Drought Resistance in Wheat

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The Queen's Anniversary Prizes 2005 & 2009

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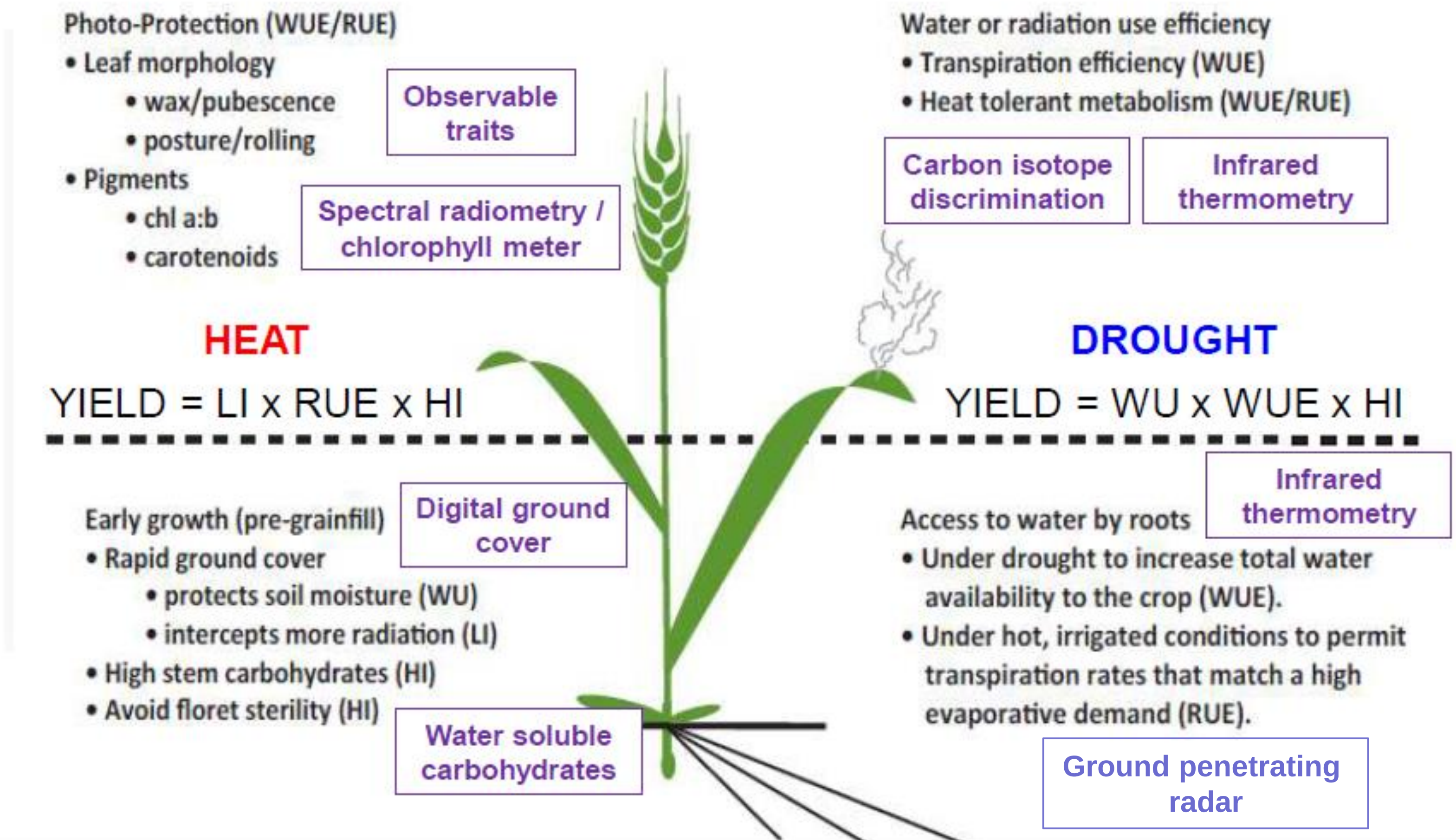
Conceptual models of stress-adaptive Physiological trait combinations



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BUT…. Droughts are variable in timing, intensity and duration

- Individual physiological and developmental traits can have positive, negative or neutral effects on yield, depending on G x E xM   etc

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Fernandez (1982)has argued that genotype yield performance under stress and no-stress conditions can be categorized into four groups:

- Group A - Genotypes express uniform superiority in both stress and no-stress condition,
- Group B - Genotypes express good performance only in yield potential but not under stress,
- Group C - Genotype presents a relatively higher yield only under stress,
- Group D - Poor yield performance in both environments.

