Ethylene induced macromolecule catabolism – the switch required for bud meristem growth resumption?

The Bud Dormancy team

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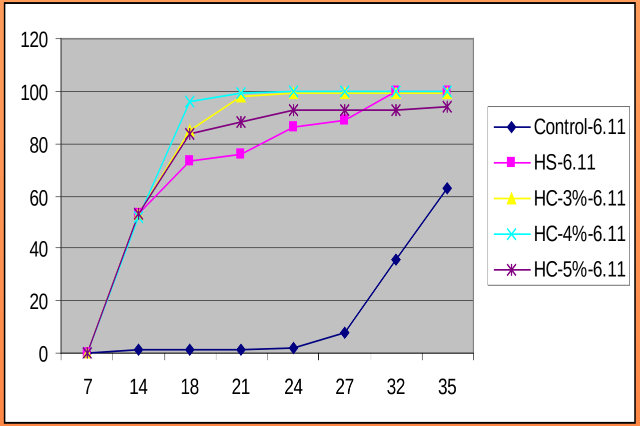
Chemical and physical stress agents induce bud dormancy release

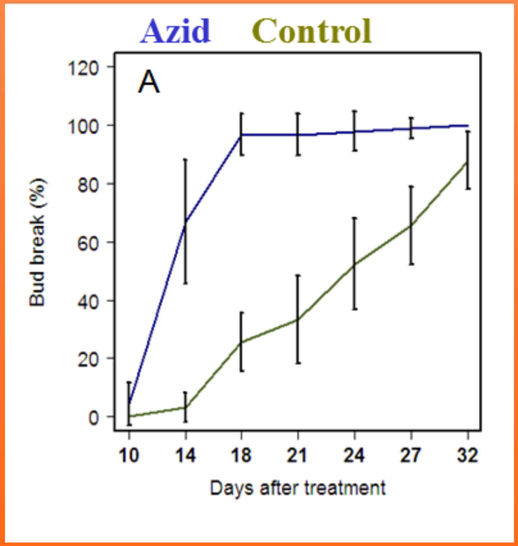
hydrogen cyanamide (HC) and Heat Shock (HS)

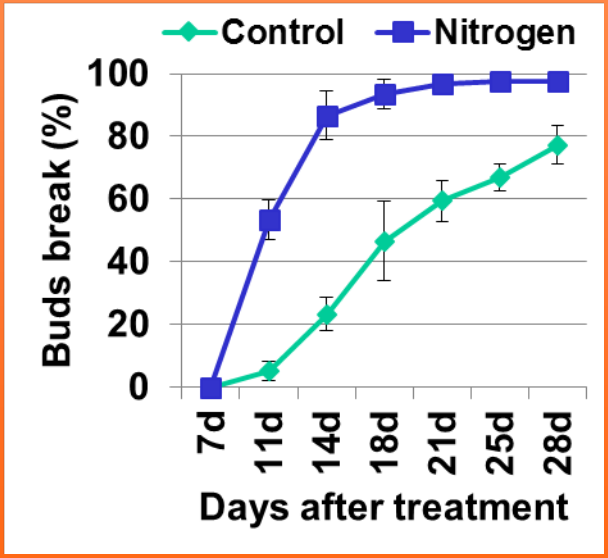


Stress-related signals may have central role in the execution of the dormancy release cascade

We may identify core functions by comparative analysis of responses to such stimuli

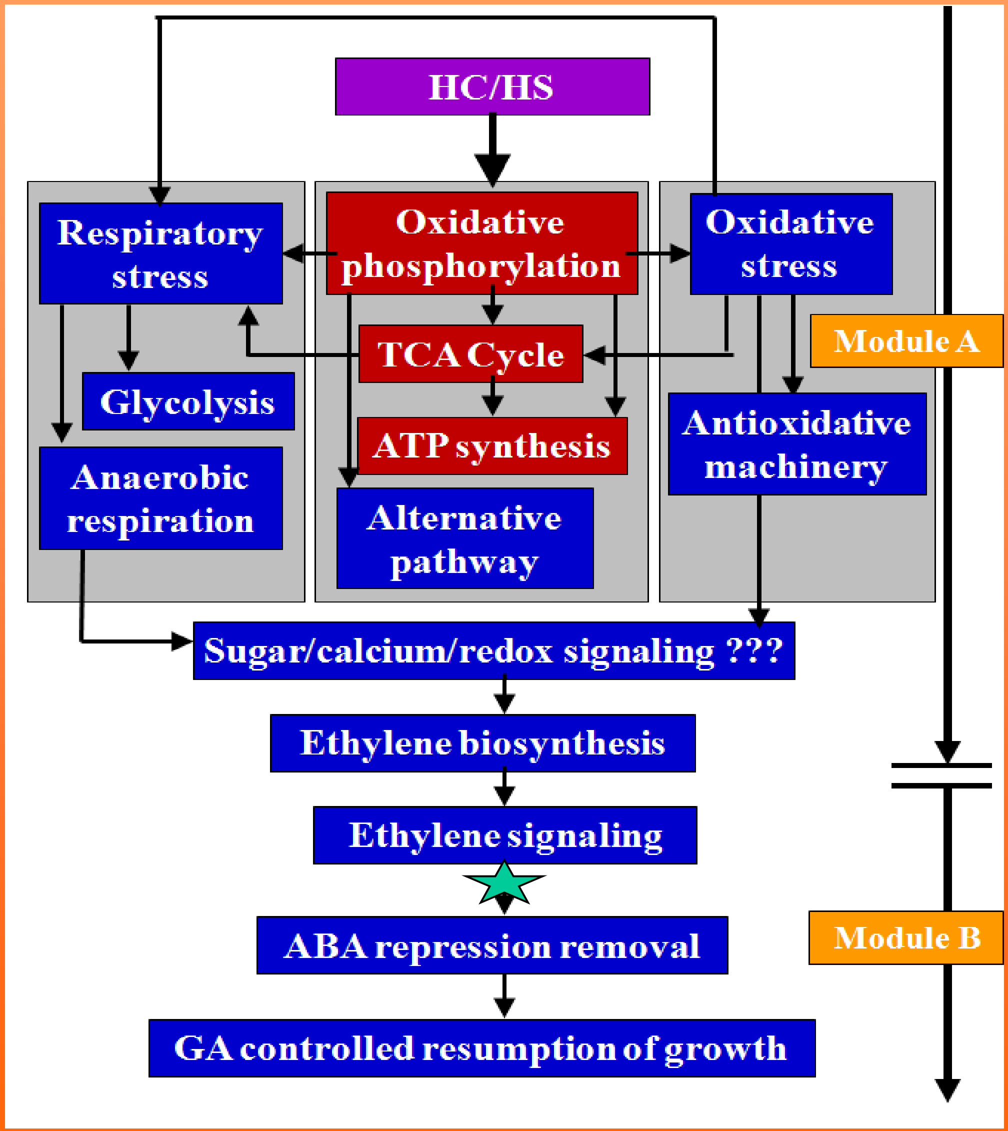
Azid (AZ)



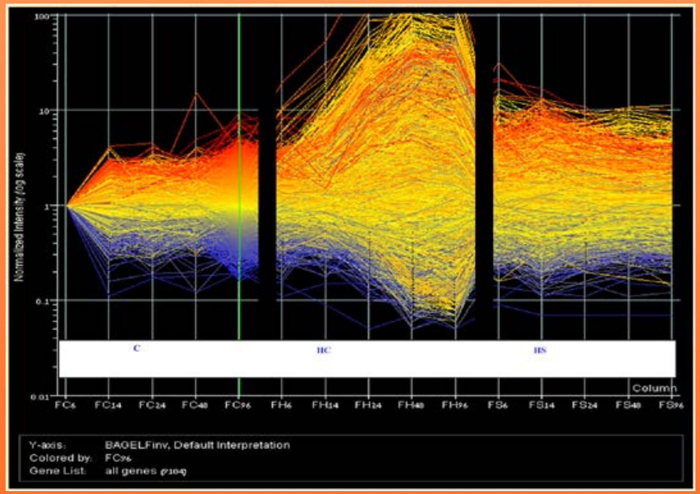


Hypoxia

Our initial model for the molecular cascade that activate dormancy release (based on years of comparative analyses of response to dormancy release stimuli…)

