Understanding Blossom End Rot in Tomatoes and Peppers

Elizabeth Mitcham
Department of Plant Sciences
UC Davis

Ca^{++} deficiency in plants

Bitter pit apple

Black heart Celery

Blossom-end rot tomato

Blossom-end rot pepper

Blossom-end rot watermelon

Tip burn lettuce

Cracking tomato

Similarities of Blossom End Rot to Bitter Pit

- Related to Ca deficiency, but incidence is not well related to Ca levels in individual fruit
- Induced by stress, such as water stress
- Initial symptoms at membrane with leakiness, then cell deterioration

Bitter Pit

Blossom-End Rot

Timing of BER Development

- Susceptibility:
  - Early development: 1/2 to 1/3 full fruit size in tomatoes
  - Uneven irrigation
  - Weather extremes
  - Sandy/quick draining soils
- No cure for tomato or pepper with BER
  - Consider removing affected fruit to conserve plant energy
  - Calcium spray may help with BER reduction in subsequent fruit
- BER incidence may decline as season progresses

- https://docs.google.com/file/d/0B7wlCd3B4SOMYWZDdXZGdU9ocUU/edit?usp=drive_web

Role of Ca^{++} as a Nutrient

- Plant responses to biotic and abiotic signals
- **Membrane structure**
- **Cell wall structure**
- **Charge balance inside vacuole**

Factors that Influence Calcium Deficiency Development in Fruit

1. Calcium uptake to the fruit
   a) Not enough calcium in soil
   b) Plant cannot take up enough Ca
2. Calcium localization within fruit cells

Healthy Fruit

Ca^{++} deficiency Blossom-end Rot

History of Ca^{++} deficiency in apple/ tomato

- 1869: first mentioned as a problem
- 1956: relationship disorder with Ca^{++} content
- 1962: spraying Ca^{++} reduces the disorder
- 1962 – today: mechanism not well understood

Is Ca^{++} deficiency always caused by low total Ca^{++} content in the tissue?

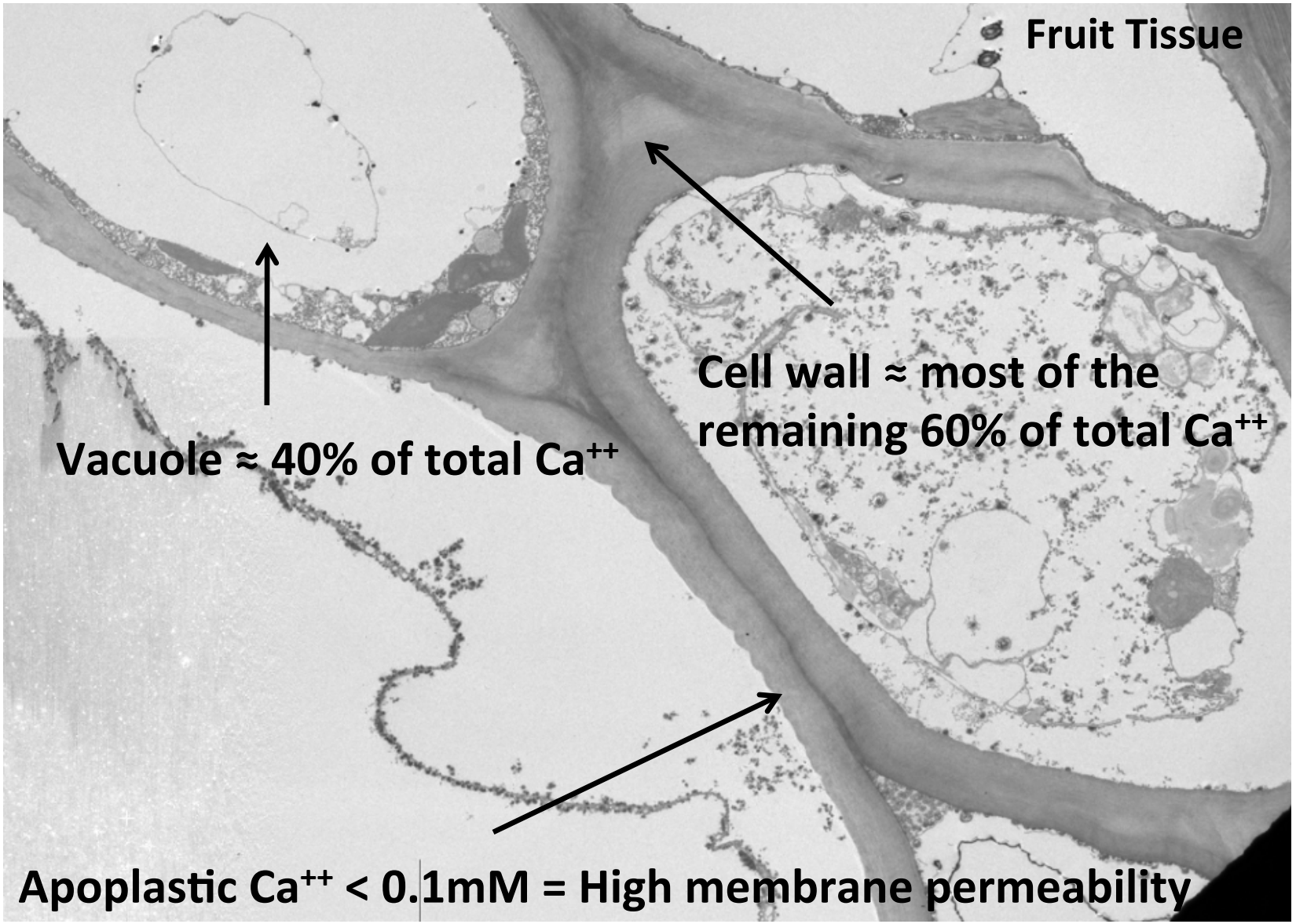
Answer: No!!!