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Summary

- What is stress tolerance?
- Components of yield
- A link to physiology?
- Importance of ethylene?
- A simple seedling phenotyping platform
- Linking hormones with yield
- Adaptive significance of hormone biology

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Five different stress indices

Index	Index value	Tolerance	Groups
SSI	Low	High	Fails in distinguish A and C
TOL	Low	High	Fails in distinguish A and C
MP	High	High	Fails in distinguish A and B
GMP	High	High	Distinguish more A compared to MP
STI	High	High	Distinguish better A

Table 1: Index interpretation: summary table

SSI

The Stress Susceptibility Index (SSI) by Fisher and Maurer (1978) is expressed by the following relationship:

$$SSI = \frac{1 - \frac{ys}{yp}}{SI}$$

ys = Yield under stress condition
yp = Yield under yield potential condition

SI = stress intensity expressed by $SI = \left[1 - \frac{\overline{Ys}}{\overline{Yp}}\right]$

$\overline{Ys}$ = mean yields overall population under stress condition
$\overline{Yp}$ = mean yields overall population under yield potential condition

Greater stress tolerance is shown by smaller value of SSI. However, it fails to distinguish group A and C owing to the fact that it favours genotypes with low yield under yield potential and high yield under stress conditions.

TOL and MP

The indices defined by Rosielle & Hamblin (1981) are the stress tolerance (TOL), which can be explained as the difference between yp(yield potential) and ys(yield stress) and the mean production (MP) by average of ys and yp.

$$TOL = yp - ys$$

The high value of TOL indicates a low stress tolerance. However, as SSI, it fails in favours of genotype with high yield under stress and low yield under normal condition. As a result, it cannot distinguish between group A and C.

$$MP = \frac{ys + yp}{2}$$

The high stress tolerance is translated by high MP value. Then again, it fails in favour of genotypes with high yield under yield potential and lower under stress. As a consequence, it cannot differentiate group A and group B.

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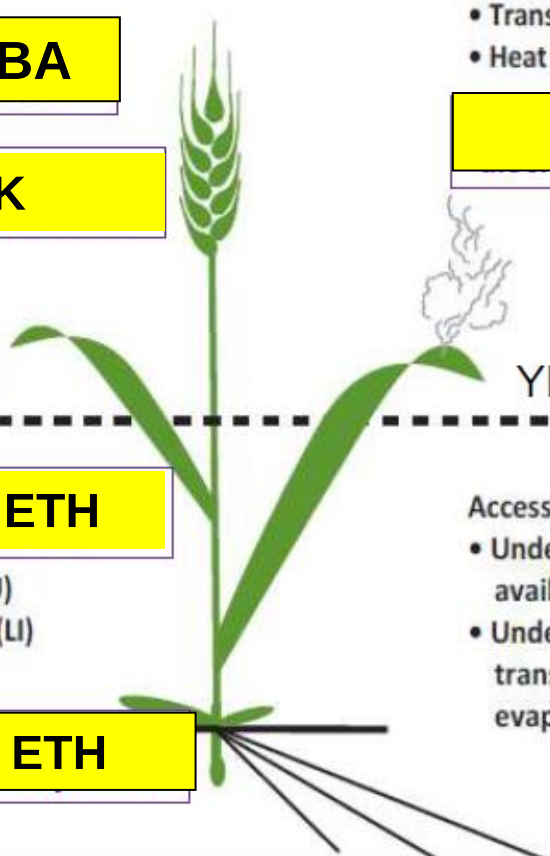
Photo-Protection (WUE/RUE)
- Leaf morphology
  - wax/pubescence
  - posture/rolling
- Pigments
  - chl a:b
  - carotenoids

ABA

CK

Water or radiation use efficiency
- Transpiration efficiency (WUE)
- Heat tolerant metabolism (WUE/RUE)

ABA + ETH +.....



HEAT

YIELD = LI x RUE x HI

DROUGHT

YIELD = WU x WUE x HI

Early growth (pre-grainfill)
- Rapid ground cover
  - protects soil moisture (WU)
  - intercepts more radiation (LI)
- High stem carbohydrates (HI)
- Avoid floret sterility (HI)

