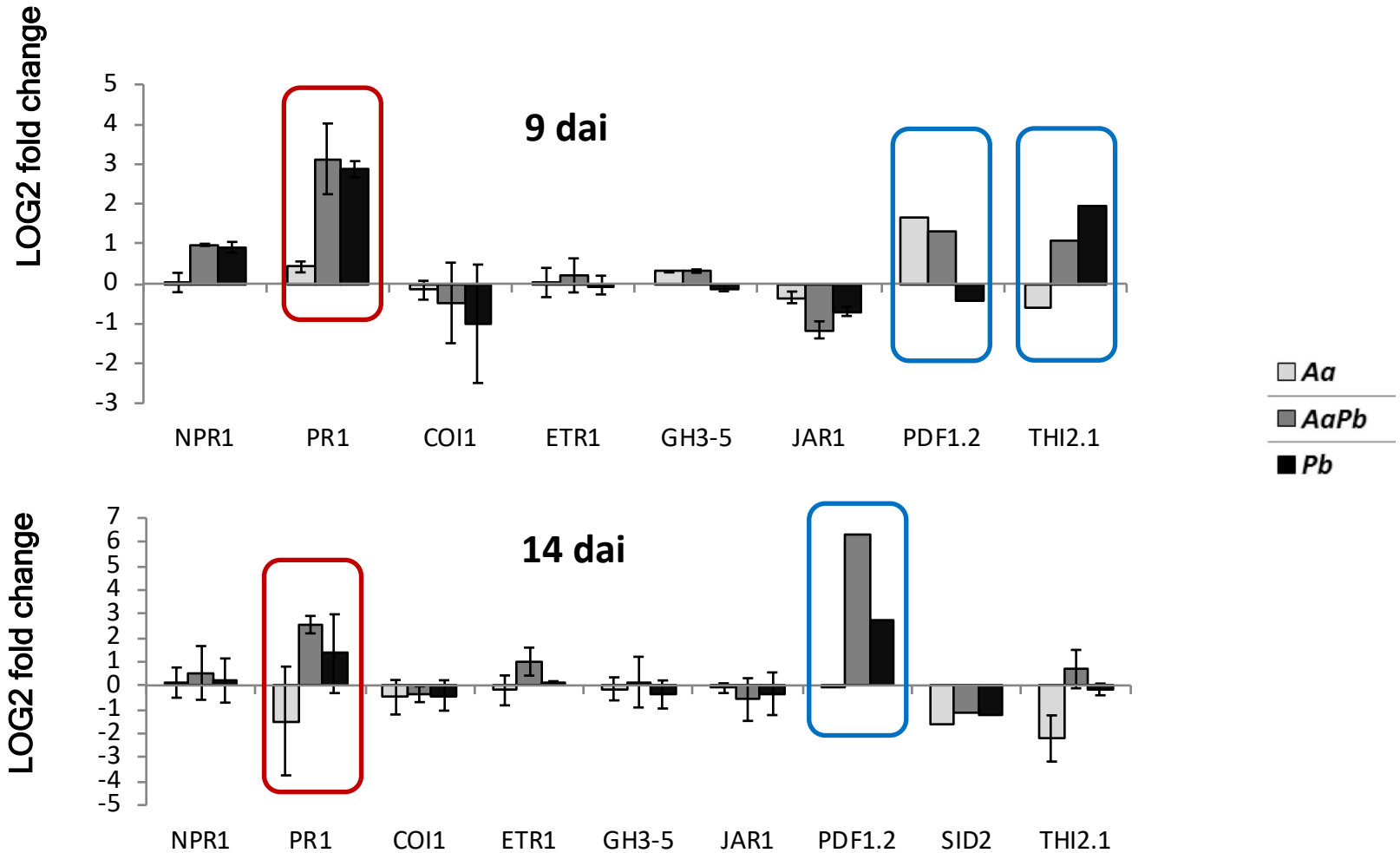


The live fungus is not necessary for inducing tolerance

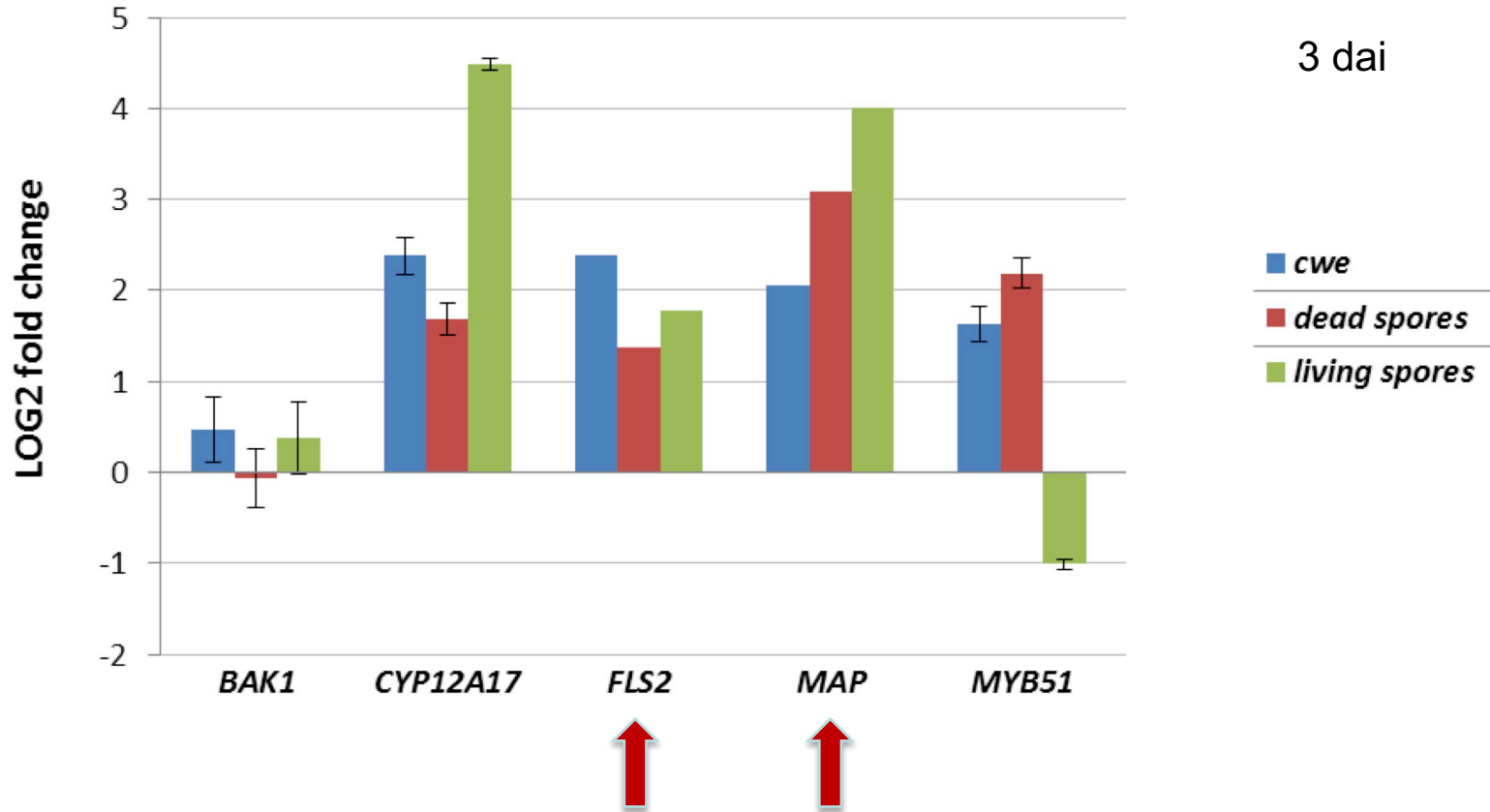
Microarray data indicate induction of