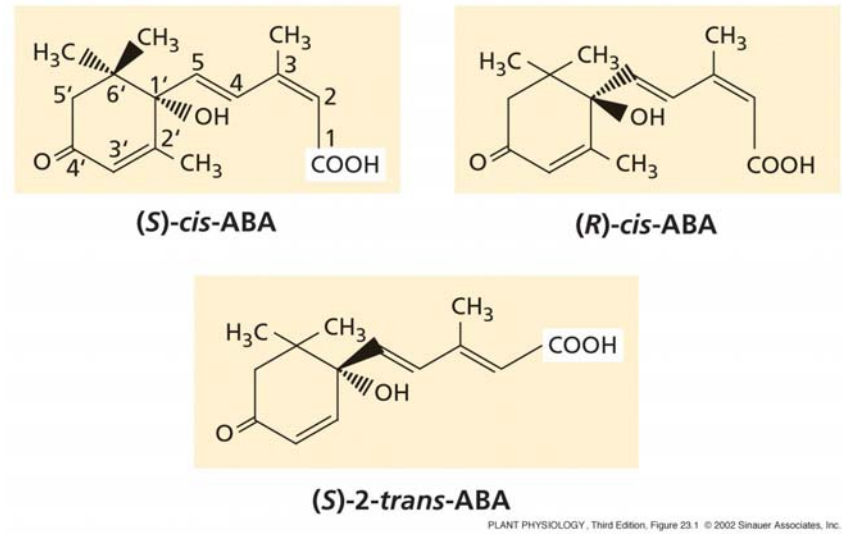
Abscisic Acid

- History
- Chemistry
- Transport
- Physiological action



History

- Discovered in Ash trees/potato tuber
- levels declined when dormancy broken
- Growth inhibitor
- GA antagonist

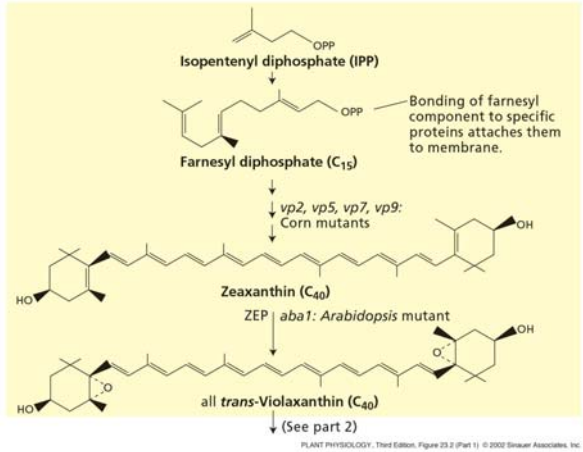
Table 10.1. *Evidence for the involvement of abscisic acid (AbA) in plant response to water stress based on the similarity of responses to water stress and exogenous AbA application (collated from Walton* 1980 *and Jones* 1981*a)*

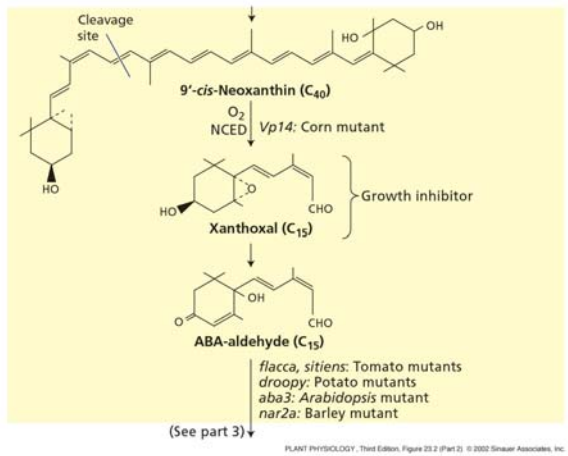
Response	Water stress	AbA	
Short term			
Stomatal conductance	Decrease	Decrease	+ + −
Photosynthesis	Decrease	Decrease (Primarily a stomatal effect)	+ + −
Membrane permeability	Increase/decrease	Increase/decrease	+
Ion transport	Increase/decrease	Increase/decrease	+
Long term: biochemical & physiological			
Proline & betaine[1] accumulation	Increase	Increase	+ +
Osmotic adaptation	Yes	Possibly	+
Photosynthetic enzyme activity	Decrease	Decrease	+
Desiccation tolerance[2]	Increase	Increase	+
Wax production	Increase[3]	Increase[4]	+
Long term: growth			
General growth inhibition	Yes	Yes	+ + +
Cell division	Decrease	Decrease	+ + +
Cell expansion	Decrease	Decrease	+ + +
Root growth	Increase/decrease	Increase/decrease	+ +
Root/shoot ratio	Increase	Increase[4,5]	+ +
Long term: morphology			
Production of trichomes	Increase	Increase	+ +
Stomatal index	Decrease	Decrease	+ +
Tillering in grasses	Decrease	Slight decrease[4]	+
Conversion from aquatic to aerial leaf type	Yes	Yes	+ +
Induction of dormancy, terminal buds or perennation organs	Yes	Yes	+ +
Long term: reproductive			
Flowering in annuals	Often advanced	Often advanced	+ +
Flower induction in perennials	Inhibited	Inhibited	+
Pollen viability	Decreased	Decreased	+
Seed set	Decreased	Decreased	+