ETH

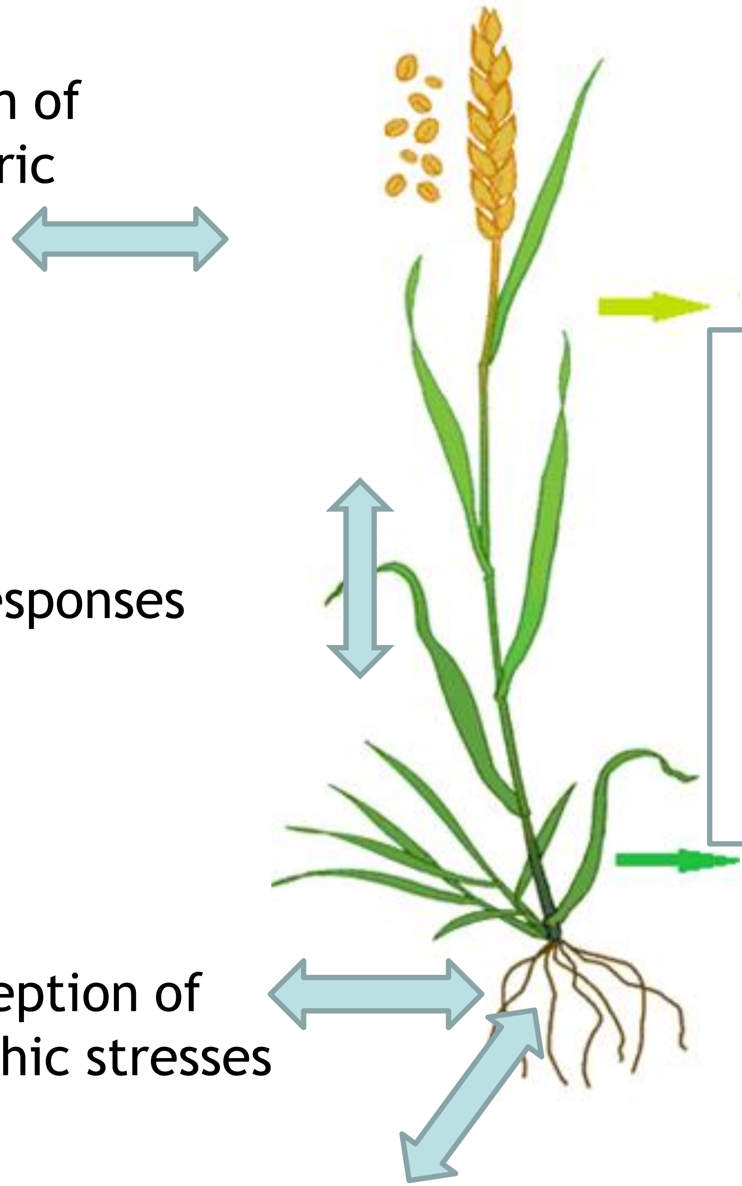
ETH

Access to water by roots
- Under drought to increase total water availability to the crop (WUE).
- Under hot, irrigated conditions to permit transpiration rates that match a high evaporative demand (RUE).

ABA

ETH

Hormone Biology: perception of stress and information content of stress signals



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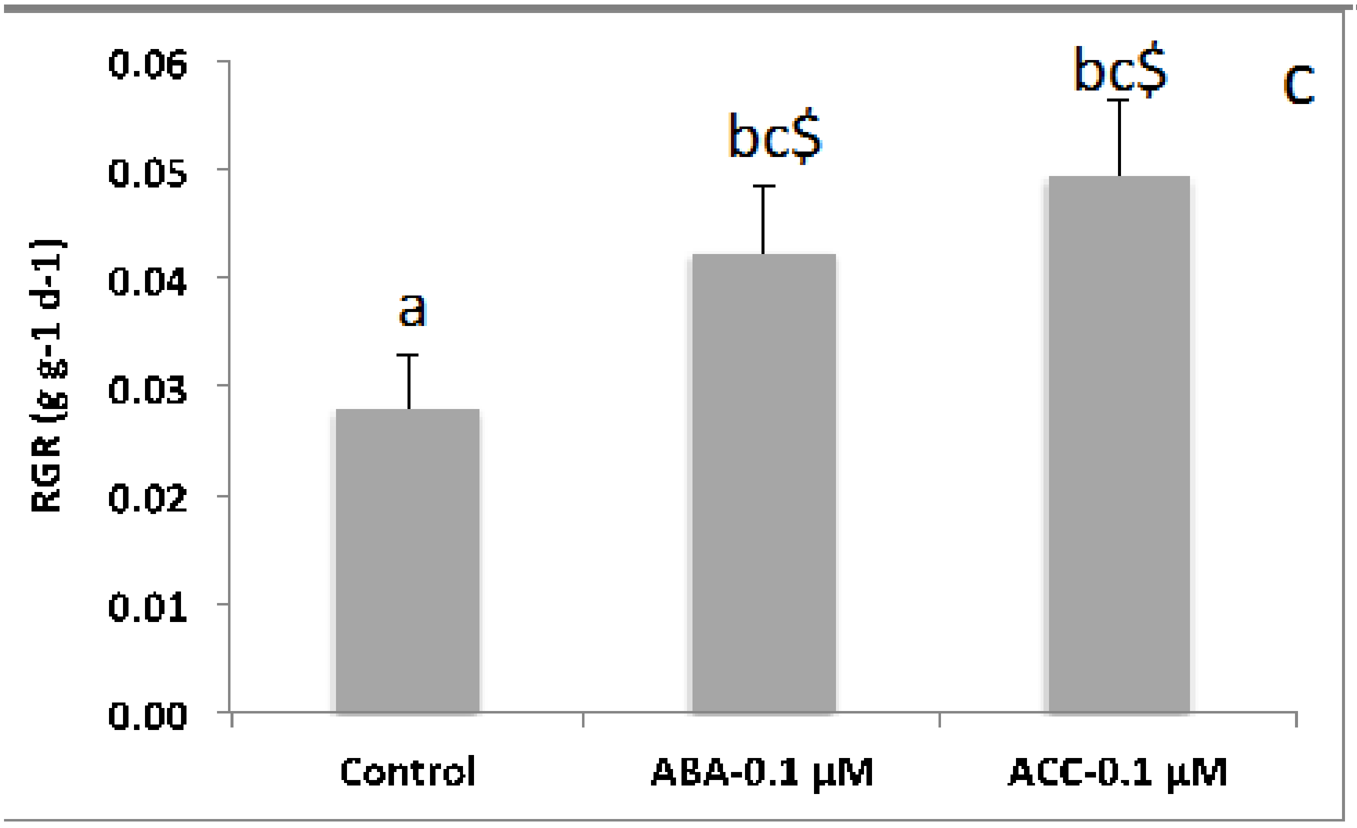
Effects of very low concentrations of hormones