plant defense genes in *Arabidopsis* by *Acremonium alternatum*



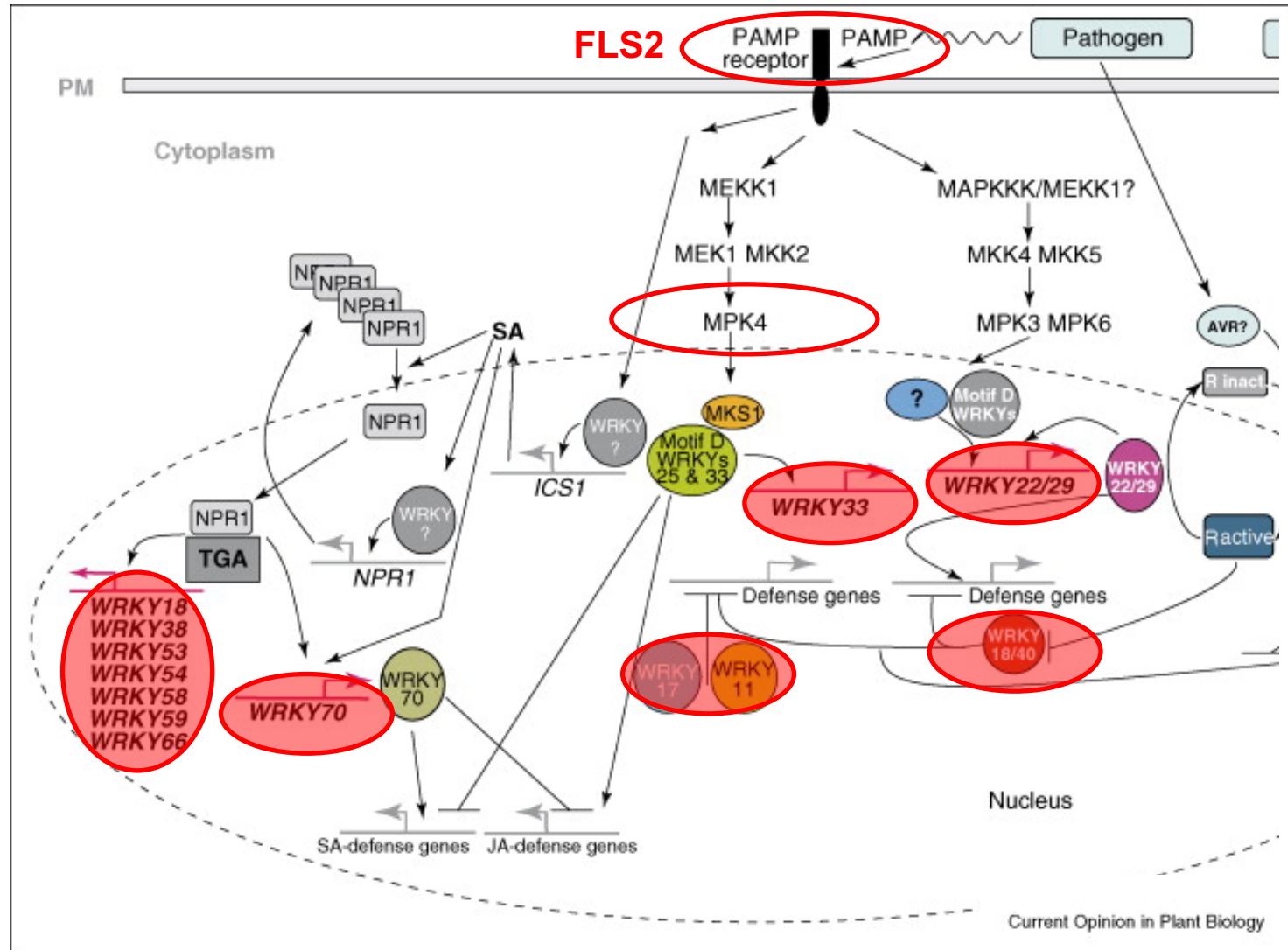
SA-dependent defense is upregulated during earlier infection events