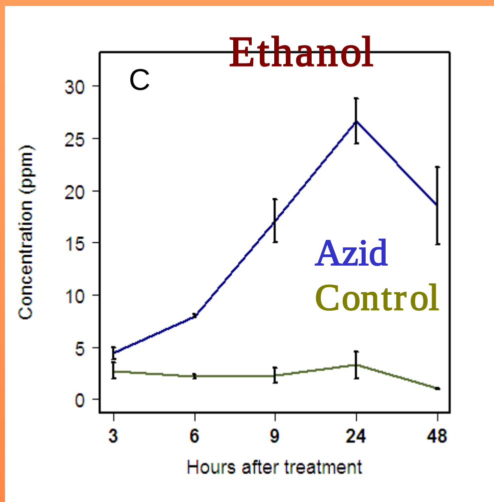


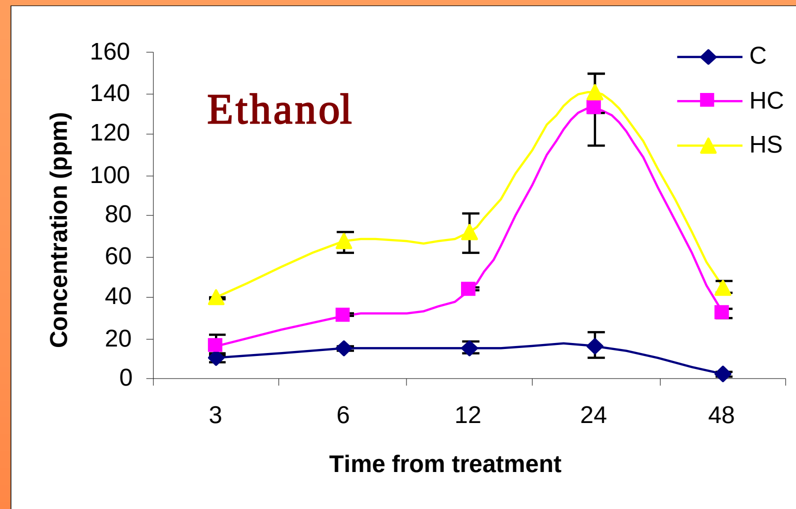
Here we bring on the tip of the fork support for the model and suggest that Ethylene induced catabolism may be a central switch of dormancy release



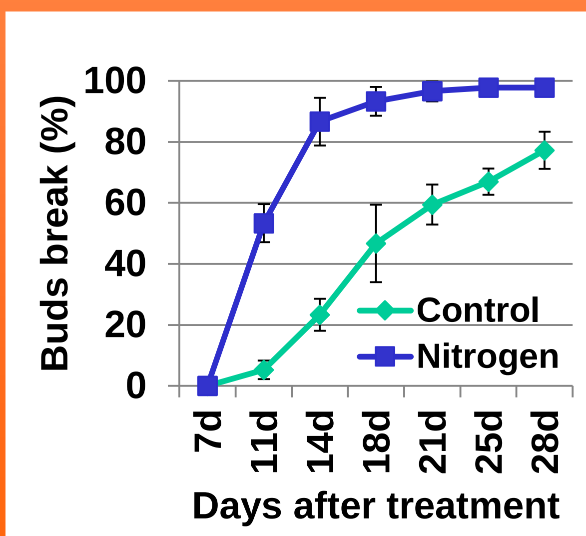
Pang et al., 2007, JExBot
Halali et al., 2008, Planta
Ophir et al.,2009, PMB

Azid, HC and HS temporarily induce anaerobic respiration, to face energy shortage caused by impaired aerobic respiration

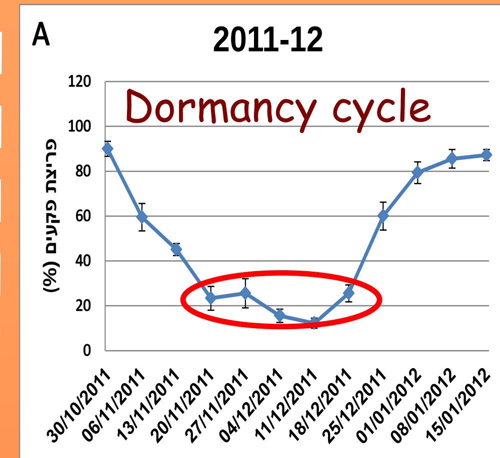


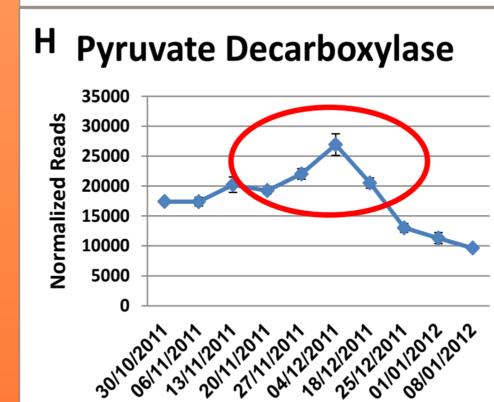


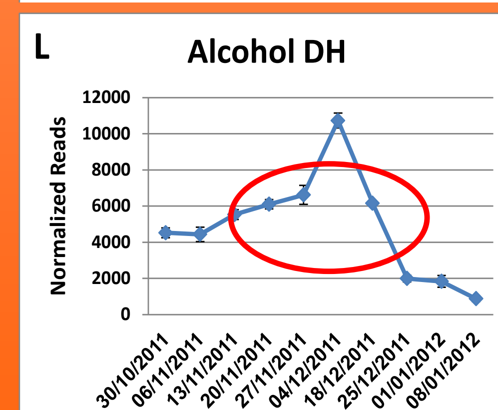
Anaerobiosis induce bud dormancy release



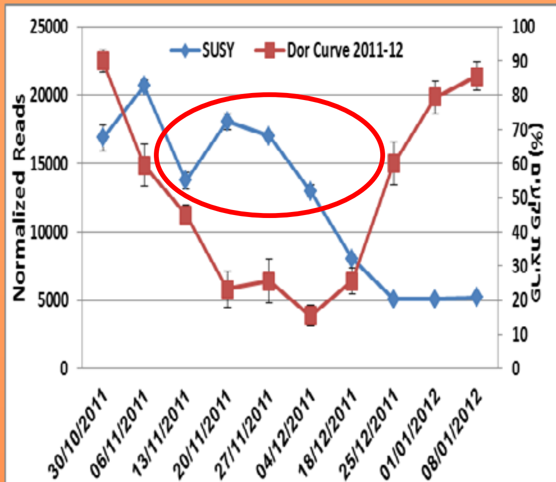
Temporary induction of fermentation also occure under vineyard conditions during deep dormancy, indicative of an energy crisis.