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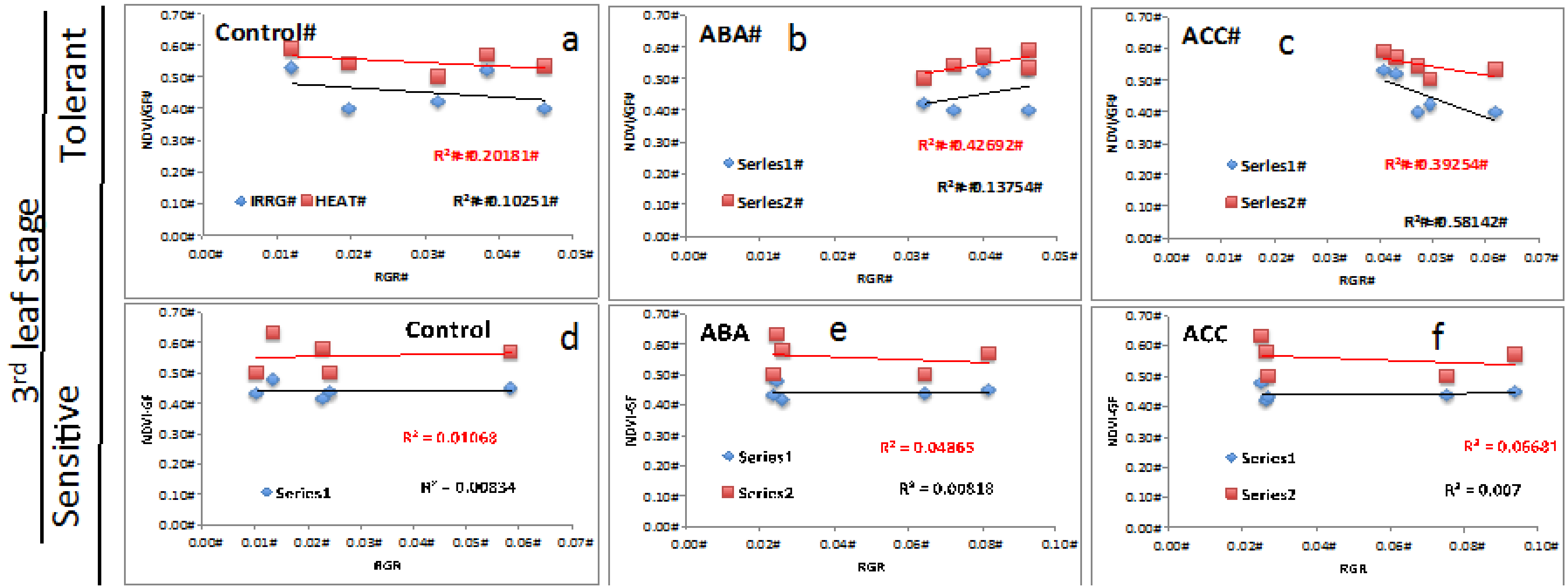