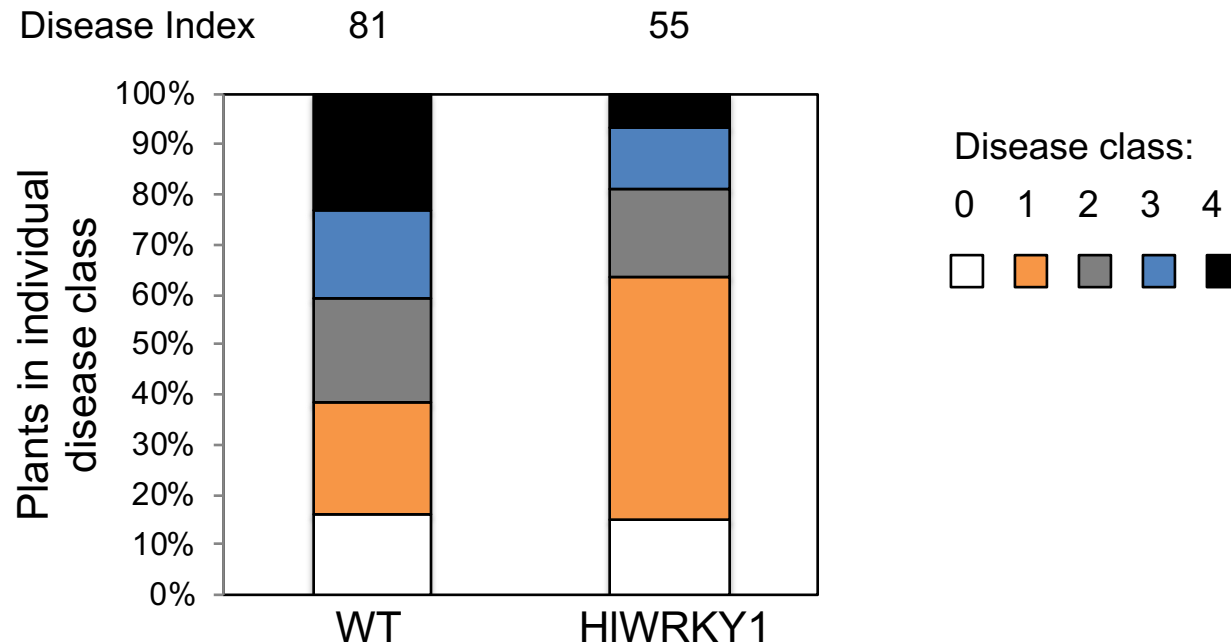
Cell wall extract and autoclaved spores induce early some “pathogen recognition” genes