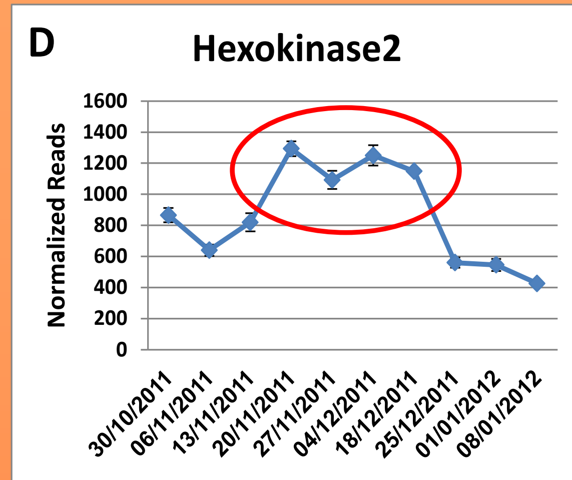


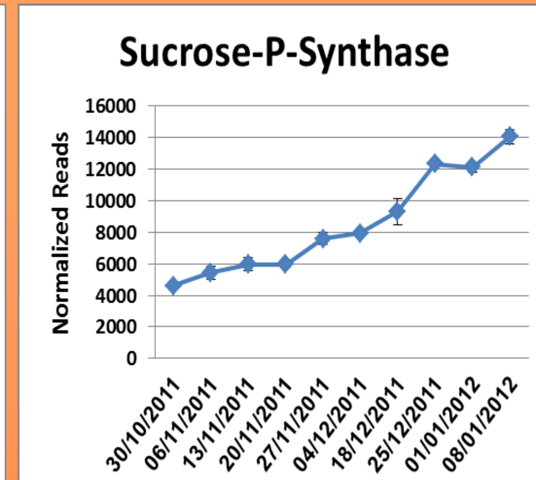




Ophir et al.,2009, PMB
Or, unpublished



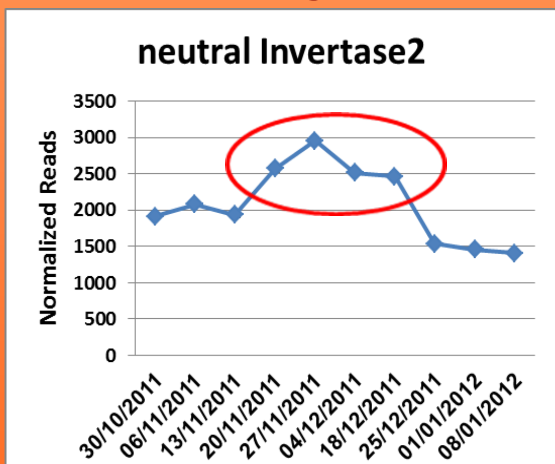


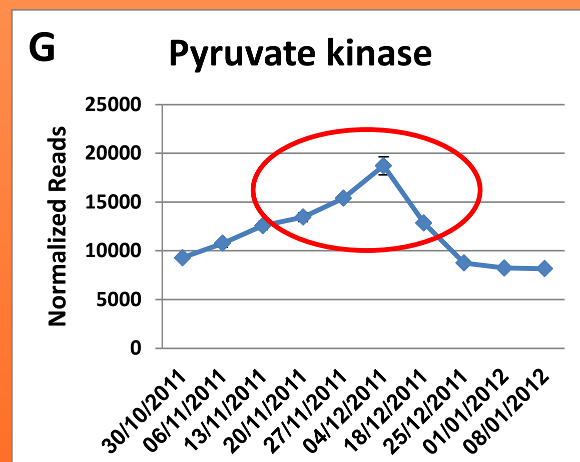


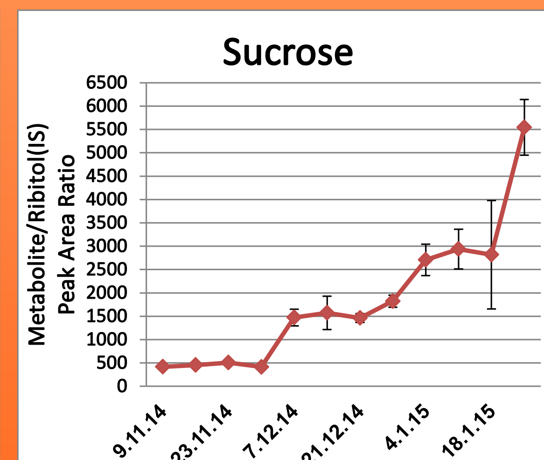
Sucrose Degradation

Glycolysis

Sucrose synthesis



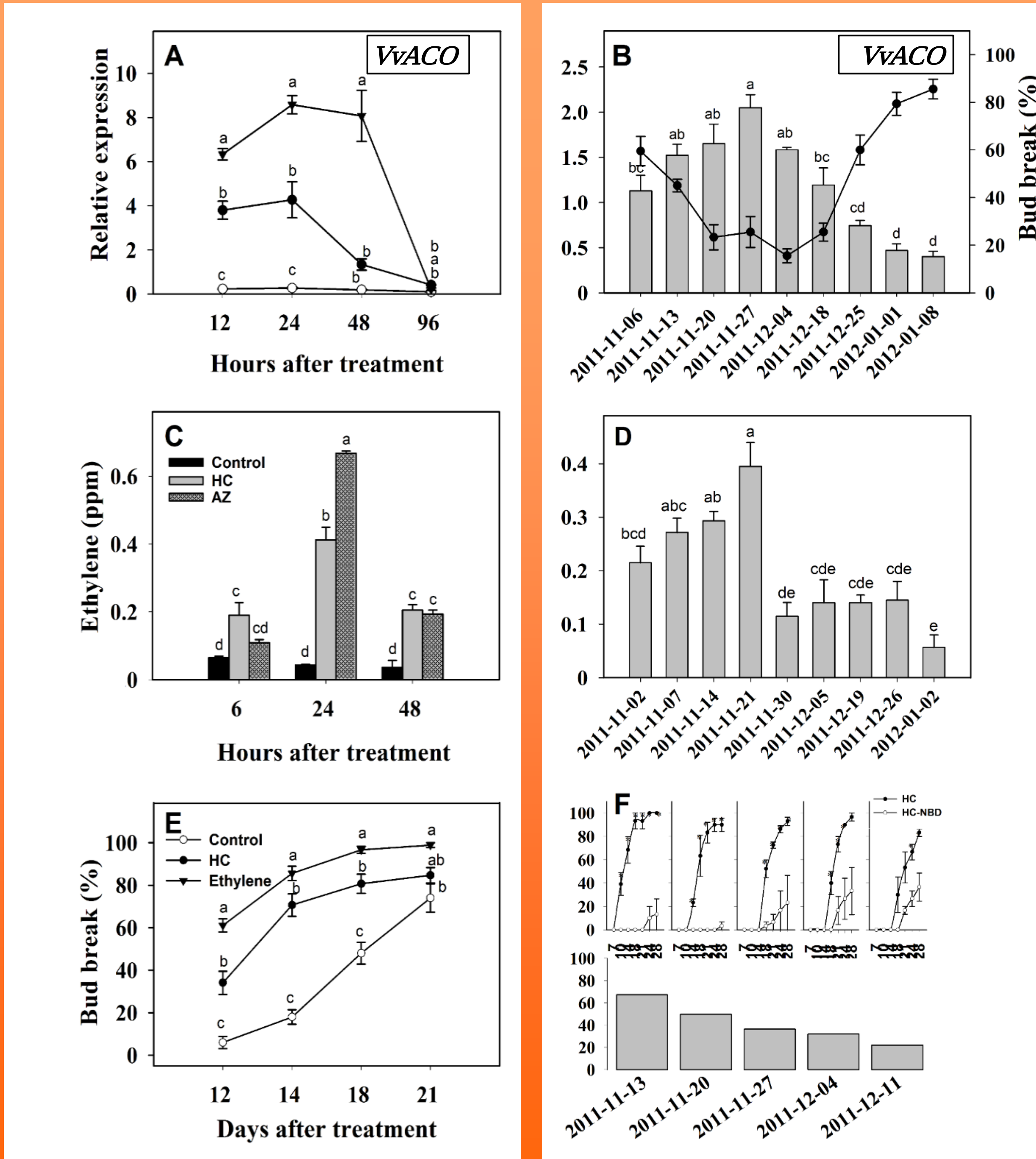




- Sucrose degradation is activated during deep dormancy
- It is probably induced in response to enhanced Glycolysis needed to supply pyruvate for anaerobic respiration
- Sucrose degradation decrease during dormancy release in parallel with increased sucrose synthesis capacity and sucrose level
- Similar regulation appears in response to HC and additional stimuli (not shown)