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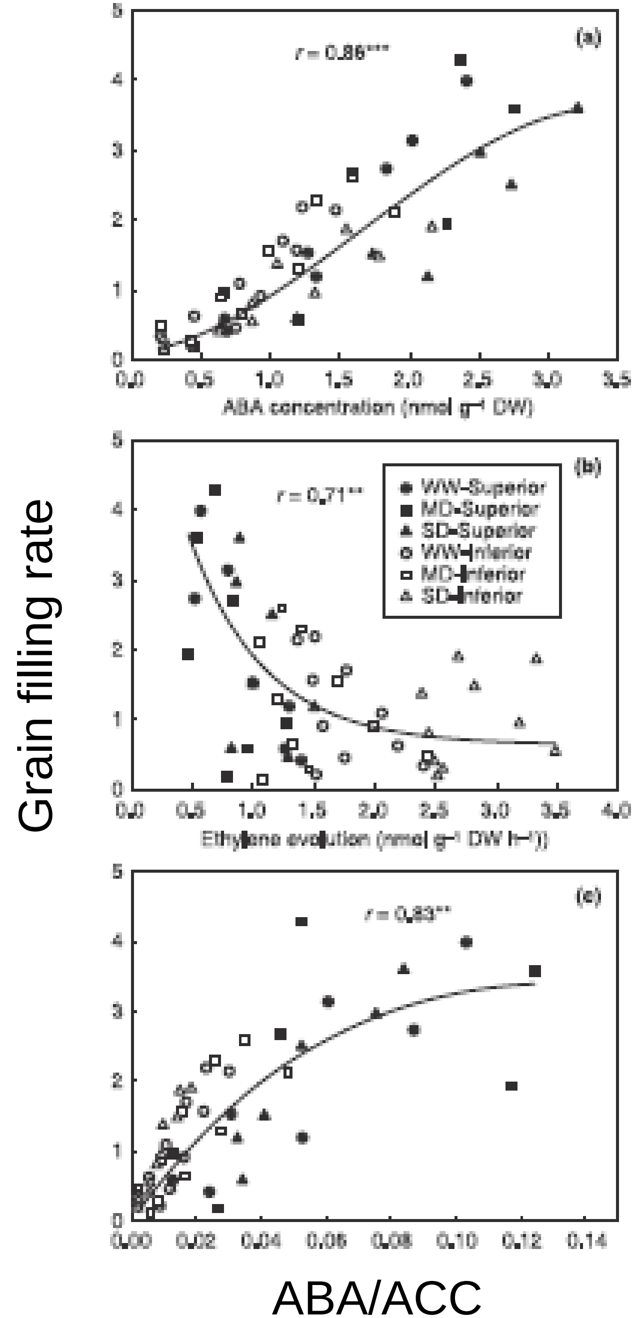
Abscisic acid and ethylene interact in wheat grains in response to soil drying during grain filling

Jianchang Yang, Jianhua Zhang, Kai Liu, Zhiqin Wang, Lijun Liu,
New Phytologist
(2006) 171, 293–303



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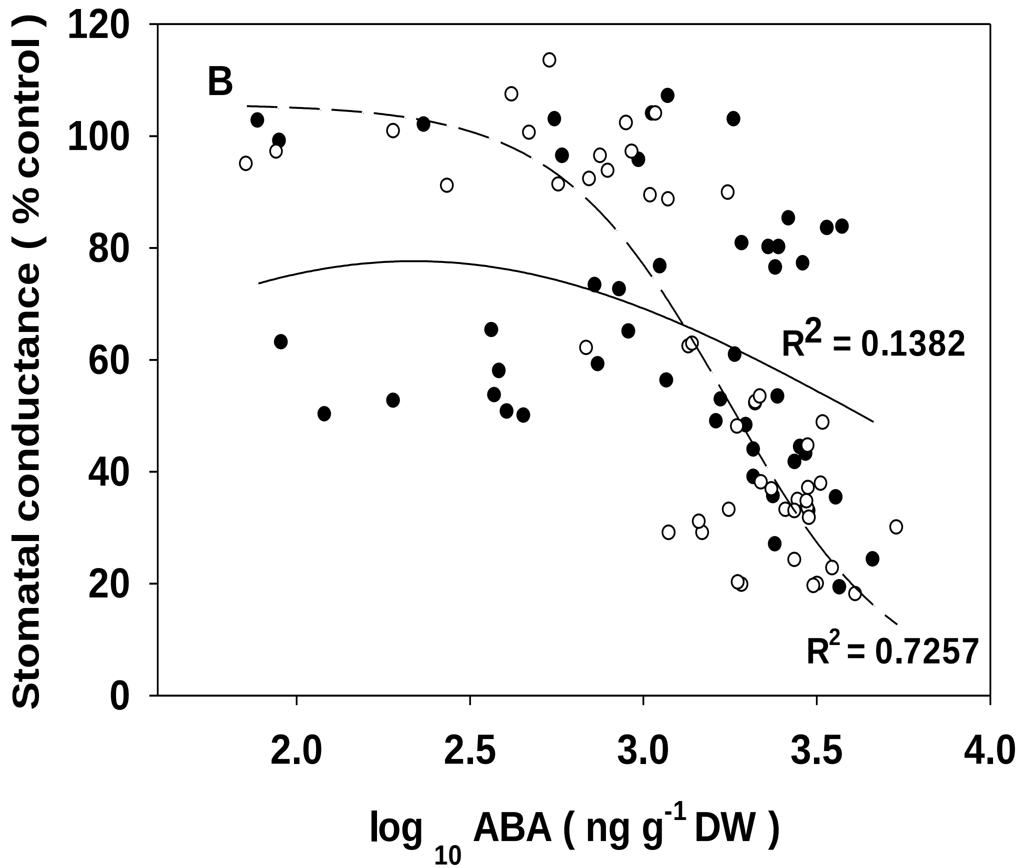
The stress hormone ABA regulates plant functioning (stomatal functioning as a model)
Note - when ethylene is not a complicating issue?