Early signaling via PTI involves WRKY transcription factors

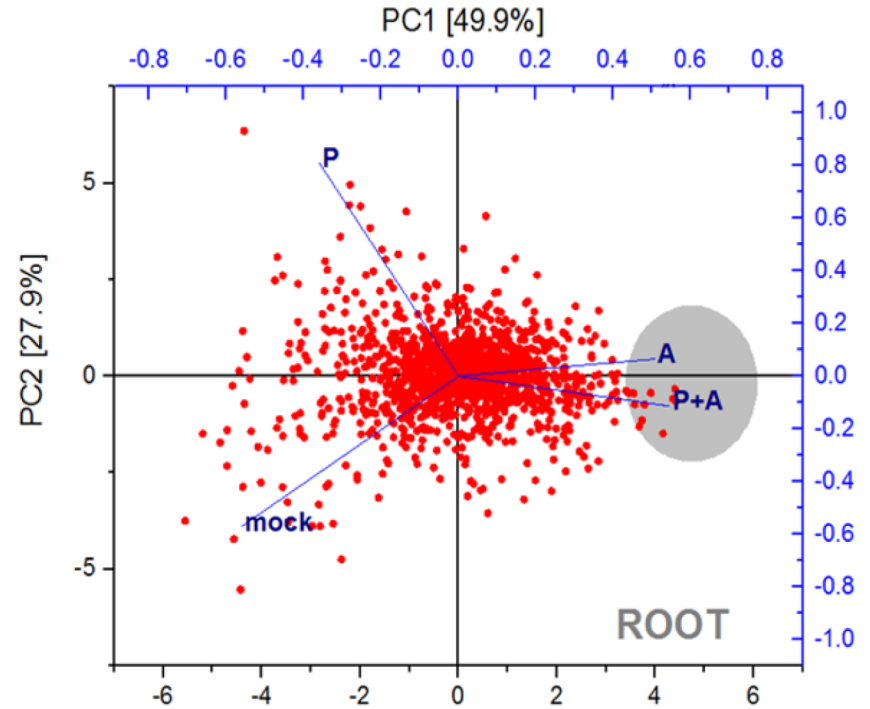
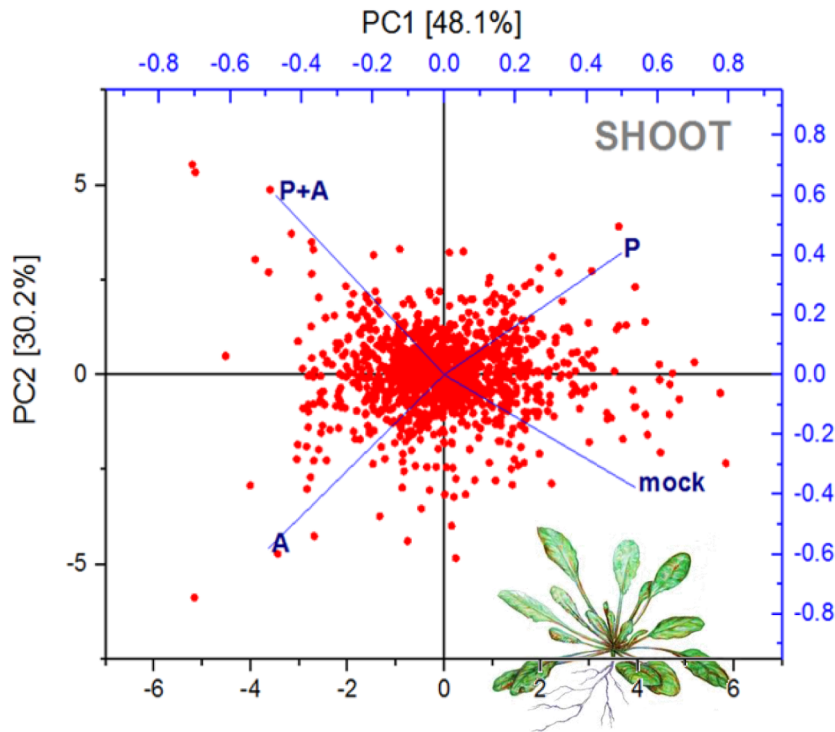


Overexpression of *WRKY1* from *Humulus lupulus* in *Arabidopsis* leads to clubroot symptom reduction

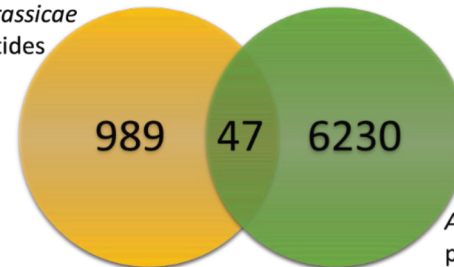


However, overexpression of *WRKY* genes from *Arabidopsis* gave only a moderate effect