Extra references: 1. Huber & Sankhla 1980; 2. Gaff 1980; 3. Baker 1974; 4. S. A. Quarrie & H. G. Jones unpublished; 5. Watts *et al.* 1981.
The strength of correlation is indicated as ranging from weak (+) to strong (+ + +)

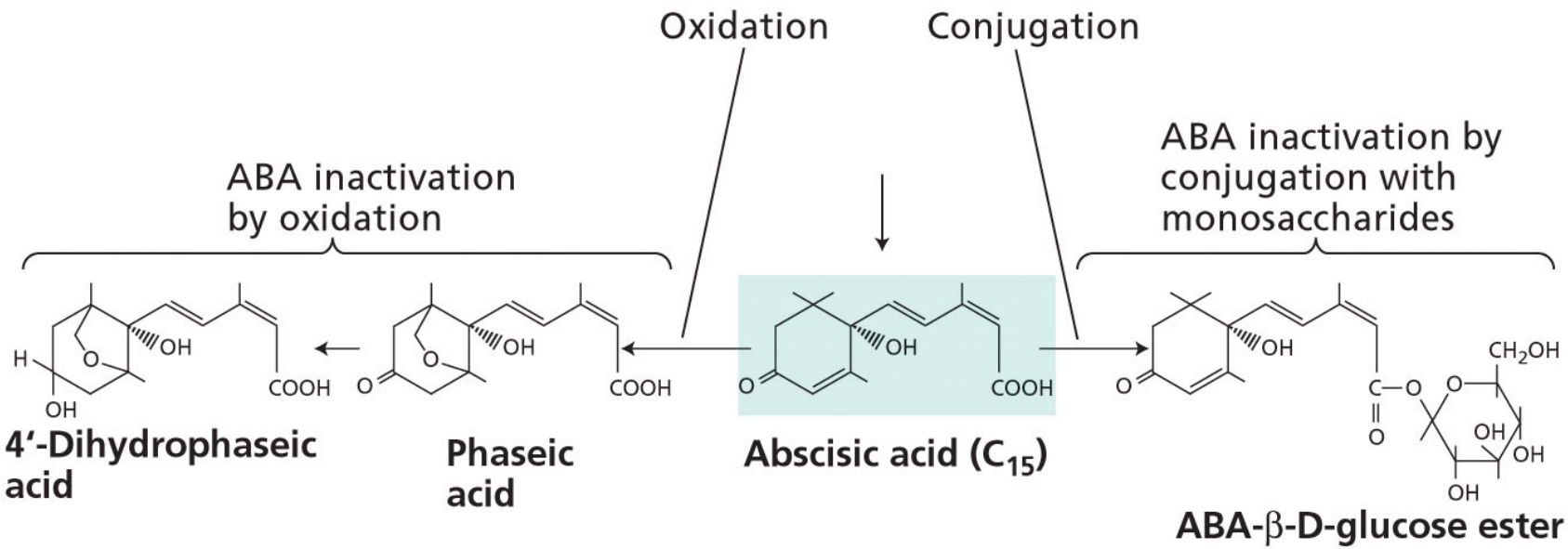
Chemistry

- synthesized in chloroplast/plastids
- maevlonic acid pathway
- cis-ABA active form
- lunuluric acid in liverworts
- photochemical production from violaxanthin
- inactivated by ABA-glucoside or O_2 oxidation