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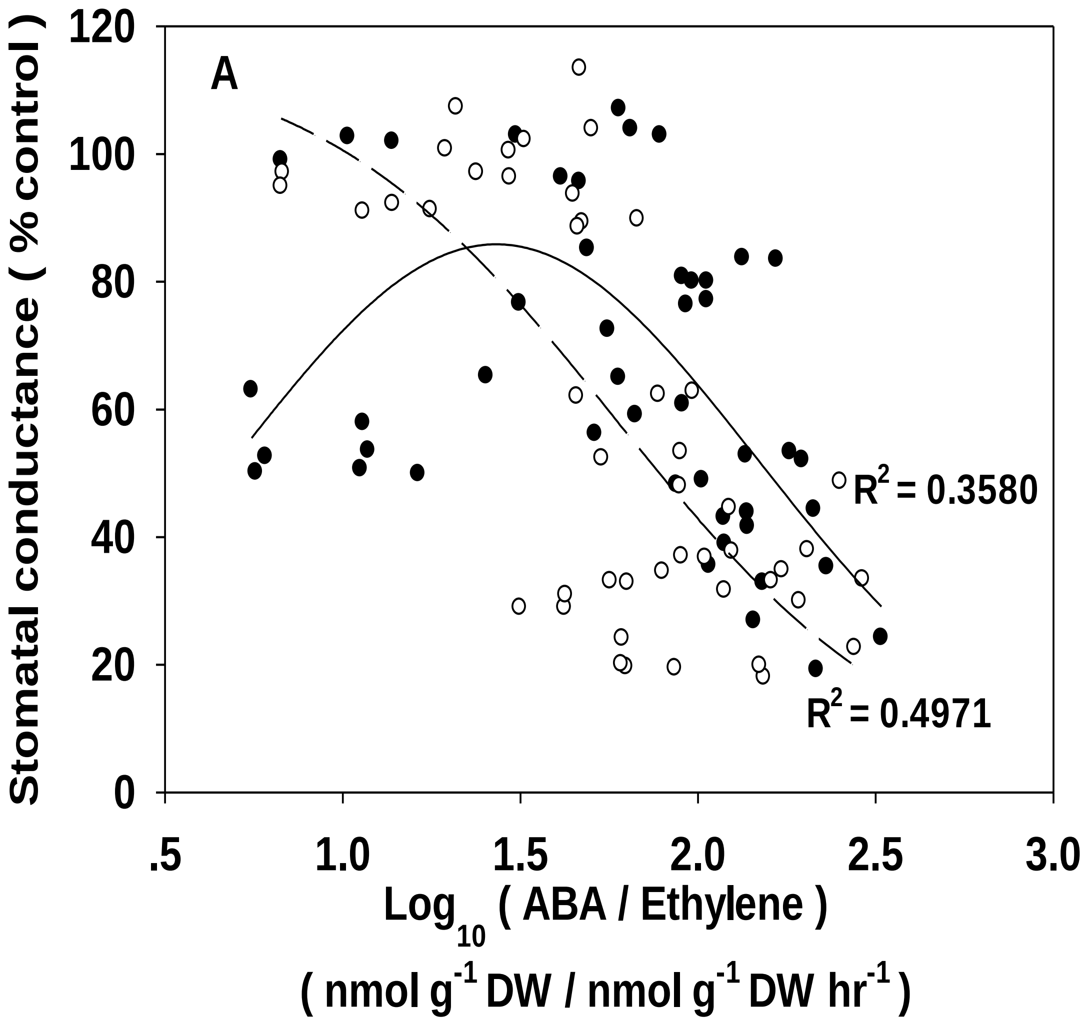
Hu, Wilkinson and Davies, 2013