In the proteome many host proteins are up-regulated in shoot and root



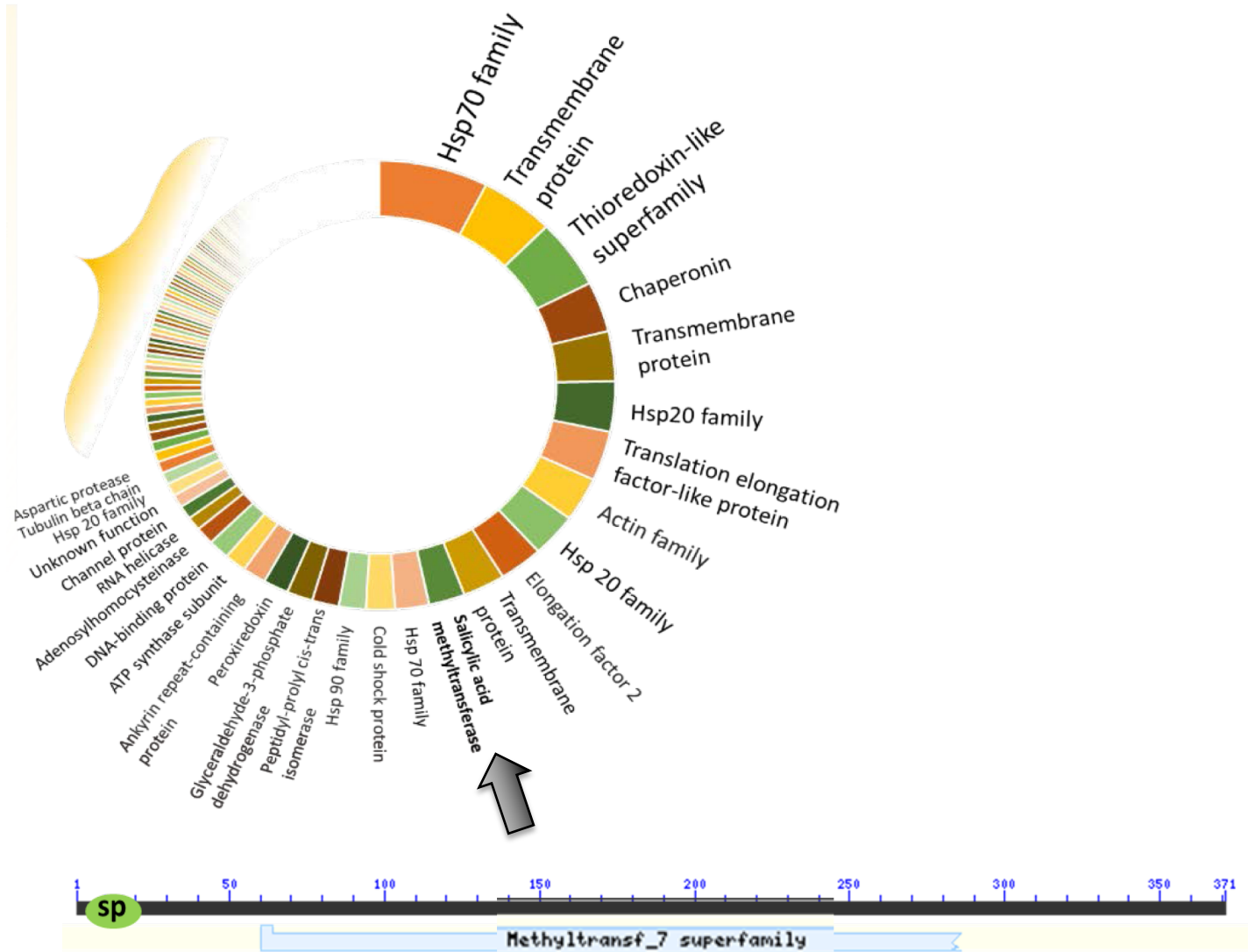
P. brassicae
peptides



A. thaliana
peptides

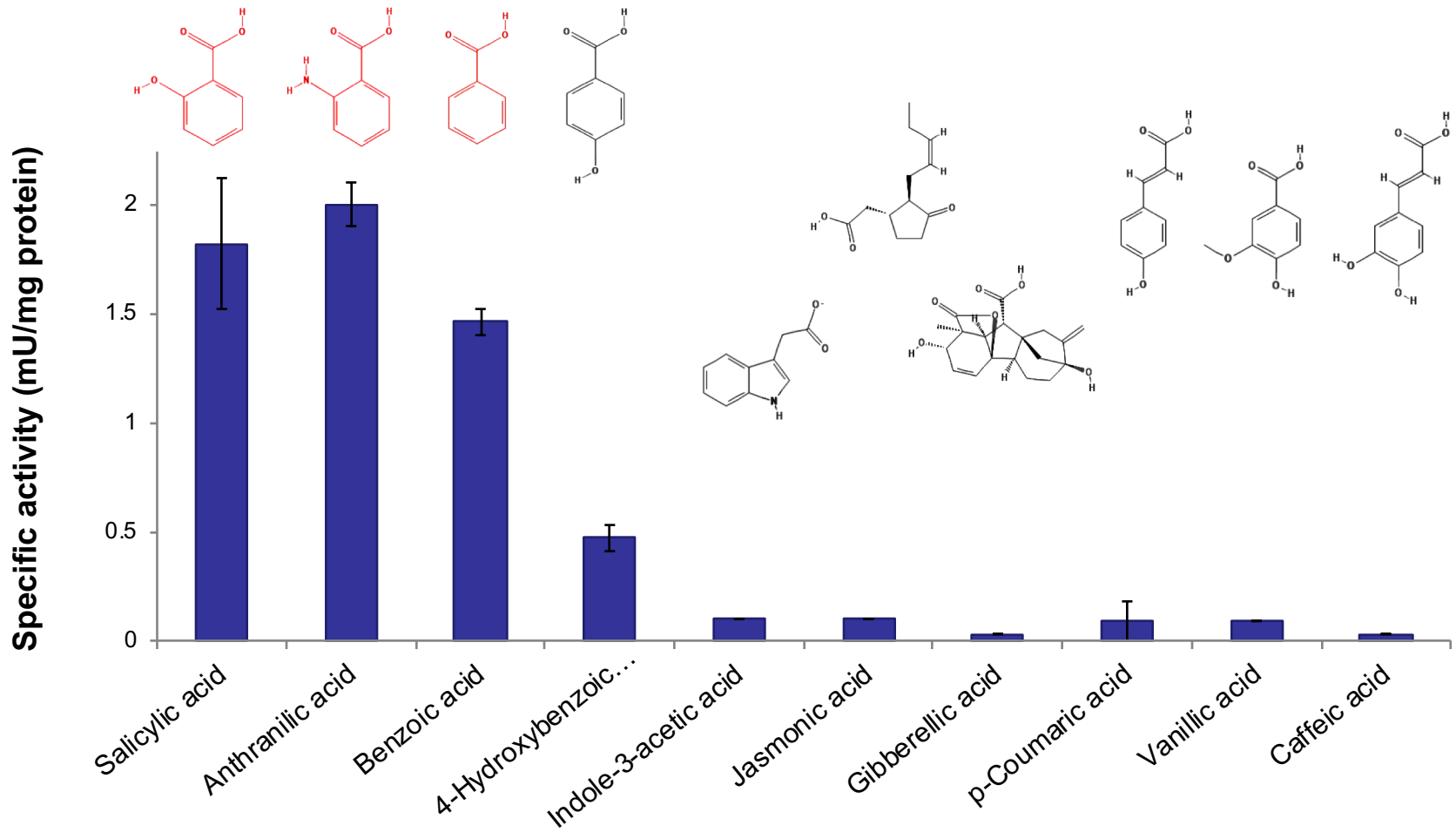
Annotation of the most abundant *P. brassicae* proteins based on their orthologs