Calcium
Location, Location, Location

- The activity of Ca transporters between cellular compartments can affect the Ca available for membrane stability to reduce calcium deficiency disorders

- Studies in tomato showed that increasing the expression of Ca^{2+} transporters in the vacuolar membrane can increase the levels of calcium in the fruit, but can also increase the incidence of blossom-end rot (PARK et al., 2005)

Main hypothesis



Vacuole and Ca^{++} homeostasis in plant cell

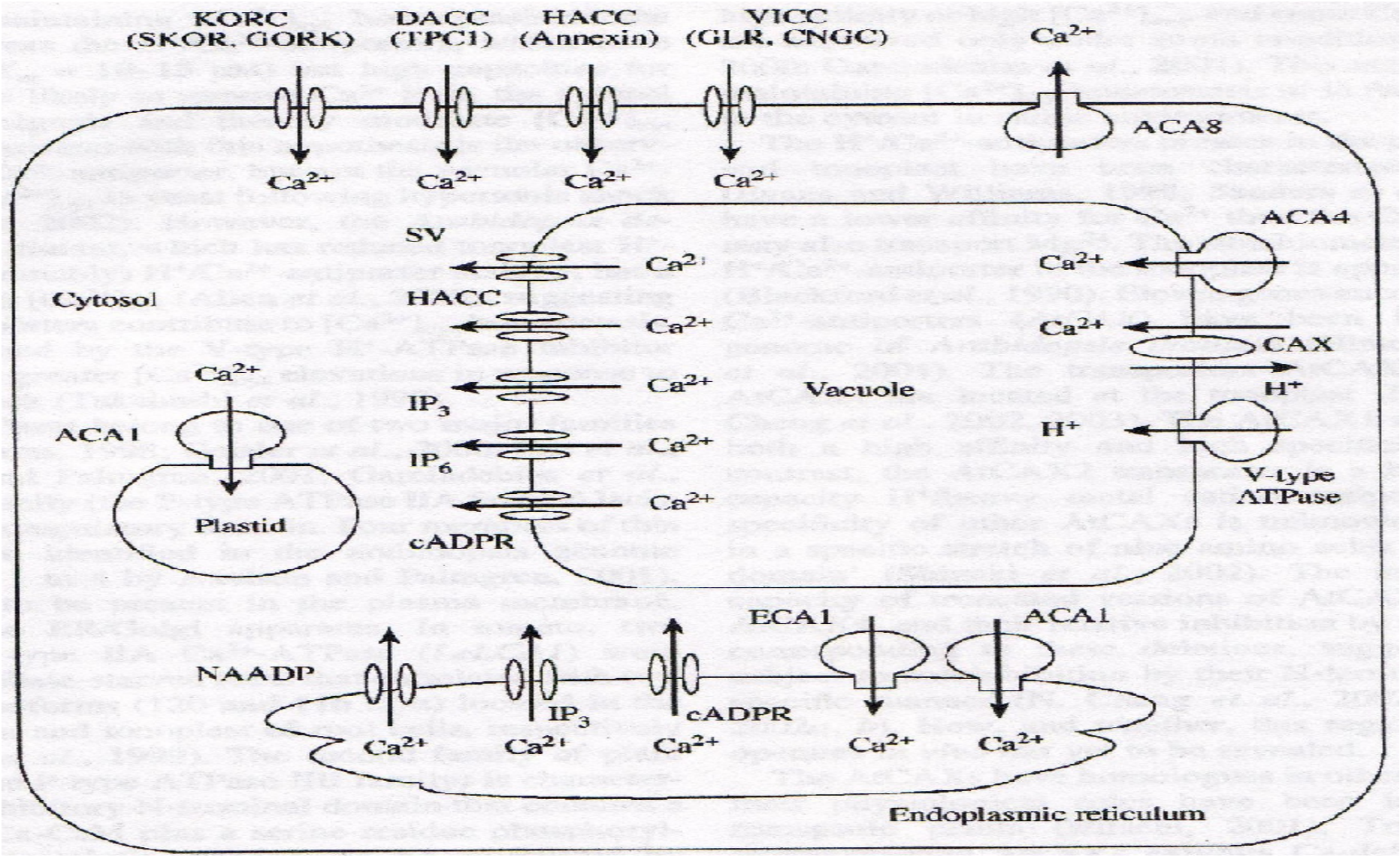


Figure. Calcium in plant cells. White & Broadley, 2003.

Gibberellins Stimulate Proteins that Pump Calcium into the Vacuole

Result is less calcium in the cell wall and apoplast

Induction of blossom-end rot in tomato with gibberellin treatment

TREATMENTS:

1 – Gibberellin 300ppm

2 – Water

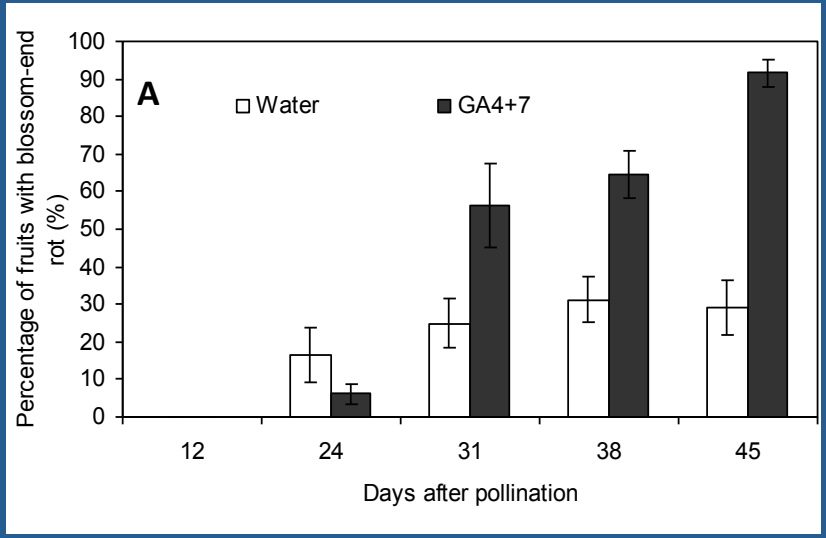
Methodology:

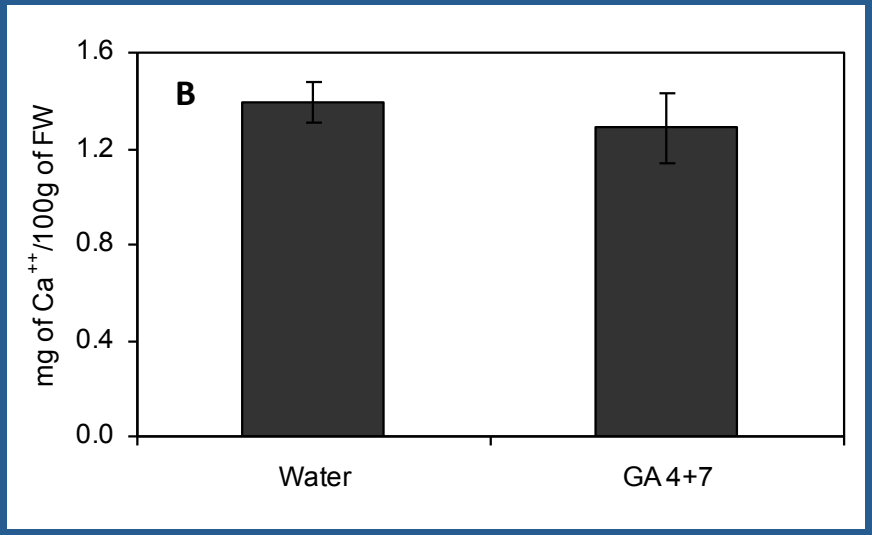
- **Pollinate and select the flowers at full bloom**
- **Cut calcium from the nutrient solution at the time of pollination**
- **Spray the plants every week with each treatment**
- **Fruit analysis: evaluations were accomplished every week**