Ethylene biosynthesis

- HC and AZ upregulate Ethylene synthesis by temporary induction of ethylene synthesis genes (ACS, ACO)
- Ethylene induce dormancy release
- Temporary increase in ethylene biosynthesis capacity is also regulated at the transcription level during the natural dormancy cycle
- Inhibition of ethylene signaling inhibit bud break and the effect is timing dependent



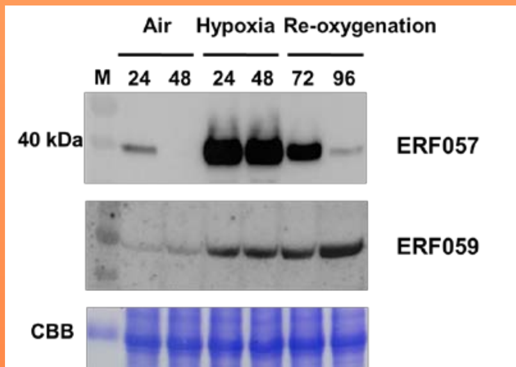
Shi et al, 2018, submitted

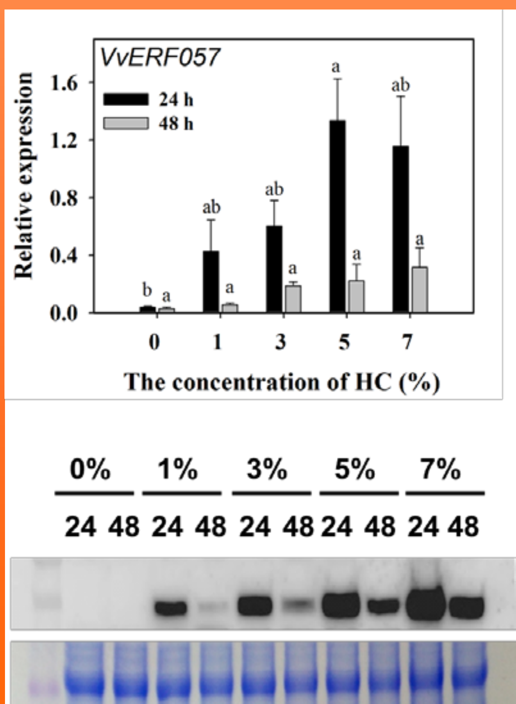
Ethylene signaling

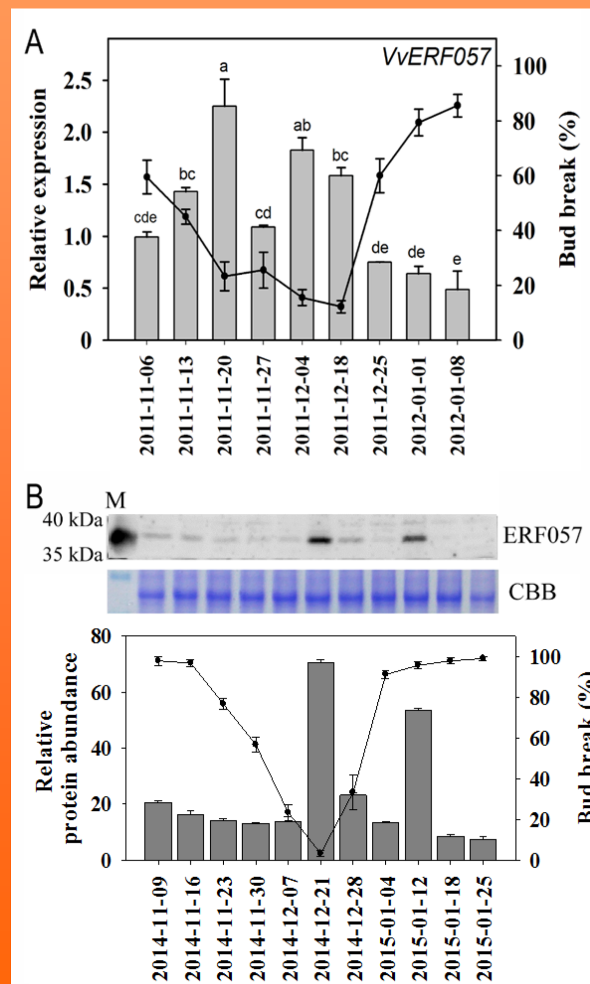
We formerly identified ERF genes, which are known sensors of energy crisis and activate hypoxic response

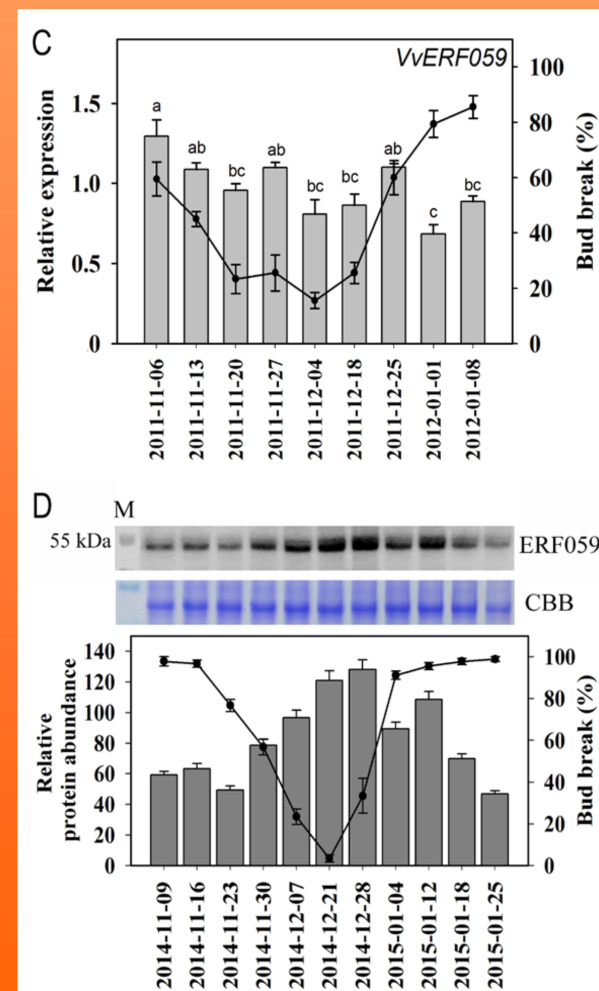
- As expected, they accumulates in response to hypoxia
- Less expected, they directly respond to HC induced signal
- They are positively regulated during deep dormancy in transcript or protein level