Inactivation



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Transport

- xylem/phloem
- move to roots
- synthesis in root caps -- basipetal transport
- move to all parts of plant
- increases during stress

Physiological action

- Stomatal closure
- Dormancy in seeds/buds
- Precocious germination

Seed dormancy

- peak mid to late embryogenesis
- dessication tolerance
- accumulation of seed storage proteins
- inhibits precocious germination/vivipary

Five basic mechanisms of coat-imposed dormancy:

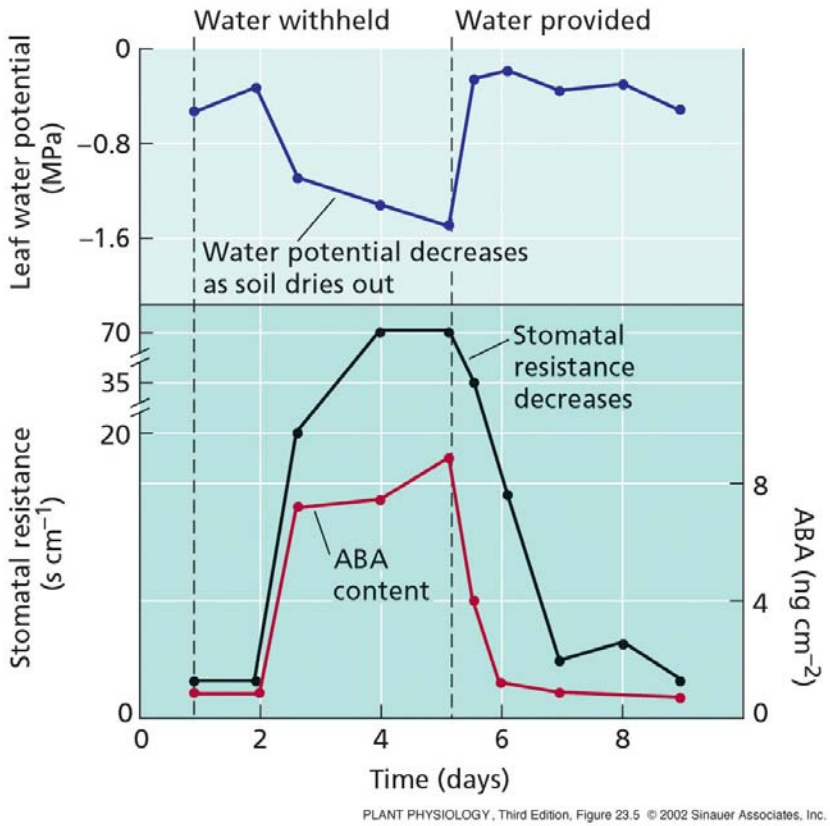
- *Prevention of water uptake.*
- *Mechanical constraint.*
- *Interference with gas exchange.*
- *Retention of inhibitors*
- *Inhibitor production.*