Veronika Malych
Miroslav Berka



PbBSMT

PbBSMT can methylate salicylic acid, benzoic acid and anthranilic acid

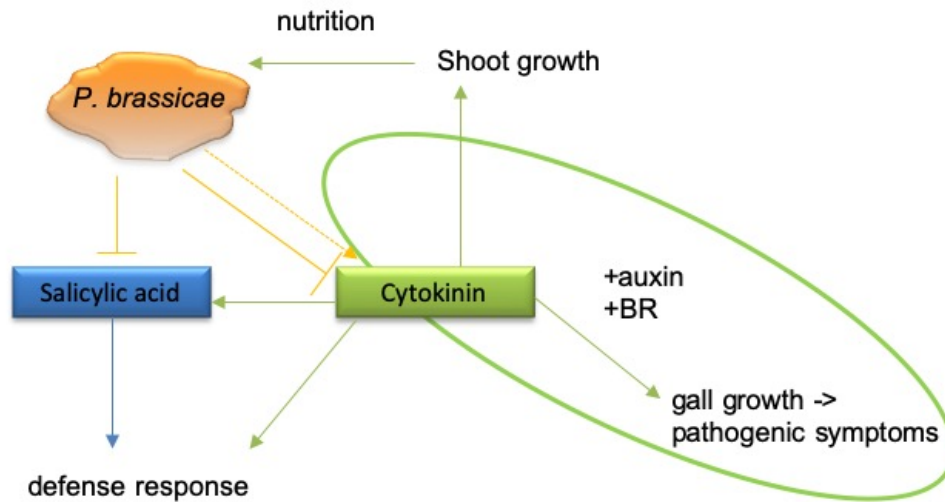


K_m value (μM) 2.5 80 100

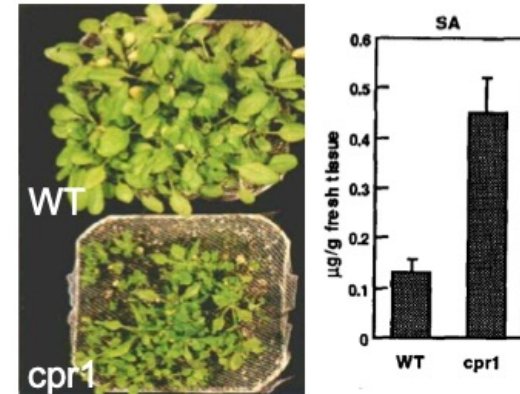


SA is most likely the natural substrate

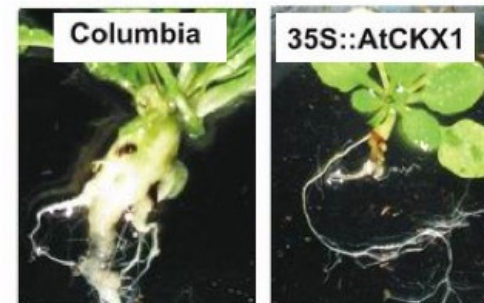
Salicylic acid – Cytokinin interactions at the crossroad of defense and growth



Cytokinins can act also as defense signals



High SA plants are dwarf
(Bowling et al. 1994 Plant Cell)



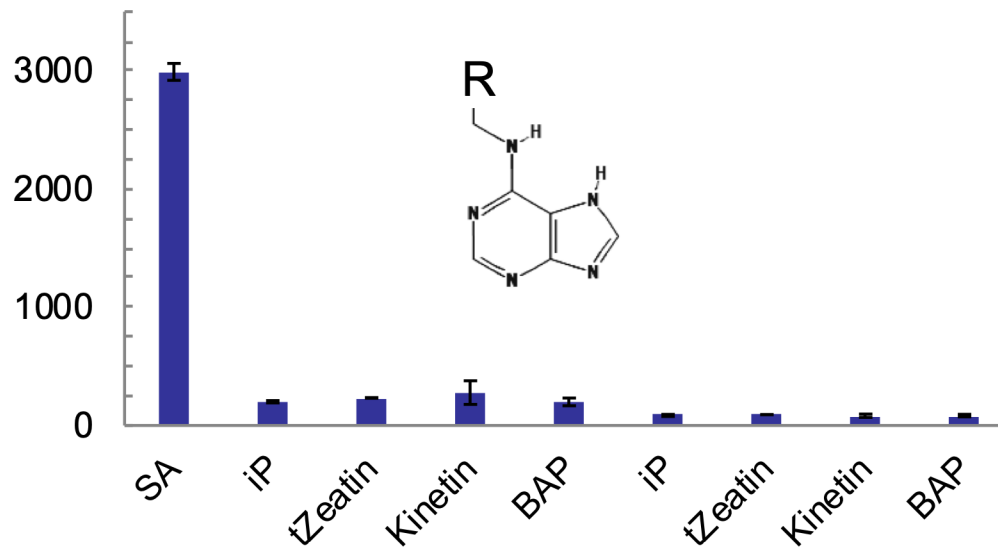
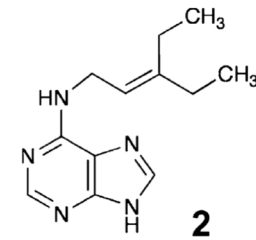
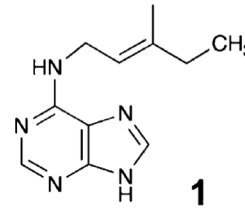
Low cytokinin levels reduce club size
(Siemens et al. 2006 MPMI)