Ophir et al.,2009, PMB
Shi et al, in preparation

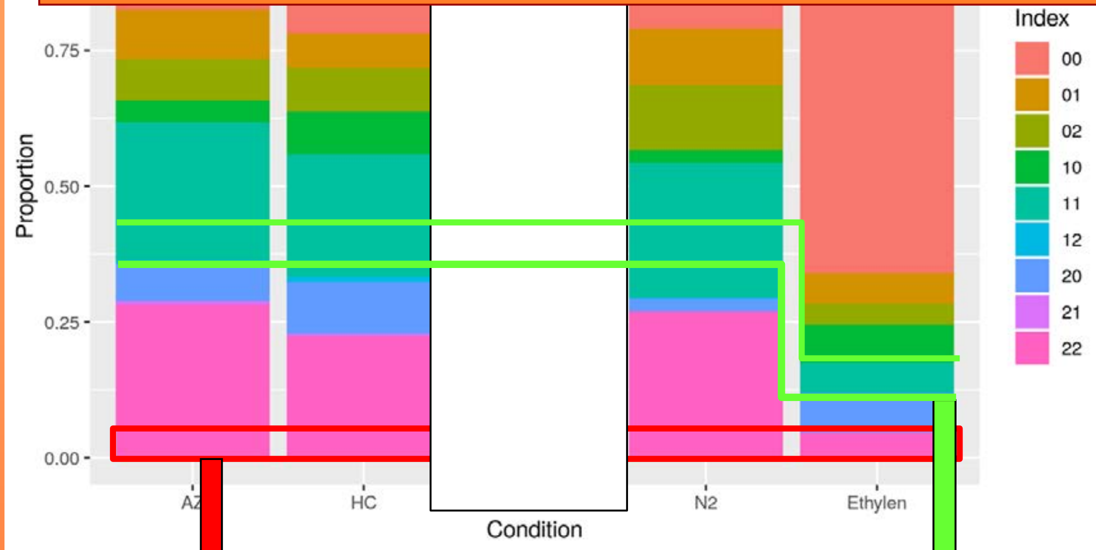


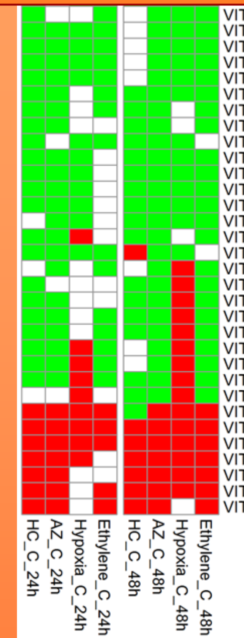


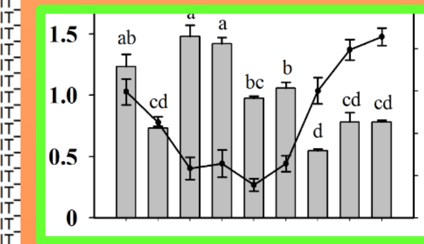


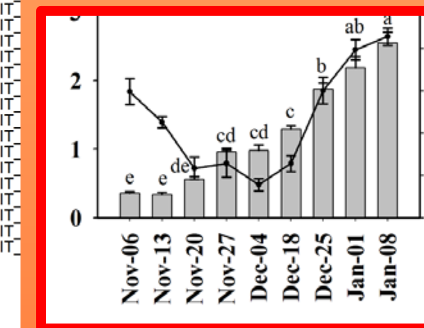


We identified all the ERFs, as well as other genes that are regulated by HC, Azid, hypoxia AND ethylene….assuming that they are primary regulators of the cascade

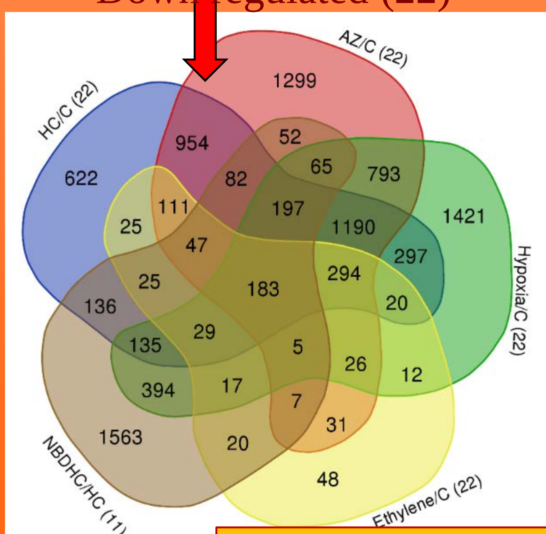




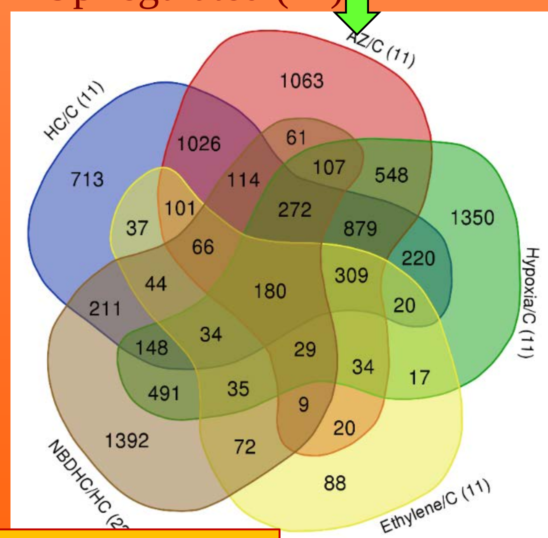


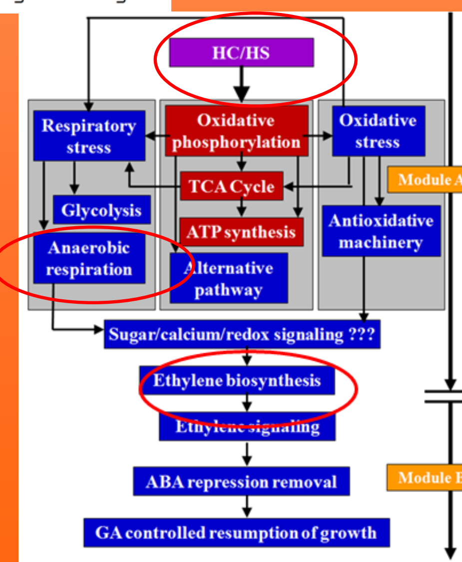


Down regulated (22)



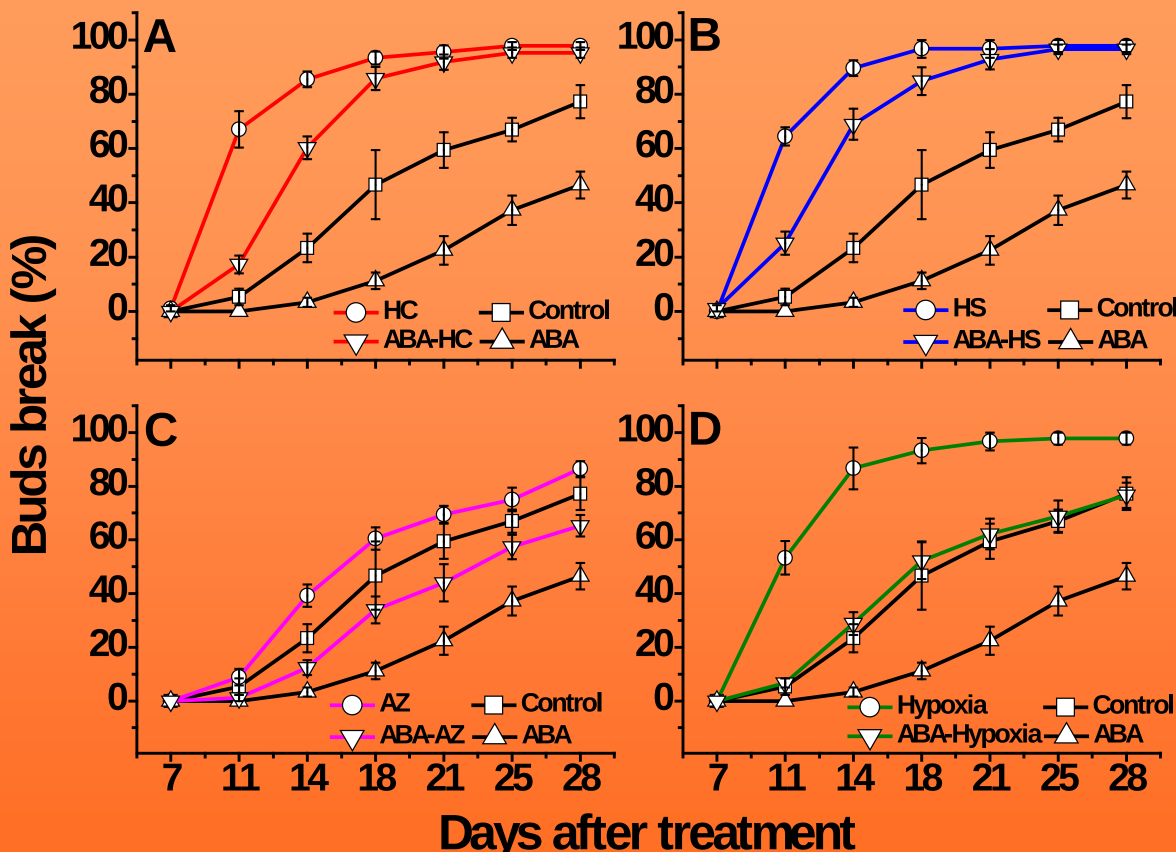
Up regulated (11)