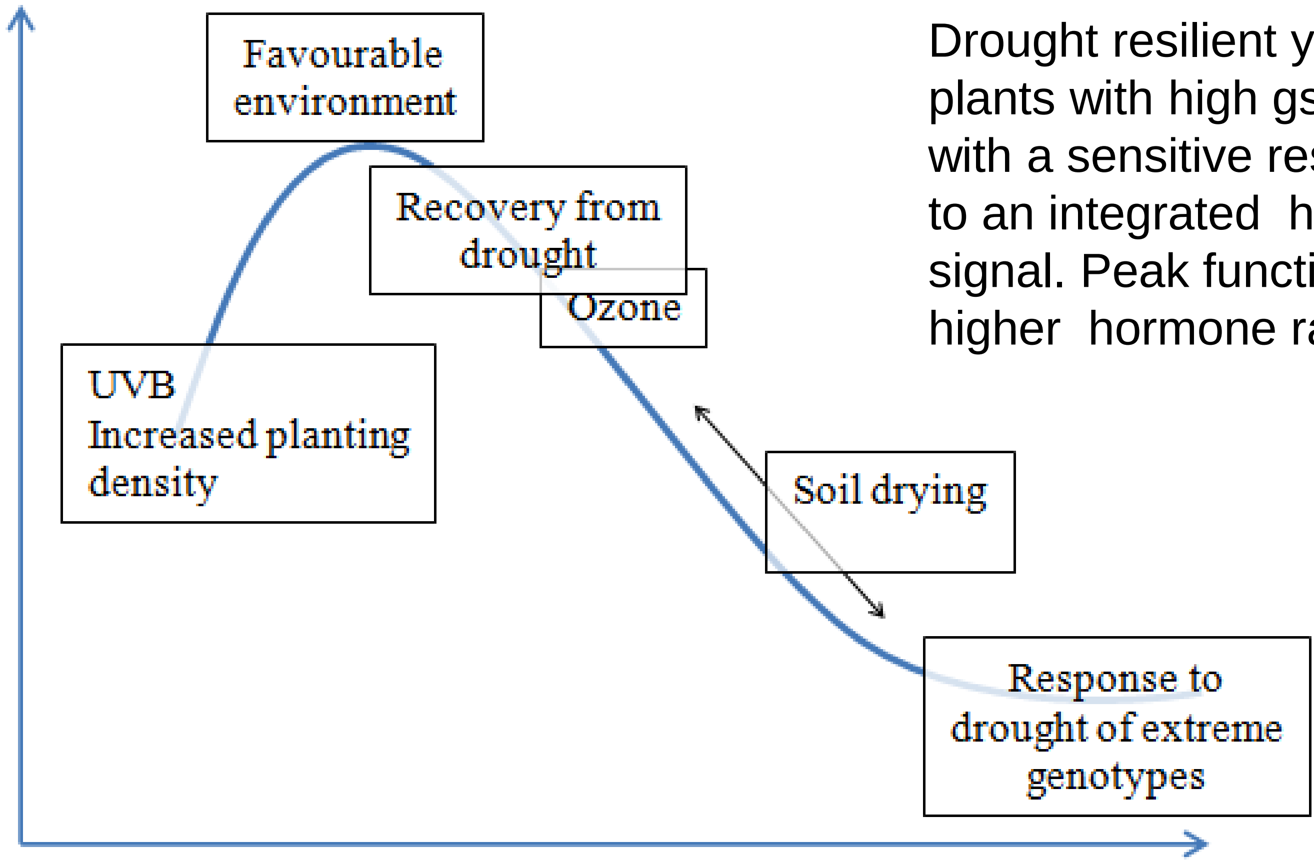
Hormone ratios provide plasticity in response (______)



Hu, Wilkinson and Davies, 2013

Hormone ratios integrating environmental impacts on plant functioning and development

Plant response (gs, root growth, shoot growth, grain filling rate)



Ratio, ABA/ethylene

Drought resilient yield: plants with high gs /growth with a sensitive response to an integrated hormone signal. Peak function at higher hormone ratios

Hu, Wilkinson and Davies, 2013

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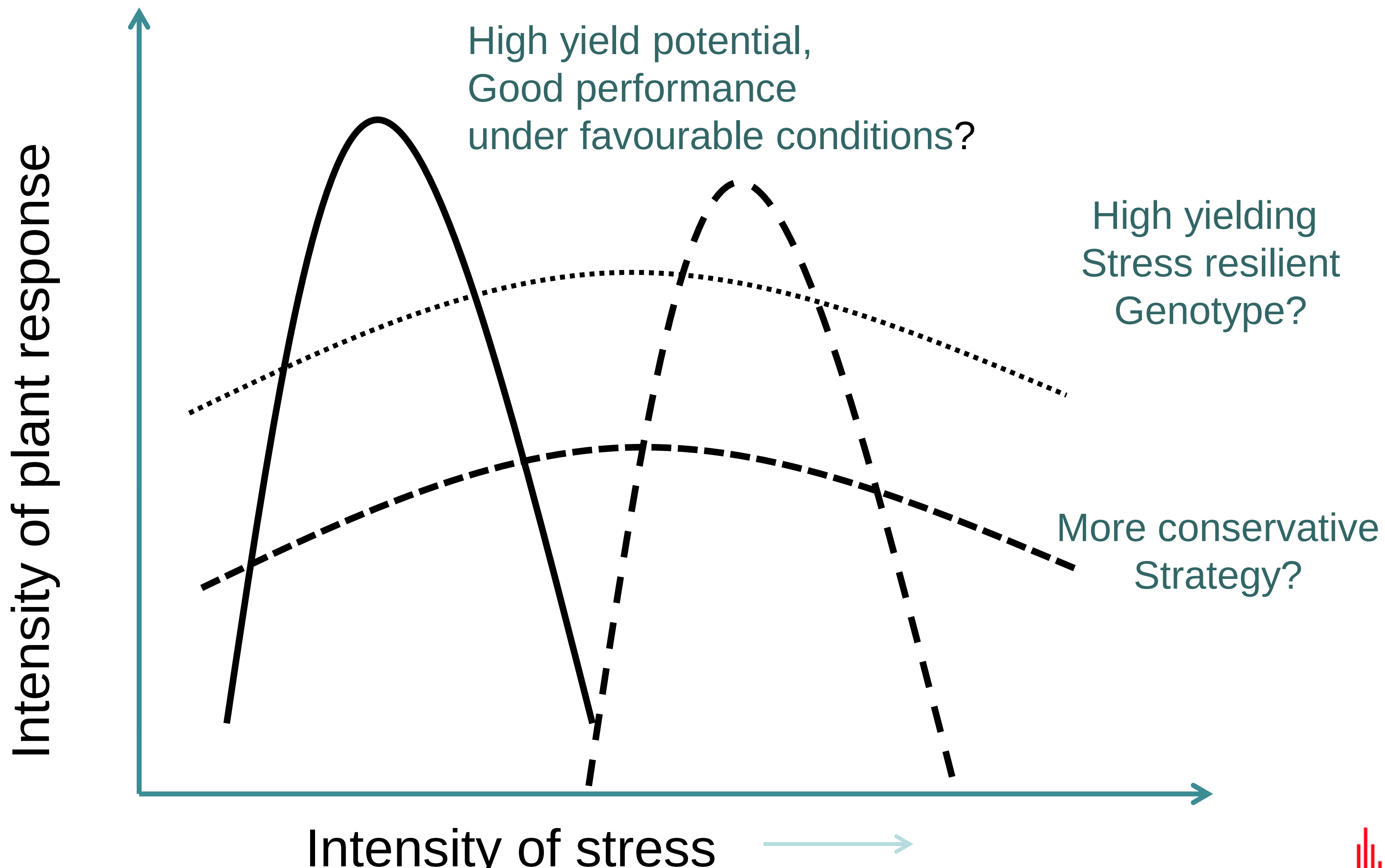
Responses to more challenging, variable environments – what do we want?