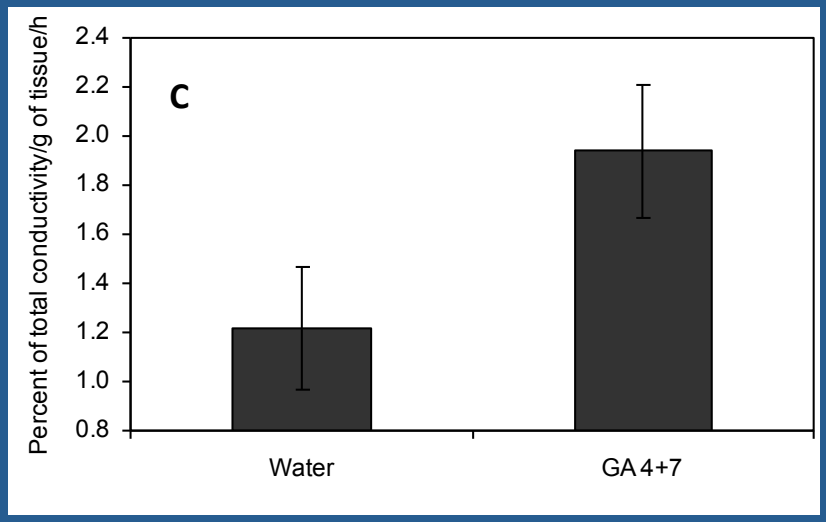
Tomato fruits 31 DAP

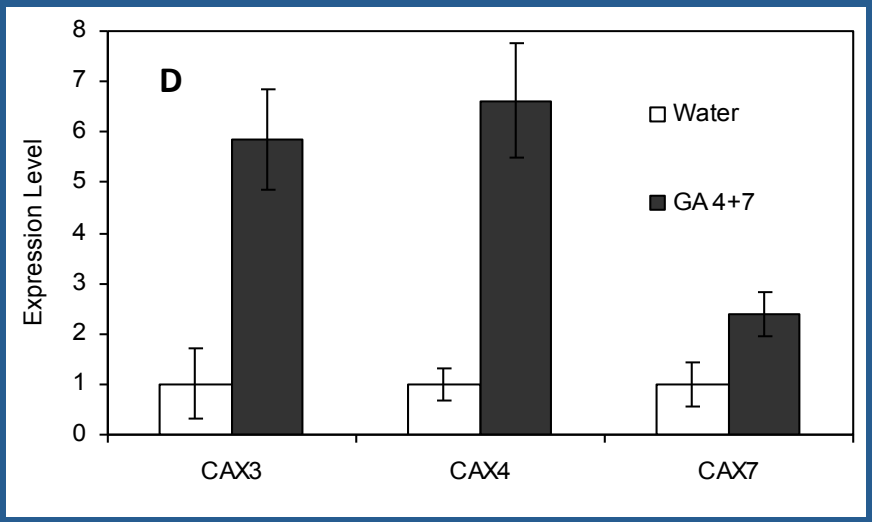
Water

GA 4+7









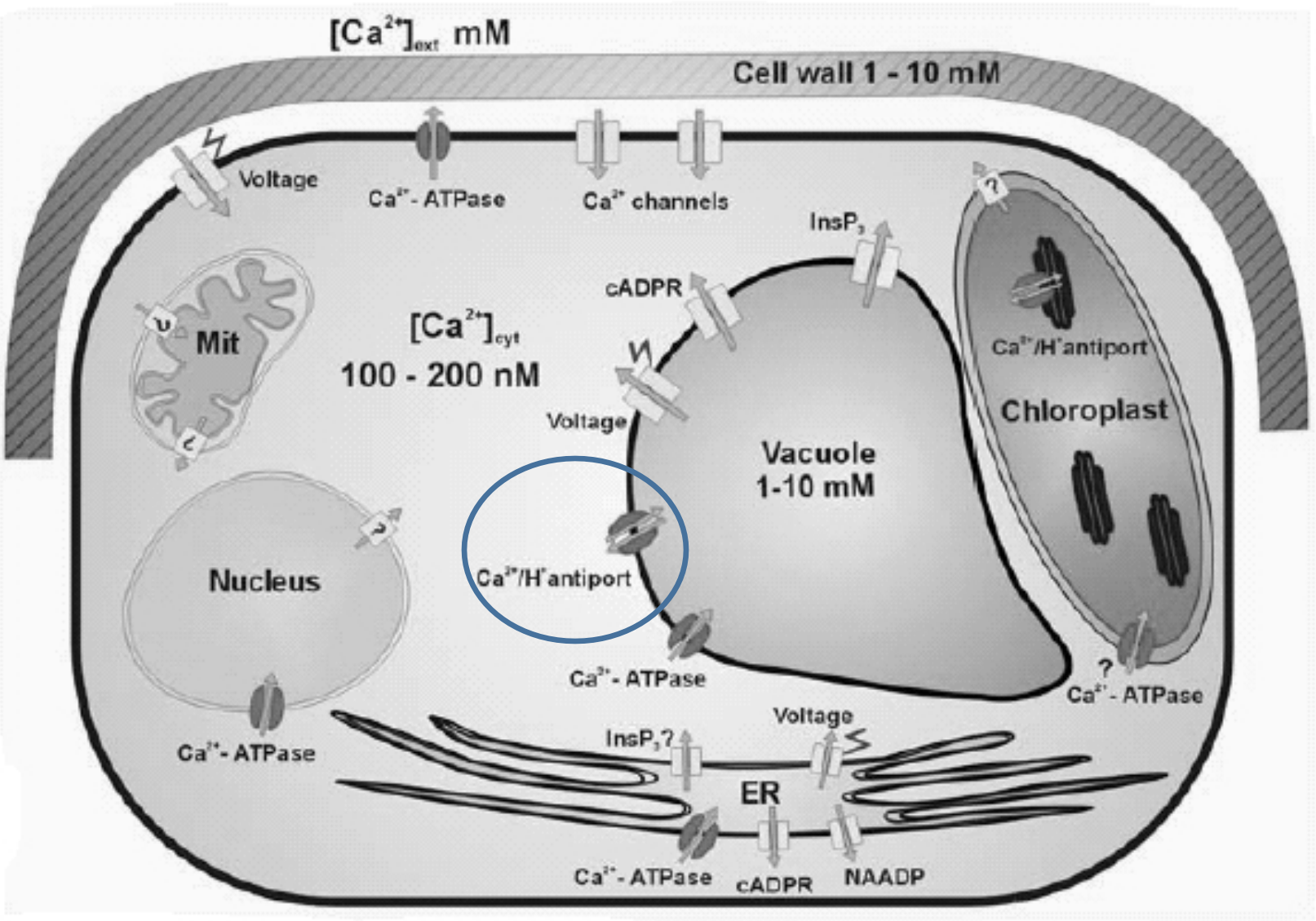
Blossom-end rot incidence in tomato plants cultivar Ace sprayed weekly with water or GA4+7 (300ppm) (A). Calcium concentration (B), ion leakage analysis (C), and expression level of putative Ca^{++}/H^{+} genes (D) at the blossom-end pericarp tissue of tomato fruit without visual symptoms of BER at 31 days after pollination.