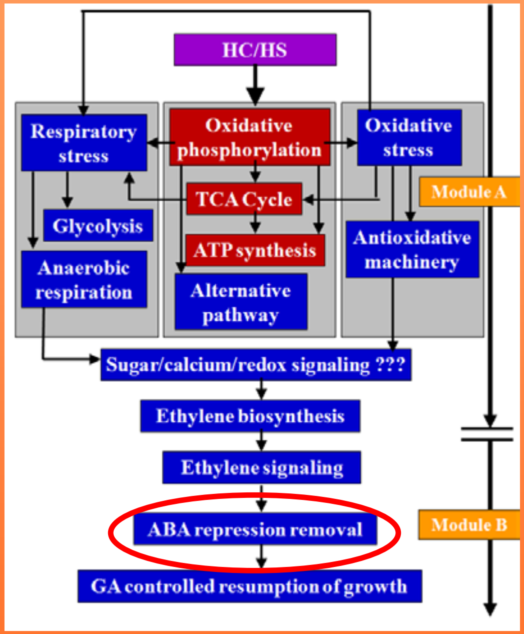




RNAseq of AZ, HC, Ethylene, hypoxia and NBDHC treated buds

ABA delay bud break and reduce the enhancing effect of HC, HS, Azid and hypoxia on dormancy release.

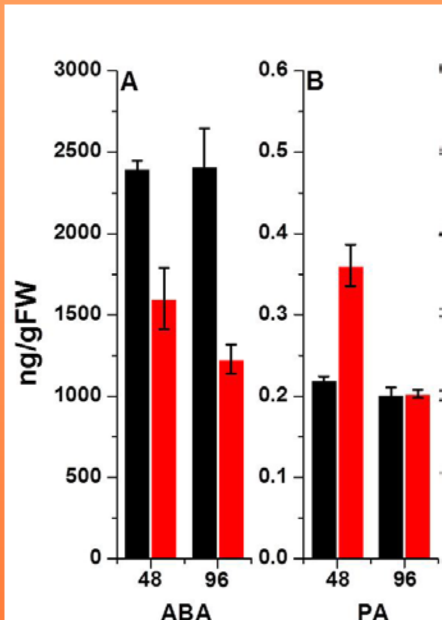


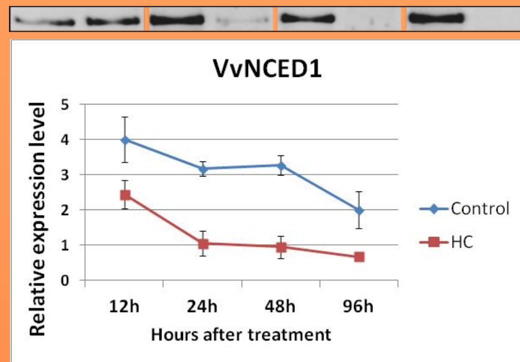


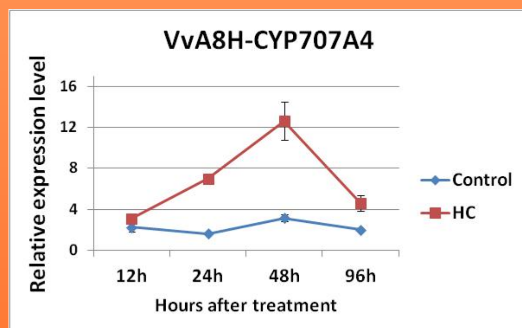
Zheng et al., 2015, JExBot

Recovery from the inhibition was demonstrated in the combined ABA-HC treatment whereas no recovery was evident in the ABA-treated, compared to the control.

HC lead to reduction of ABA levels and increase of level of ABA degradation products in the buds

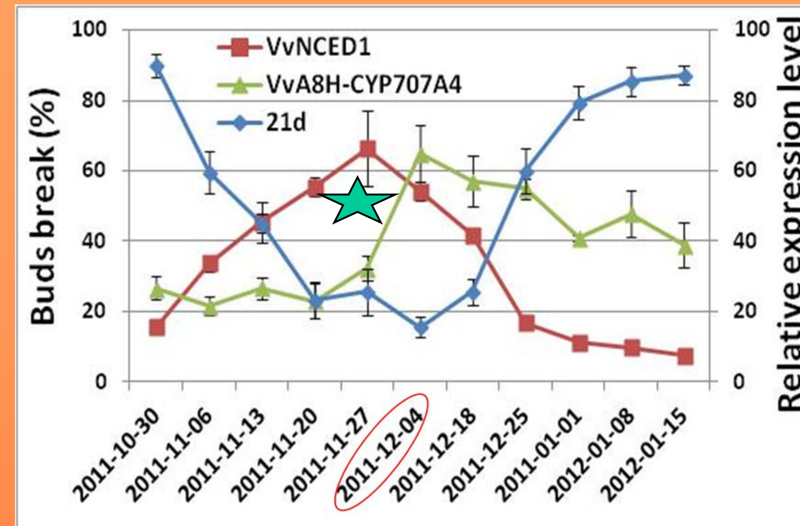


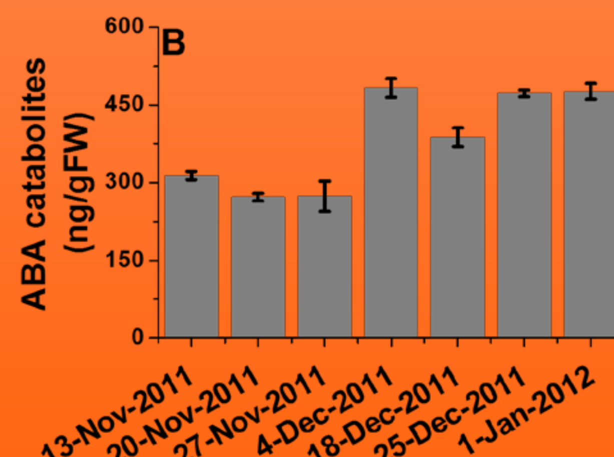




Down-regulation of VvNCED1 and up-regulation of VvA8H-CYP707A4 levels by HC may be responsible together for decreased ABA level and increased ABA catabolites level in response to HC.