Environmental Factors Control the Release from Seed Dormancy

- **Afterripening**
- **Chilling**
- **Light**

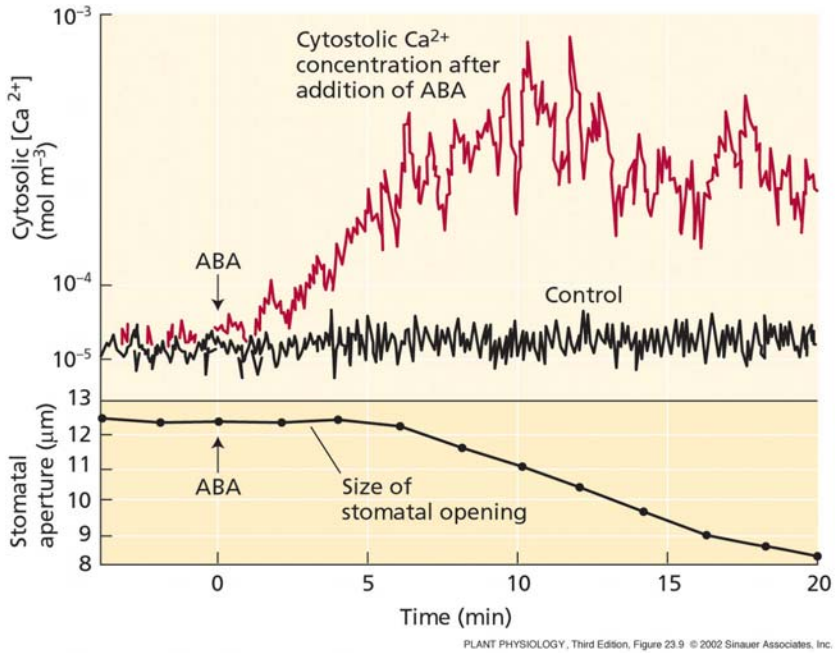
Stomatal closure

- ABA weak acid
- normal conditions enters mesophyll cells
- stress causes pH to rise in xylem sap
- ABA doesn't enter mesophyll cell, ABA-
- moves to guard cells
- activates K+/ Cl- channels out of guard cell
- causes stomatal closure
- evidence/data shown on pH changes with application of ABA



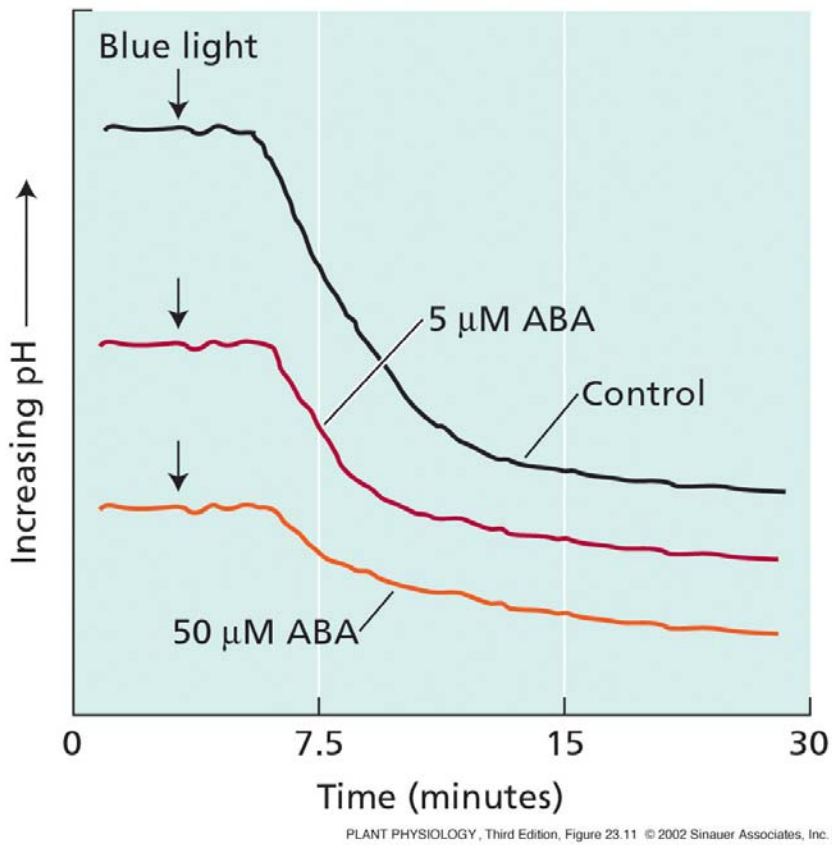
Stomatal closure

- ABA induces increase in cytosolic Ca^{+2} concentration
- ABA reduces the size of the stomatal aperature



Light effects

- Blue light pulse opens stomata
- Addition of ABA inhibits acidification of medium
- ABA inhibits plasma membrane H^+ - ATPase