Increased Calcium Levels and Prolonged Shelf Life in Tomatoes Expressing Arabidopsis H^+/Ca^{2+} Transporters[1]

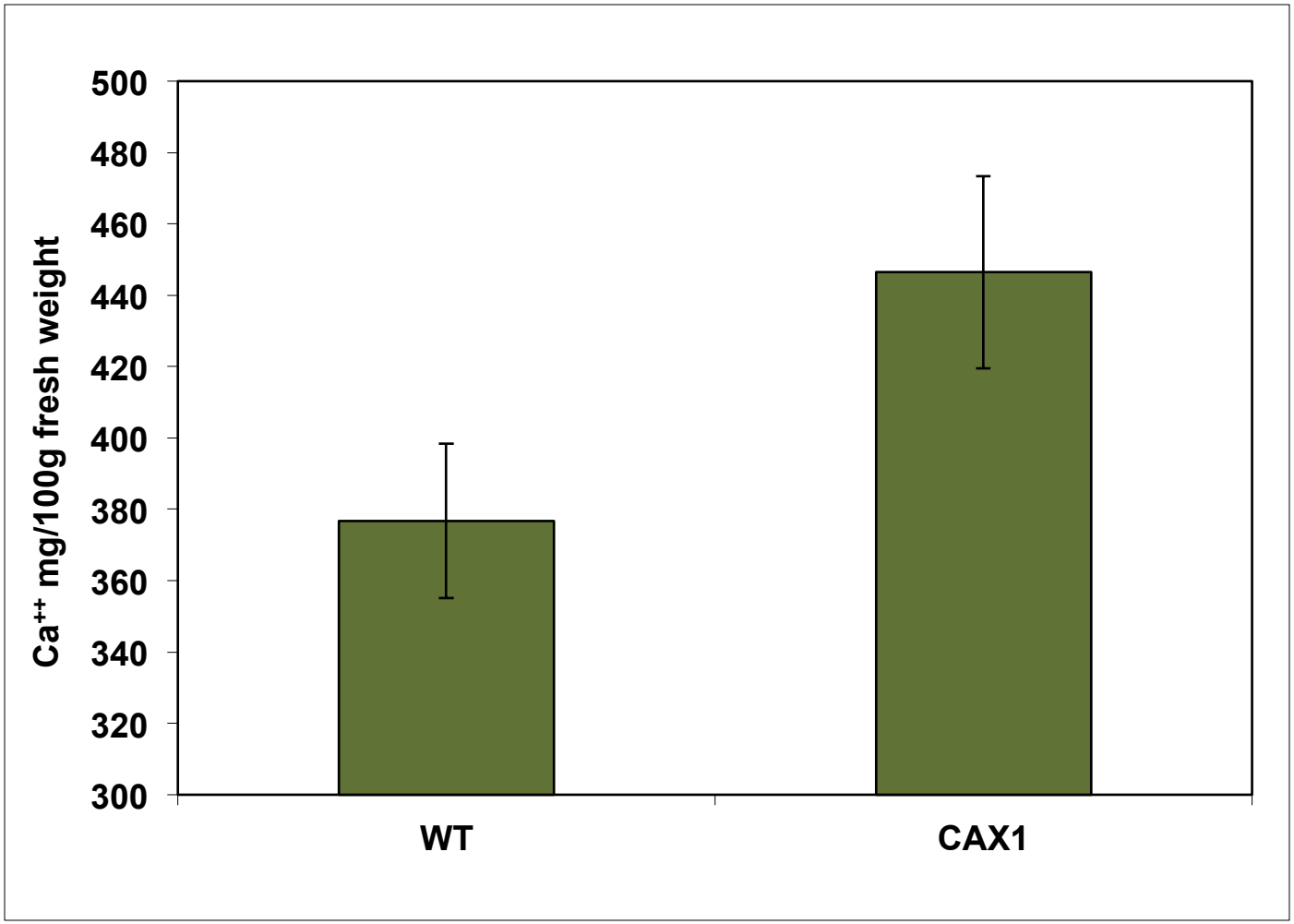
Sunghun Park*, Ning Hui Cheng, Jon K. Pittman[2], Kil Sun Yoo, Jungeun Park, Roberta H. Smith, and Kendal D. Hirschi

Vegetable and Fruit Improvement Center, Texas A&M University, College Station, Texas 77845 (S.P., K.S.Y., J.P., R.H.S., K.D.H.); and Plant Physiology Group, United States Department of Agriculture/Agricultural Research Service, Children's Nutrition Research Center, Baylor College of Medicine, Houston, Texas 77030 (N.H.C., J.K.P., K.D.H.)

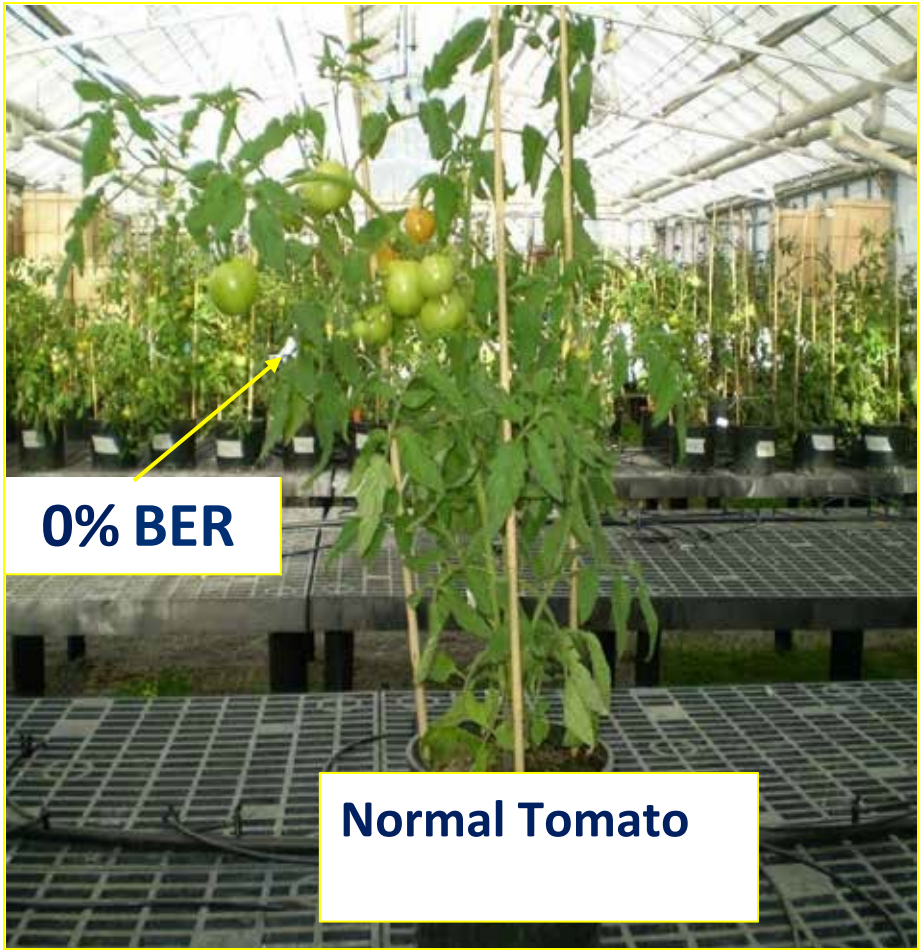
Cellular regulation of Ca^{2+} partitioning/distribution