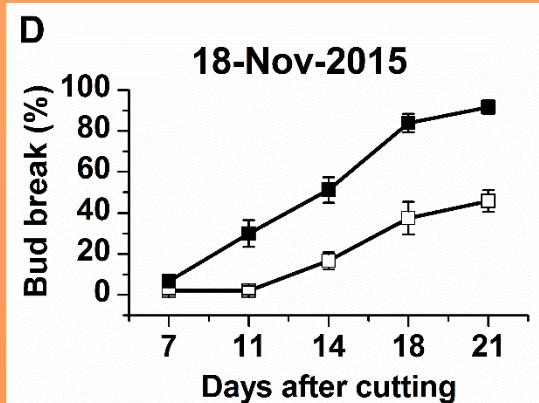
Natural dormancy cycle

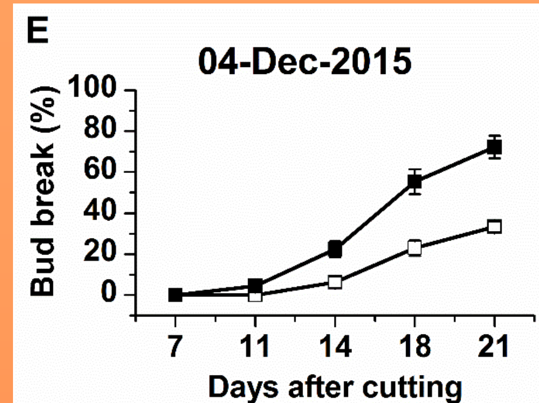


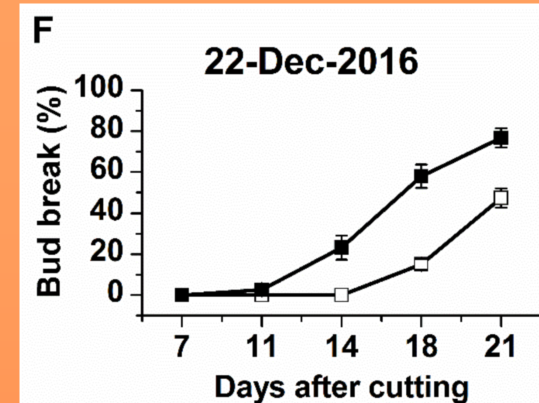


Zheng et al., 2015, JExBot
Zheng et al., 2018, PCE

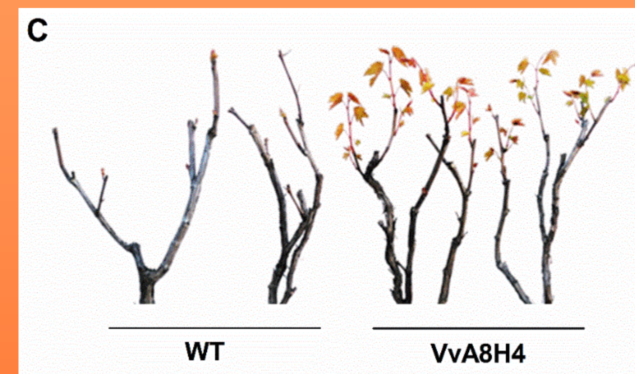
cuttings test



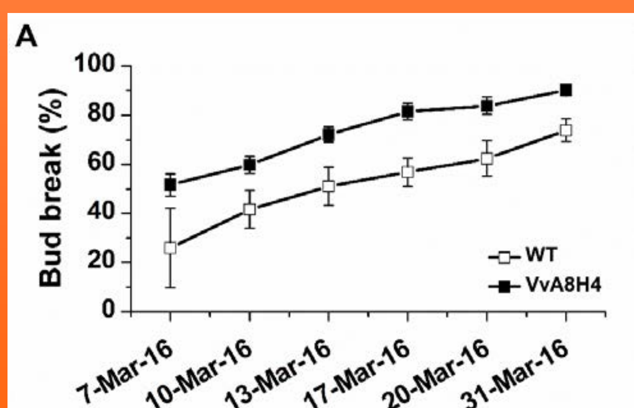


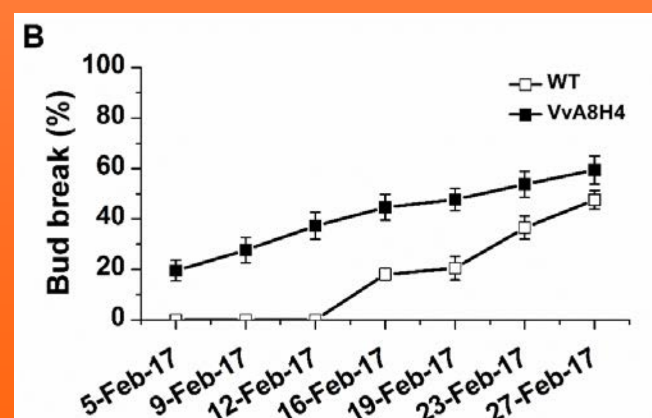


The OE VvA8H-CYP707A4 grapevine lines presented significantly improved rate and level of dormancy release