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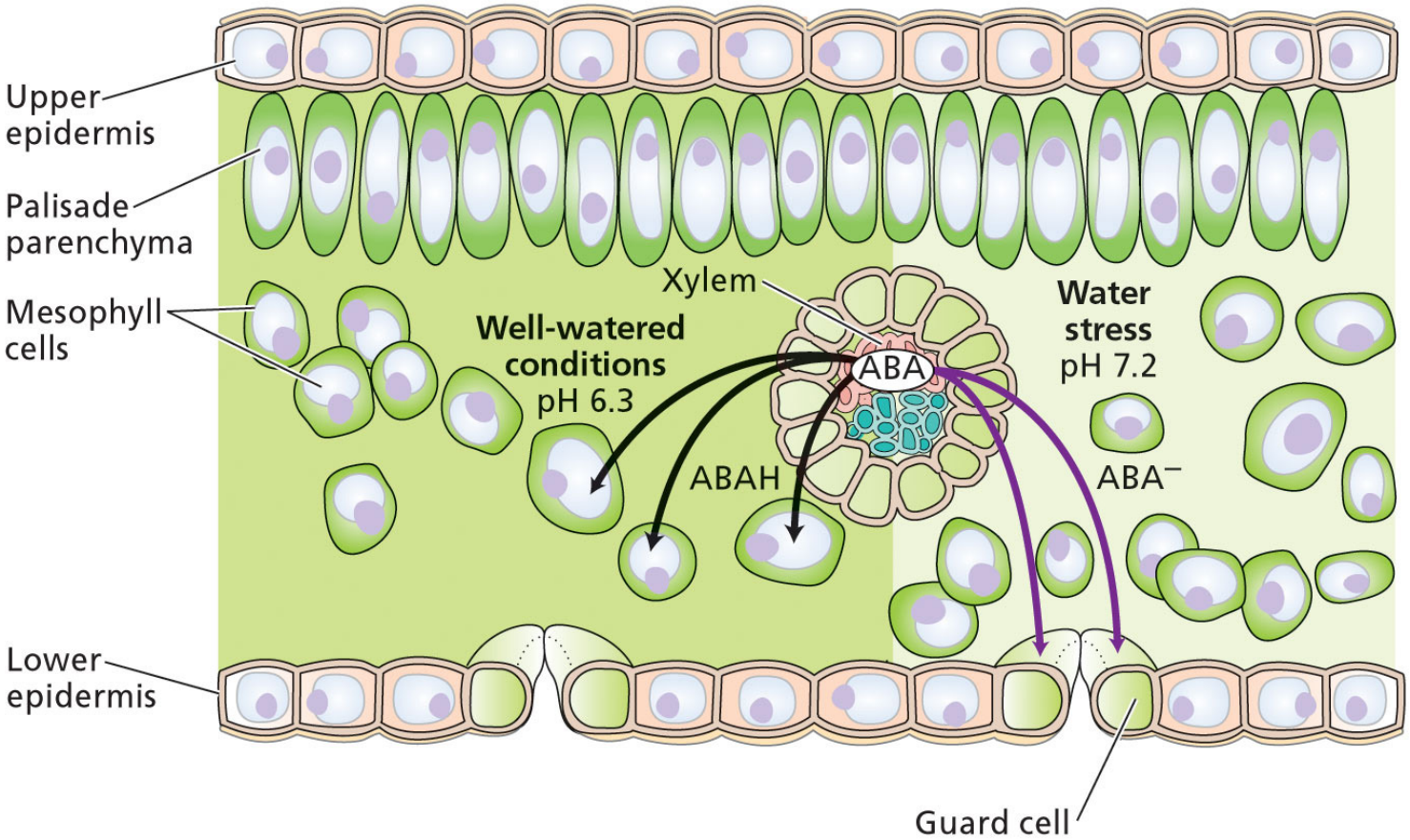
Redistribution of ABA in Leaf