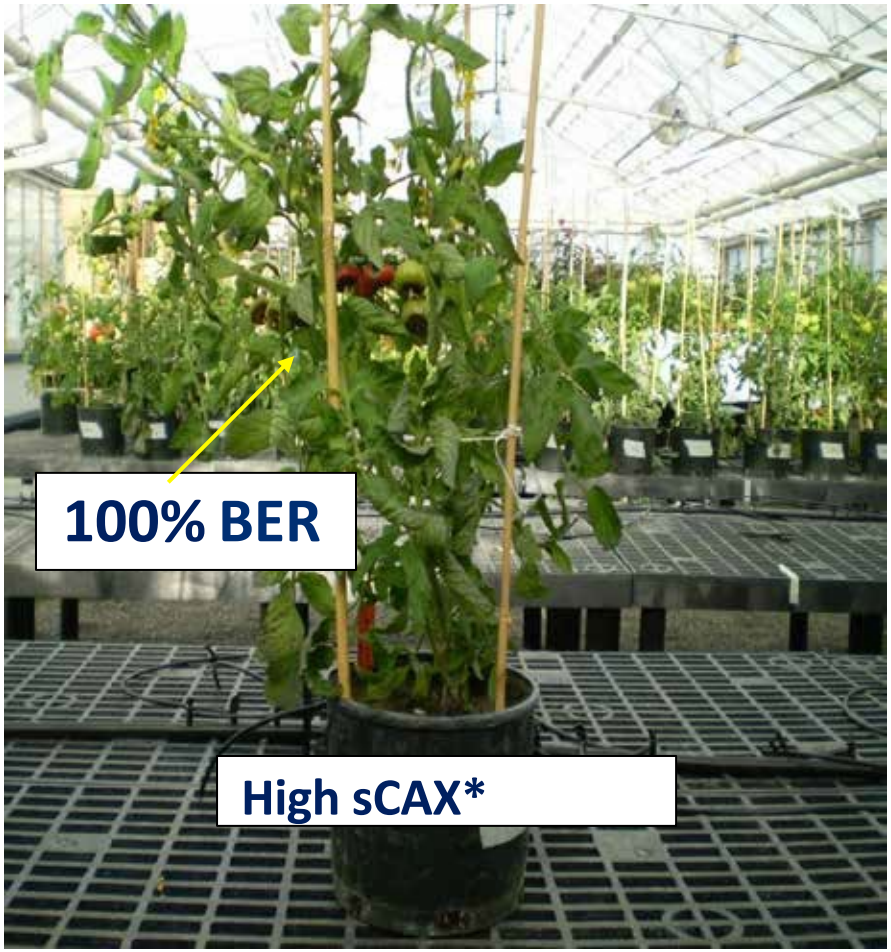


Total Ca^{++} content at the blossom-end of wild type and increased CAX1 tomato fruit four weeks after pollination.