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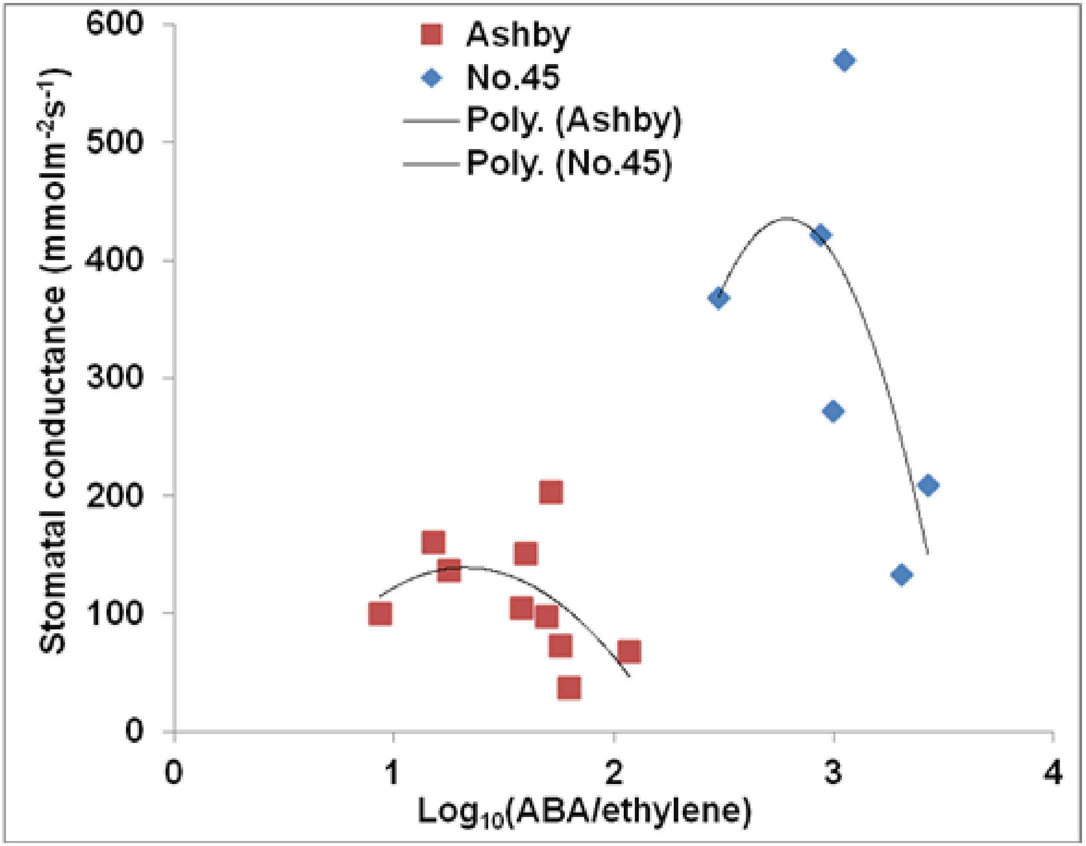

Fig 4.3. The relationships of stomatal conductance and Ratio of ABA/Ethylene of plants suffering a two-week drought stress. The 3-week old plant suffering drought stress was supplied with only 50% of its water loss each day and then were harvested after successive 48h periods of drought tress. Leaves were collected for measurement of Ethylene evolution rate and ABA concentration. The data shown in the figure are the average of 4 replicates.