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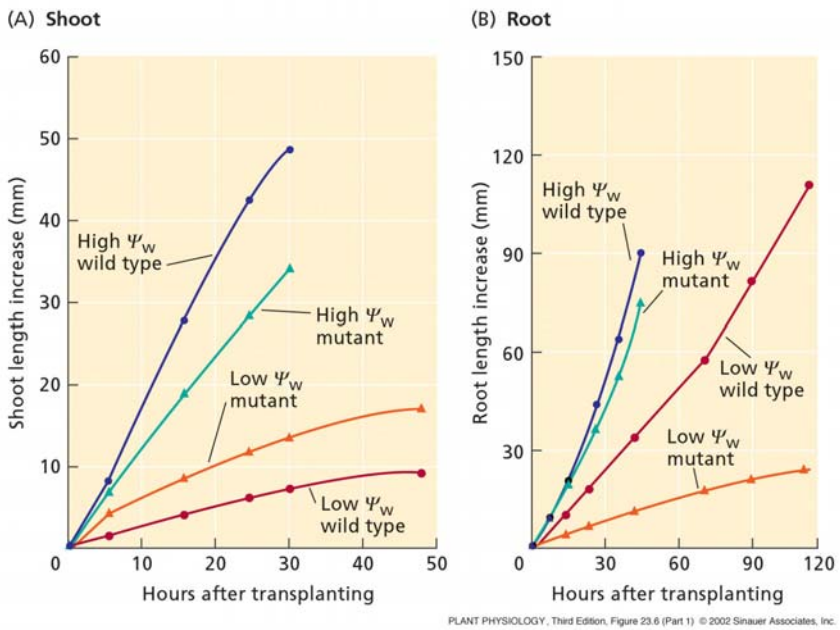
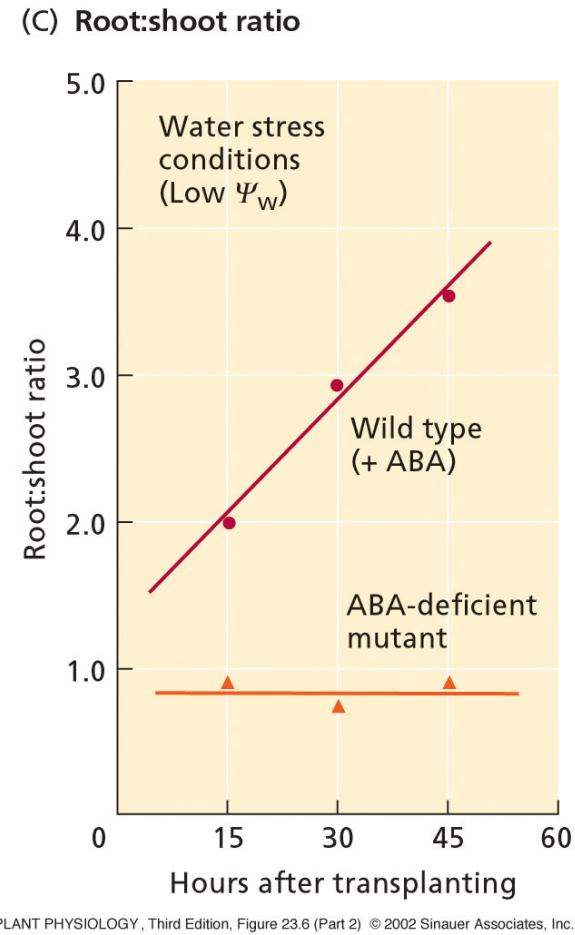
Water Potential





CAM induction

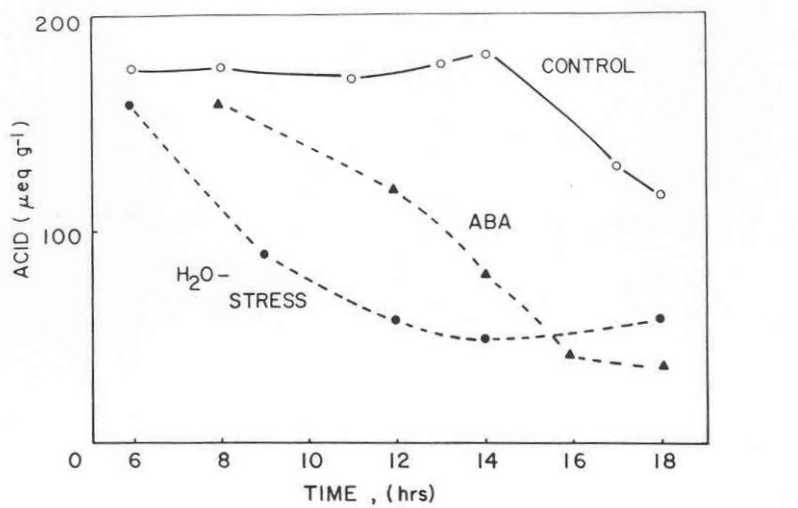


Figure 4. Titratable organic acid levels in well-watered, nonstressed (control) plants, in abscisic acid treated plants to close stomata, and in water-stressed plants during the light period.

Signaling

- ABA binds to receptor
- Form Reactive oxygen species
- Activate Ca^{+2} channels
- Intracellular Ca^{+2} goes up, inhibit K^+ channels
- Membrane depolarization activates K^+ channels out
- Stomata close