PbBSMT cannot methylate cytokinins

Methylated Cytokinins from the Phytopathogen *Rhodococcus fascians* Mimic Plant Hormone Activity^{1[OPEN]}

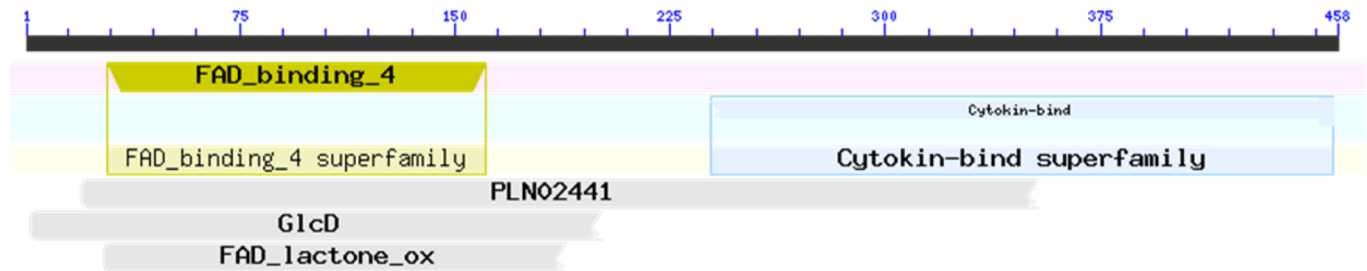
Venkatesan Radhika², Nanae Ueda, Yuuri Tsuboi, Mikiko Kojima, Jun Kikuchi, Takuji Kudo, and Hitoshi Sakakibara*

Plant Physiol. Vol. 169, 2015

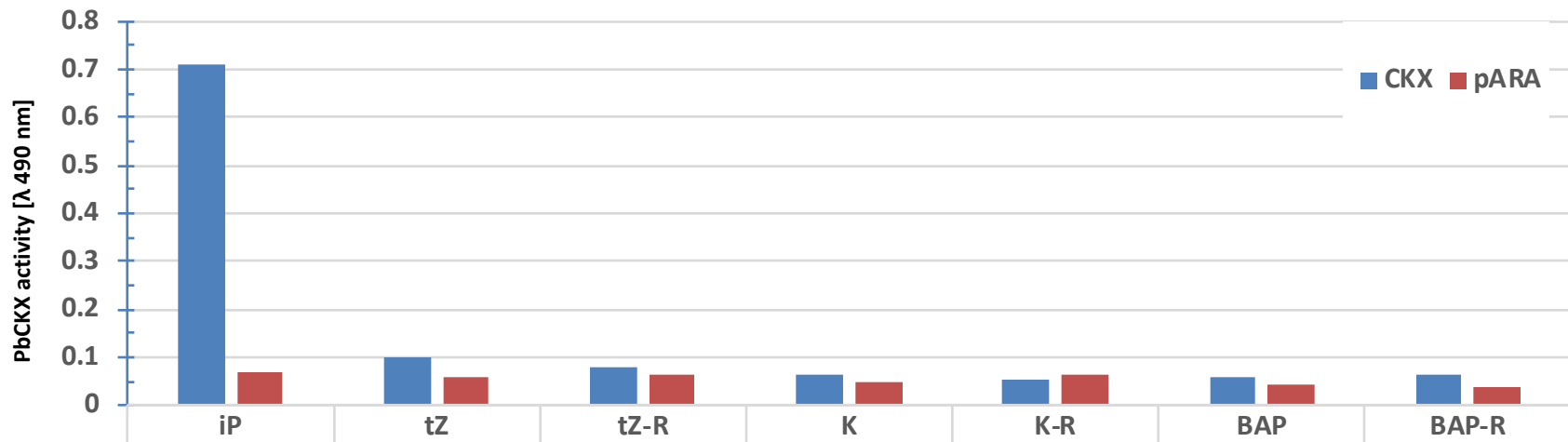
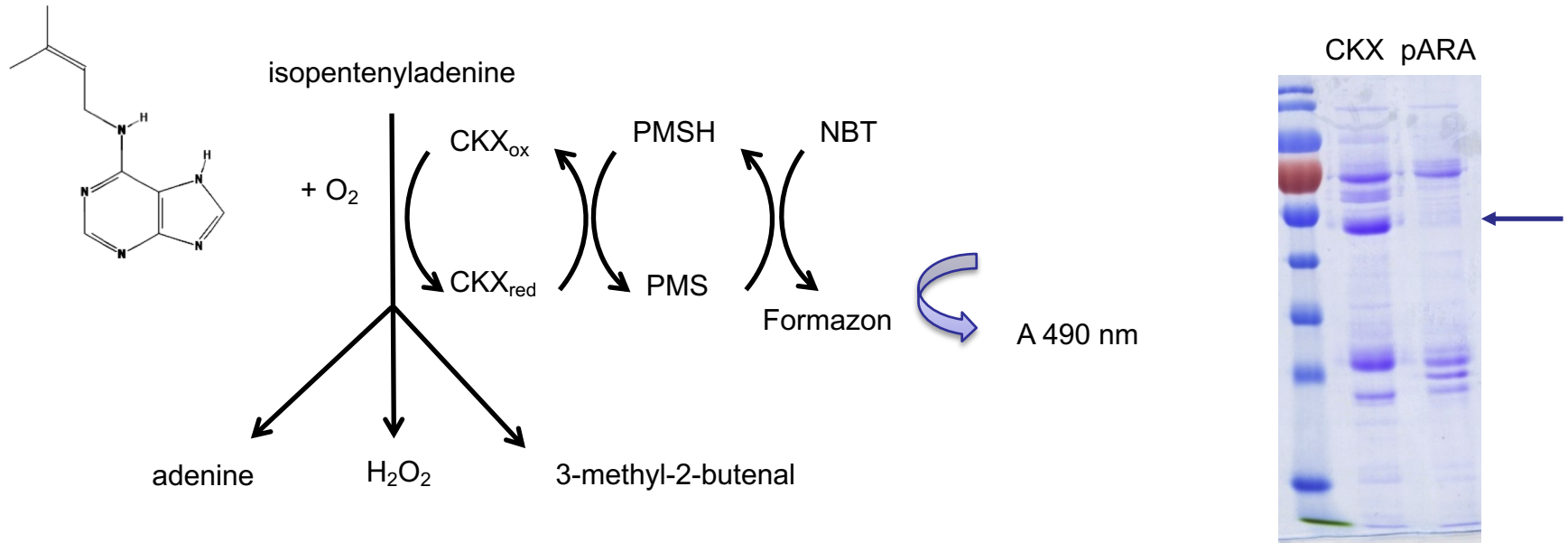