Storing calcium in the vacuole increases blossom end rot



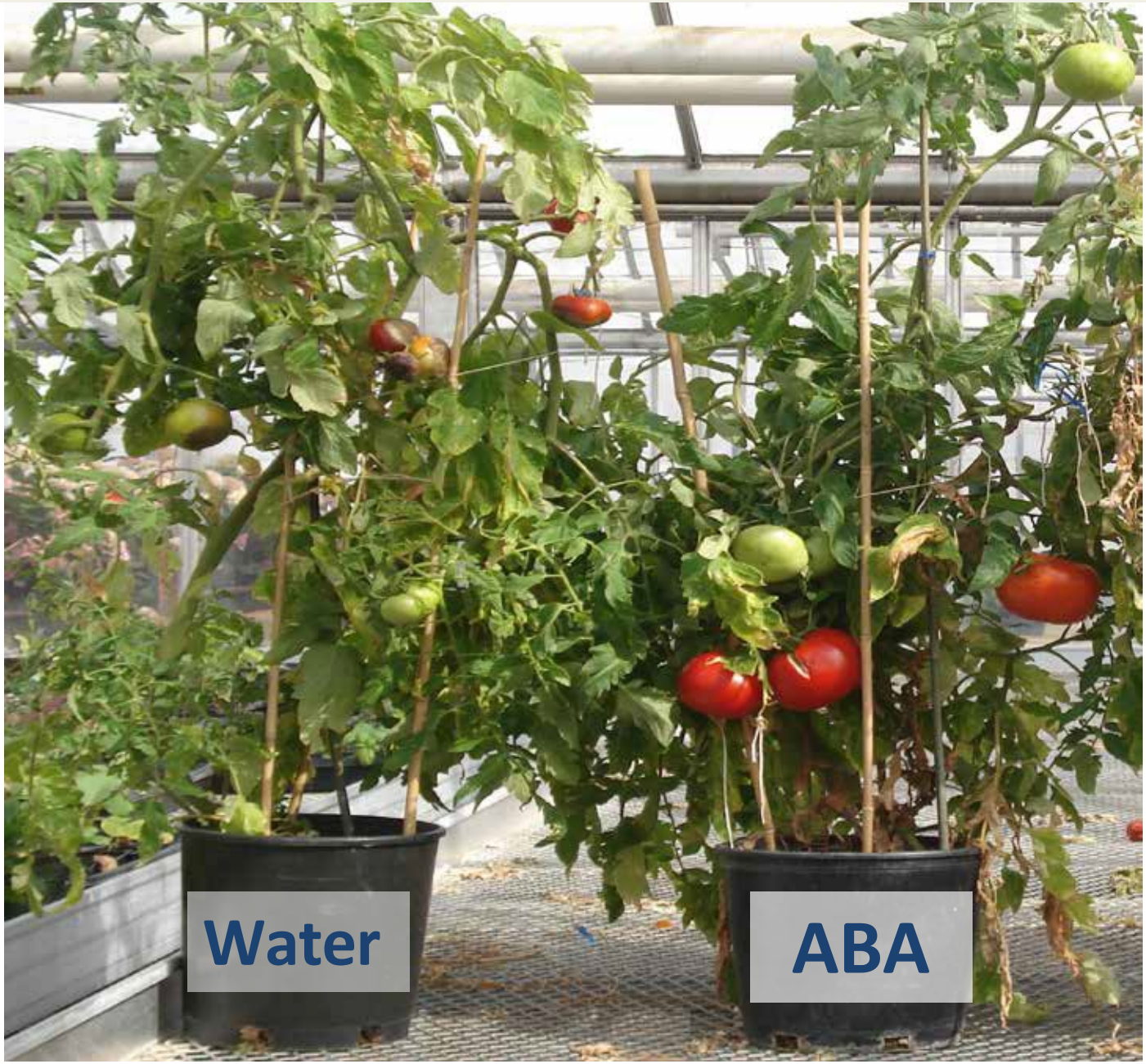


*Tomatoes expressing *CAX1*, an Arabidopsis Ca^{2+}/H^{+} antiporter

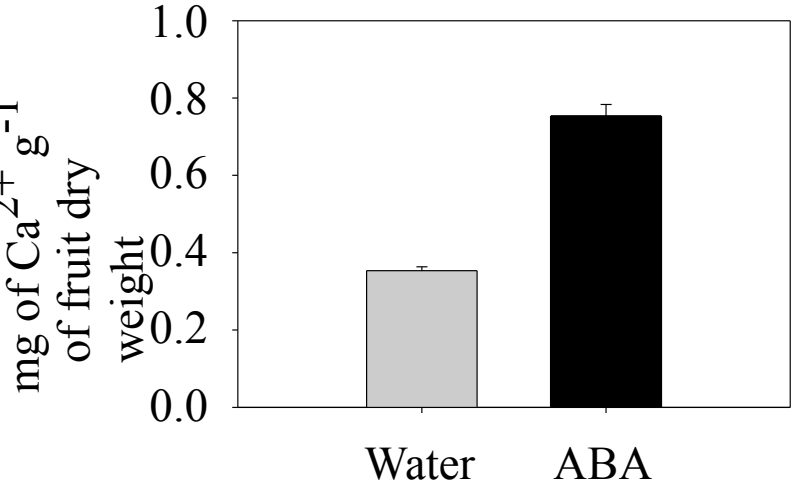
Abscisic Acid is a Natural Plant Hormone

- Growth inhibitor
- Induced by stress conditions
- Causes stomates to close
  - Reduces water loss and photosynthesis

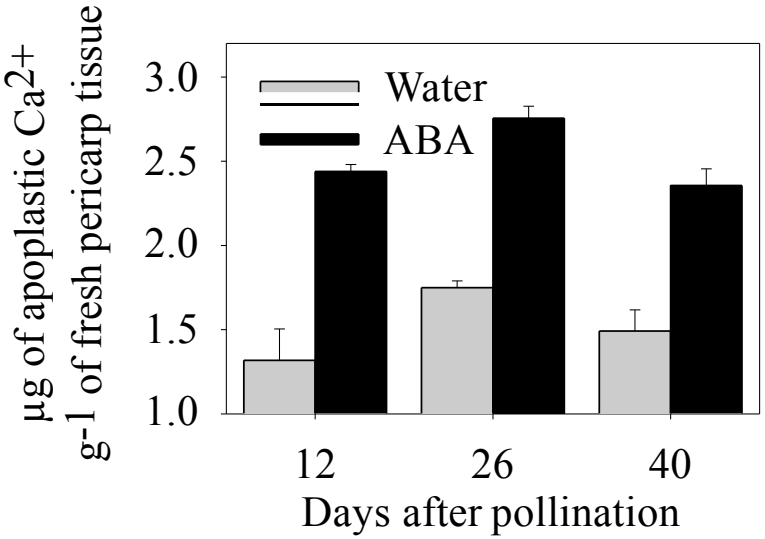
Cultivar Ace – 140 days after seed germination



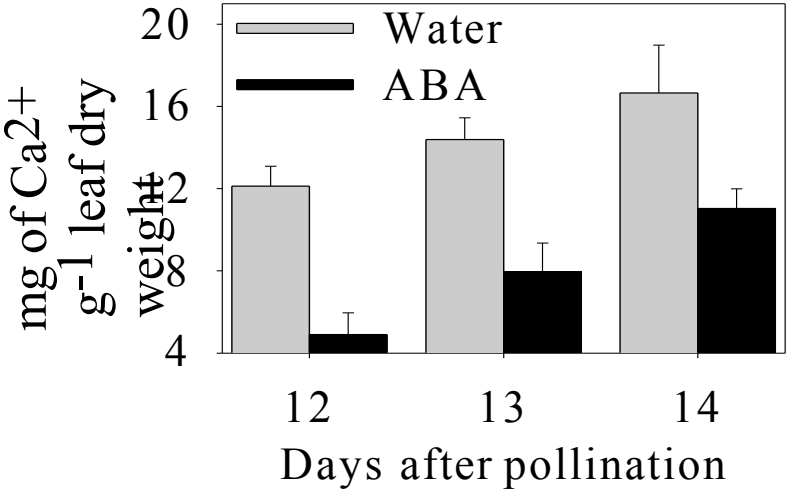
Fruit [Ca^{2+}] – 45 DAP



Apoplastic [Ca^{2+}]



Leaf [Ca^{2+}]