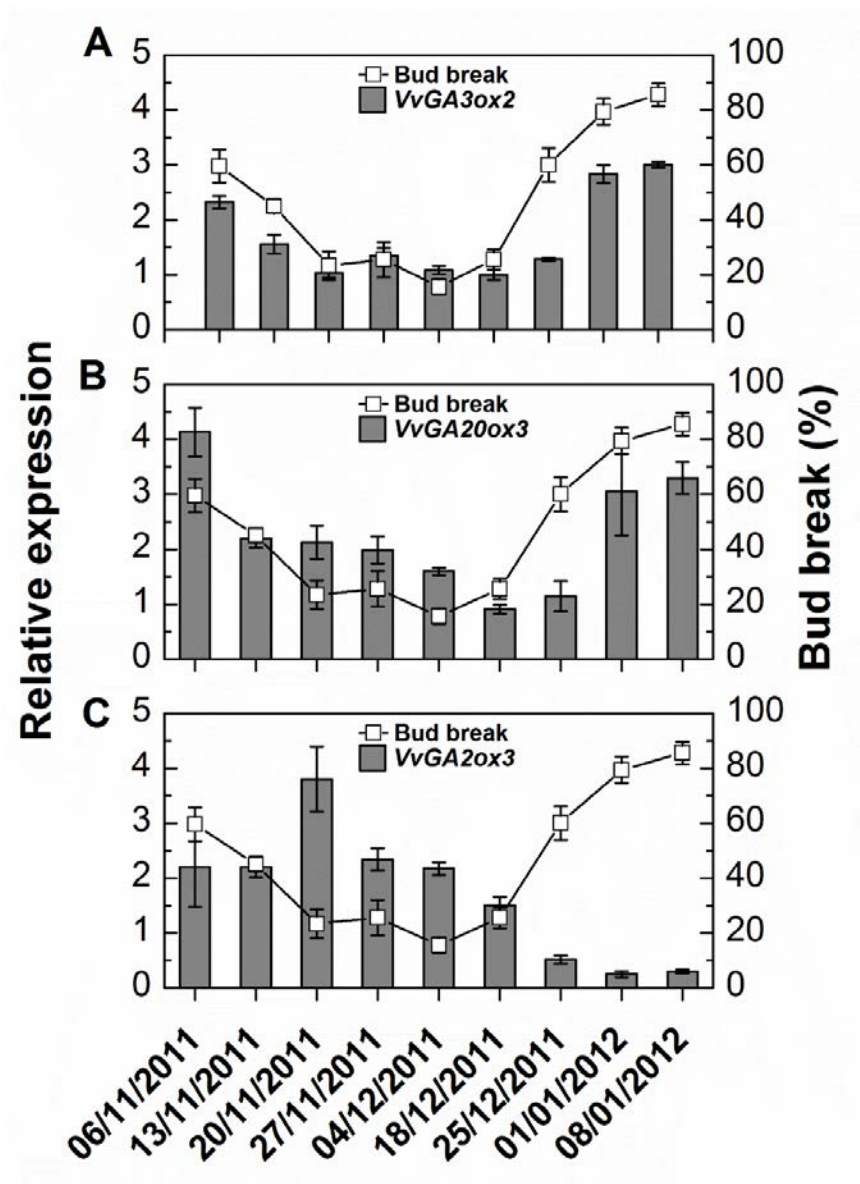


All vine test





Zheng et al., 2018, PCE

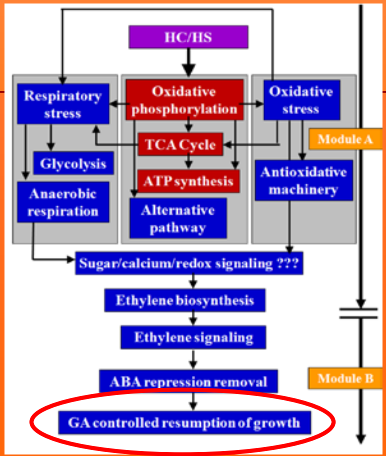


Profiling the expression of GA metabolism throughout the natural dormancy cycle suggests during endodormancy release:

- levels of active GA biosynthetic enzymes increased
- levels of active GA degradation enzyme decreased

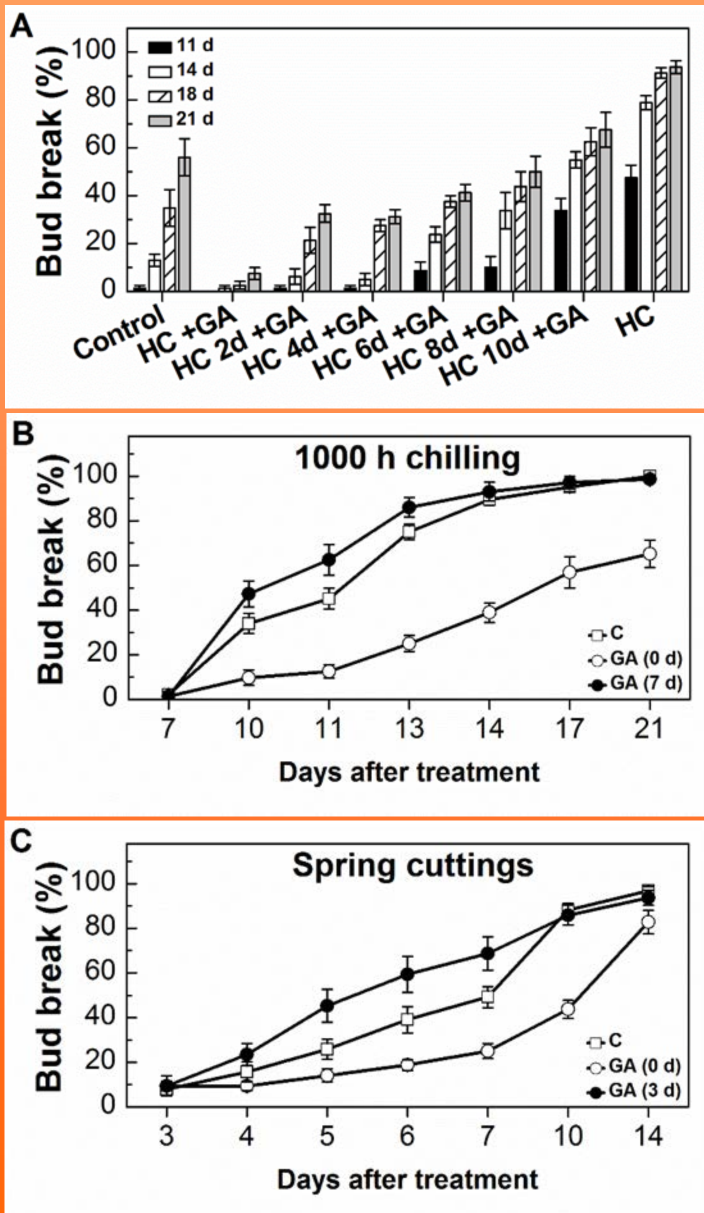
These results are in agreement with the initial model

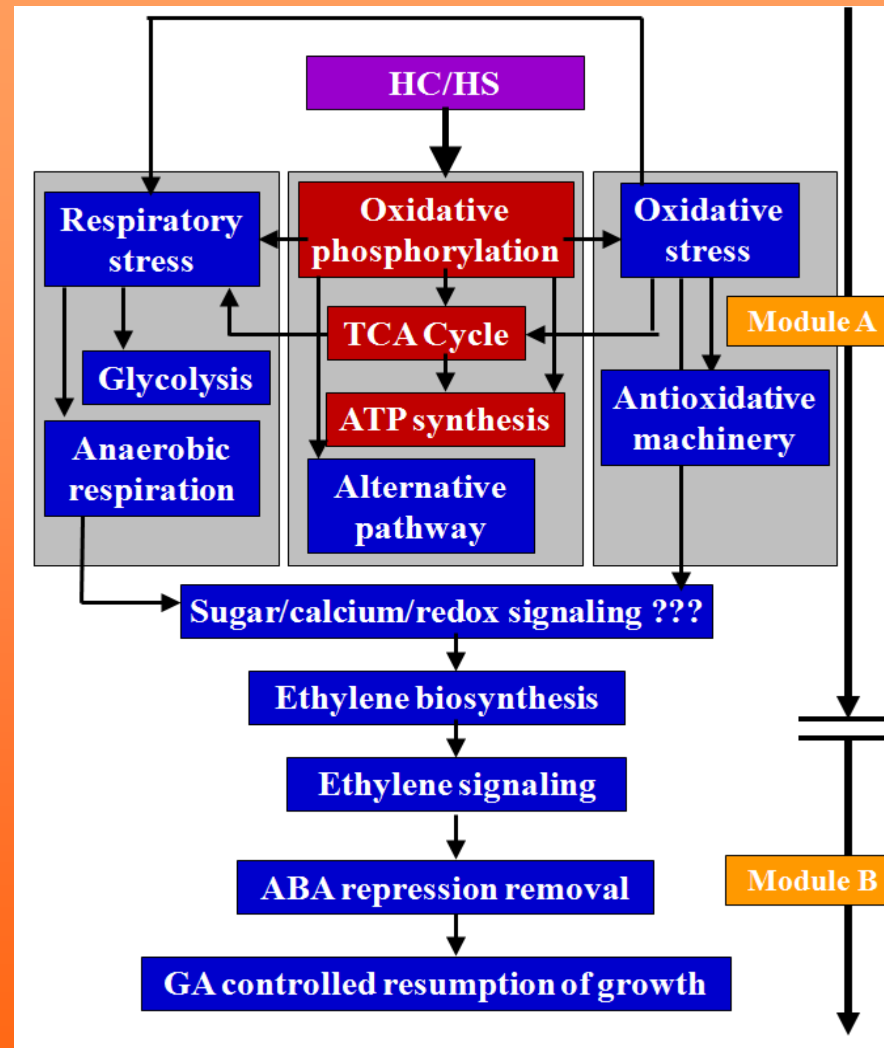
However… In reality, things appears to be more complicated…



Zheng et al., 2018, JExBot

During initial steps of meristem activation, GA has a strong inhibiting effect. Once meriatem is activated, GA has an enhancing effect, probably on primordia growth





Zheng et al., 2018, JExBot

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