The genome sequence of the clubroot pathogen revealed candidate genes encoding enzymes for cytokinin metabolism

PbCKX



The PbCKX protein can degrade isopentenyladenine, but not other cytokinins *in vitro*

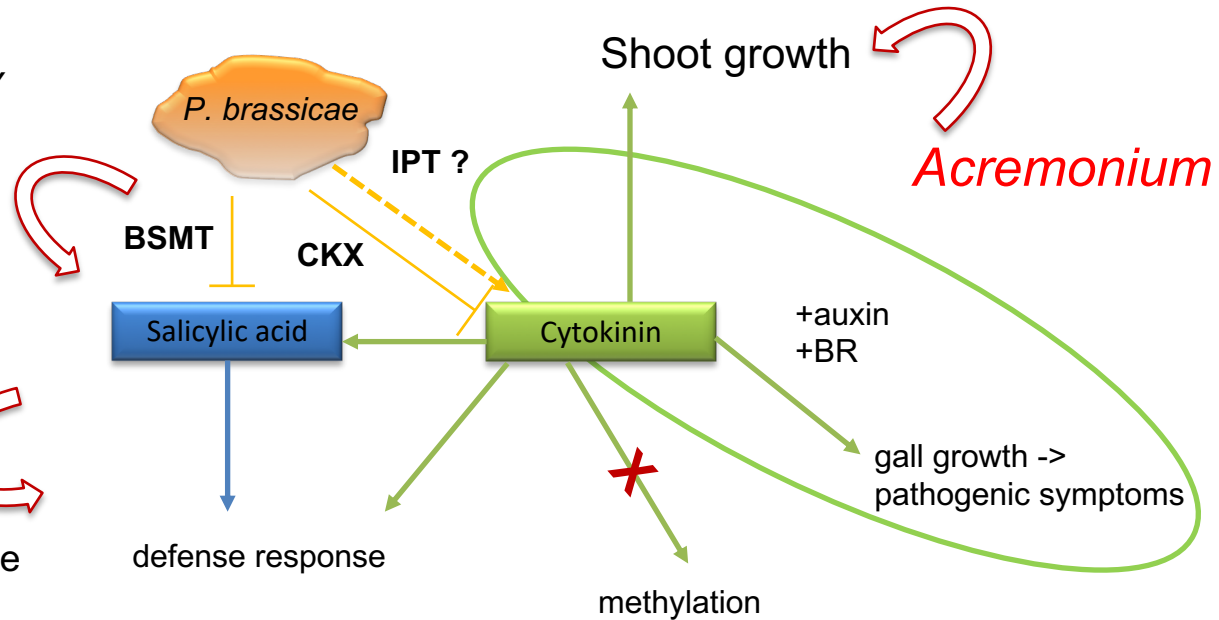


Defense induction is possible

Circumvent by high expression of WRKY transcription factors

Acremonium

Priming SA-dependent defense



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the group - especially:
Susann Auer
Diana Seidler

and all former members who contributed

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