Conclusions

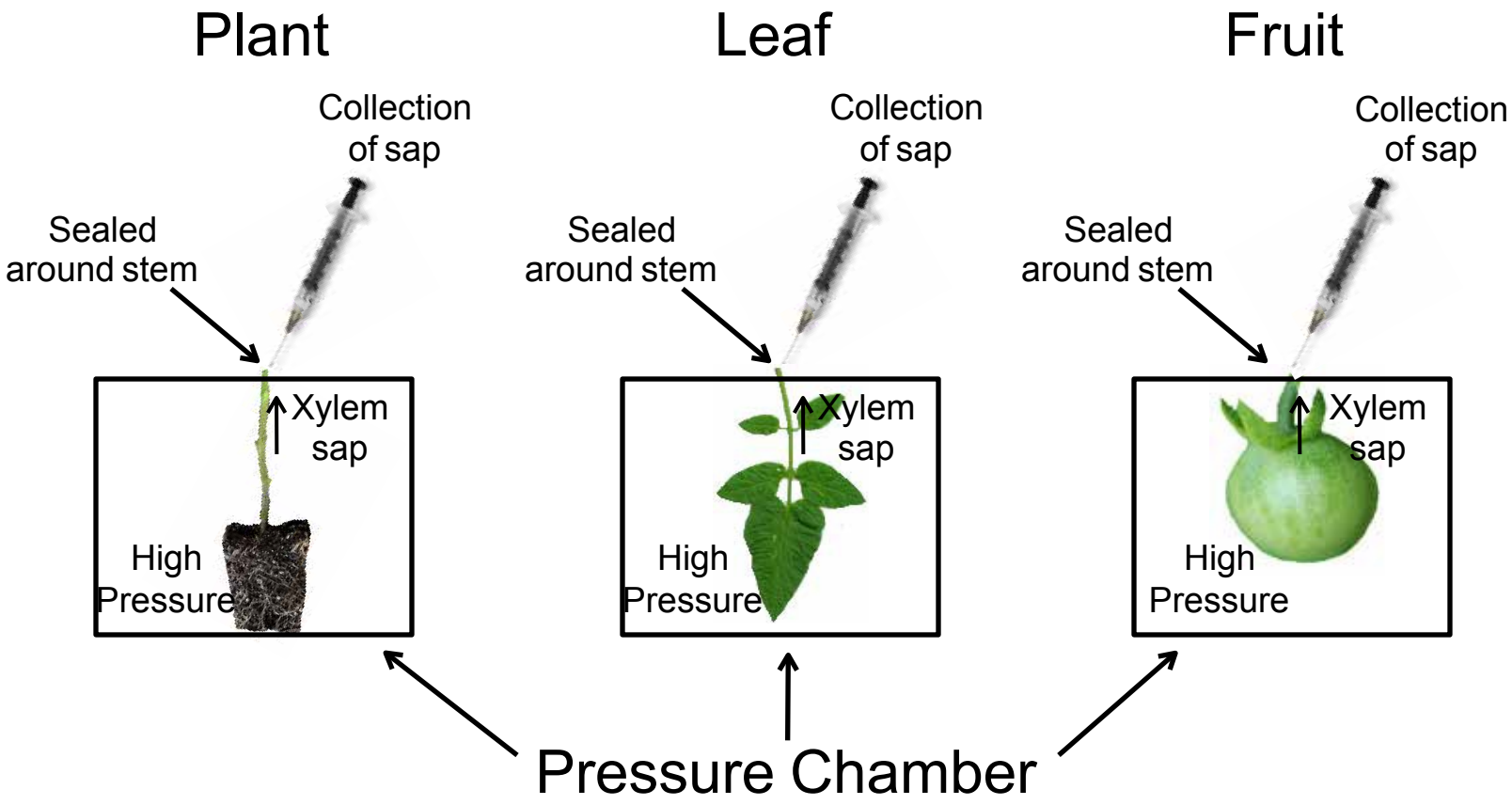
- ABA prevents BER development in tomato
- Increases plant water and Ca use efficiency
- Ca^{++} accumulation in ABA treated fruit cannot be fully explained by xylemic water uptake driven by fruit transpiration and growth

Analysis of Xylem Sap Calcium and Flow Rates in Tomato

Determine the effect of ABA on:

- Ca concentration during fruit growth and development
  - in the stem xylem sap
  - in the leaf xylem sap
  - in the fruit xylem sap
- Xylem sap flow rate during fruit growth and development
  - in the stem
  - in the leaf
  - in the fruit
- Plants treated with ABA as a whole (spray) and fruit only (dip)

Extraction of Xylem Sap



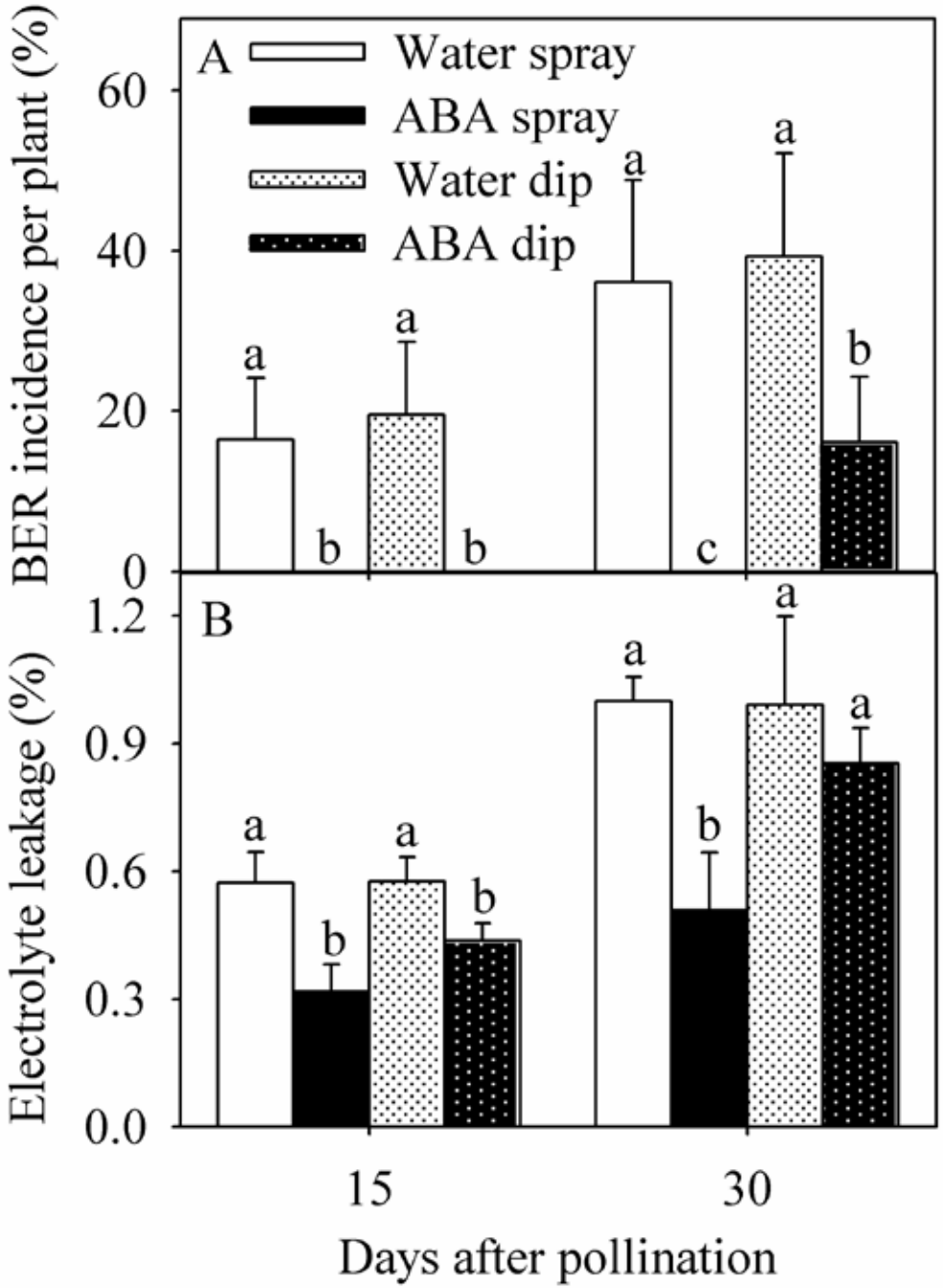
(Schurr, 1998)

Ca Concentrations and Sap Flow Rates

Ca concentration in the xylem sap

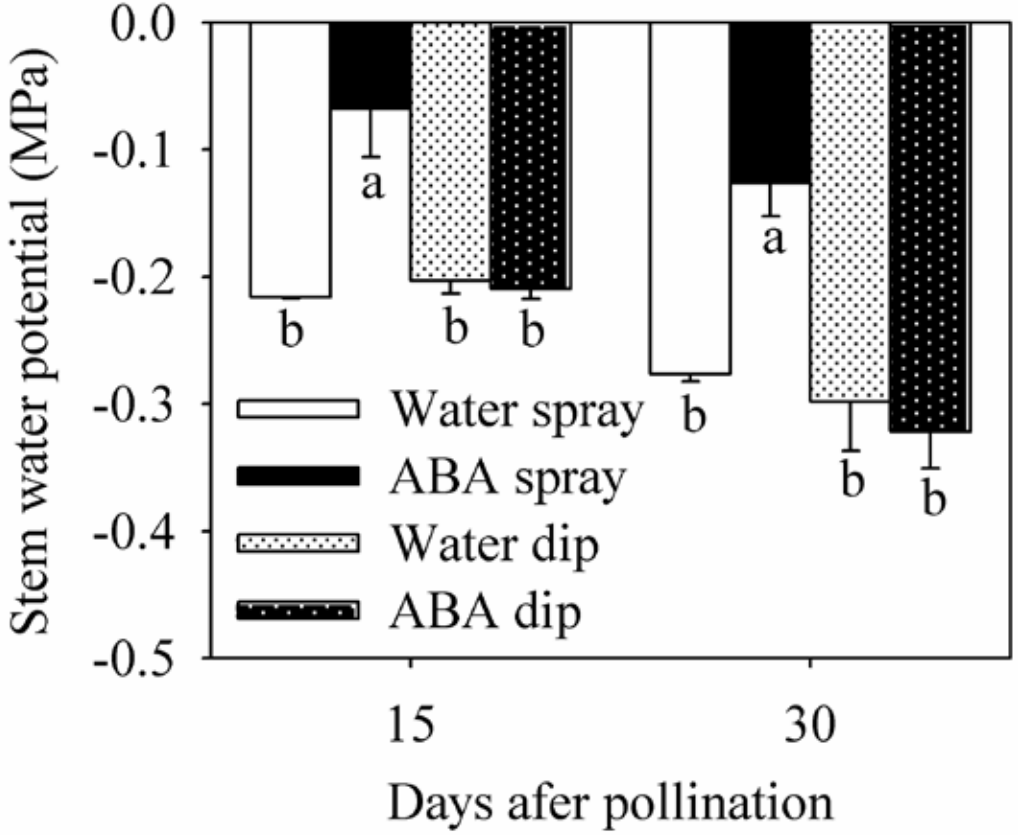
Ca concentration in leaf and fruit tissue

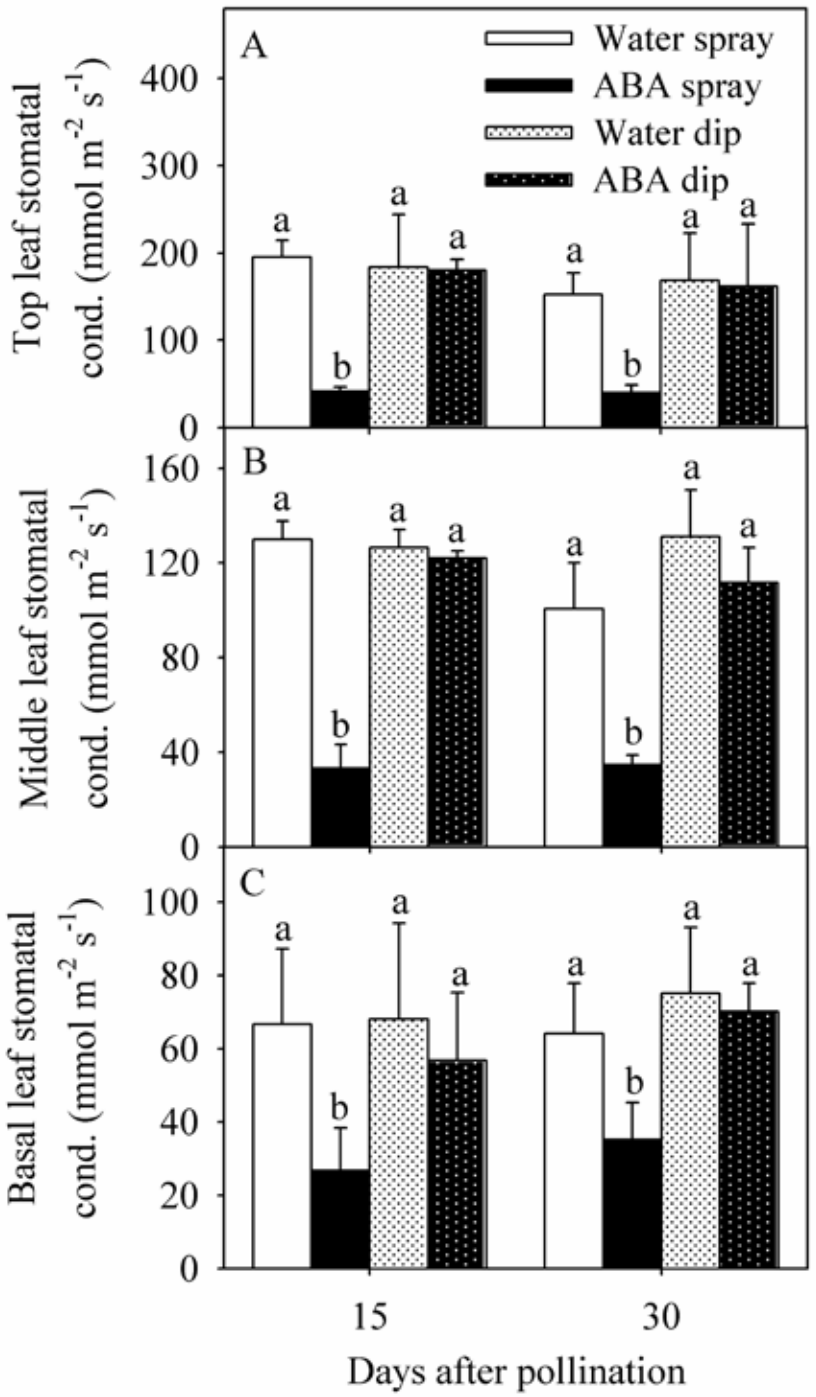
Xylem sap flow rate in the stem, leaf peduncle, and fruit peduncle will be measured with a heat pulse technique utilizing an external sap flow sensor

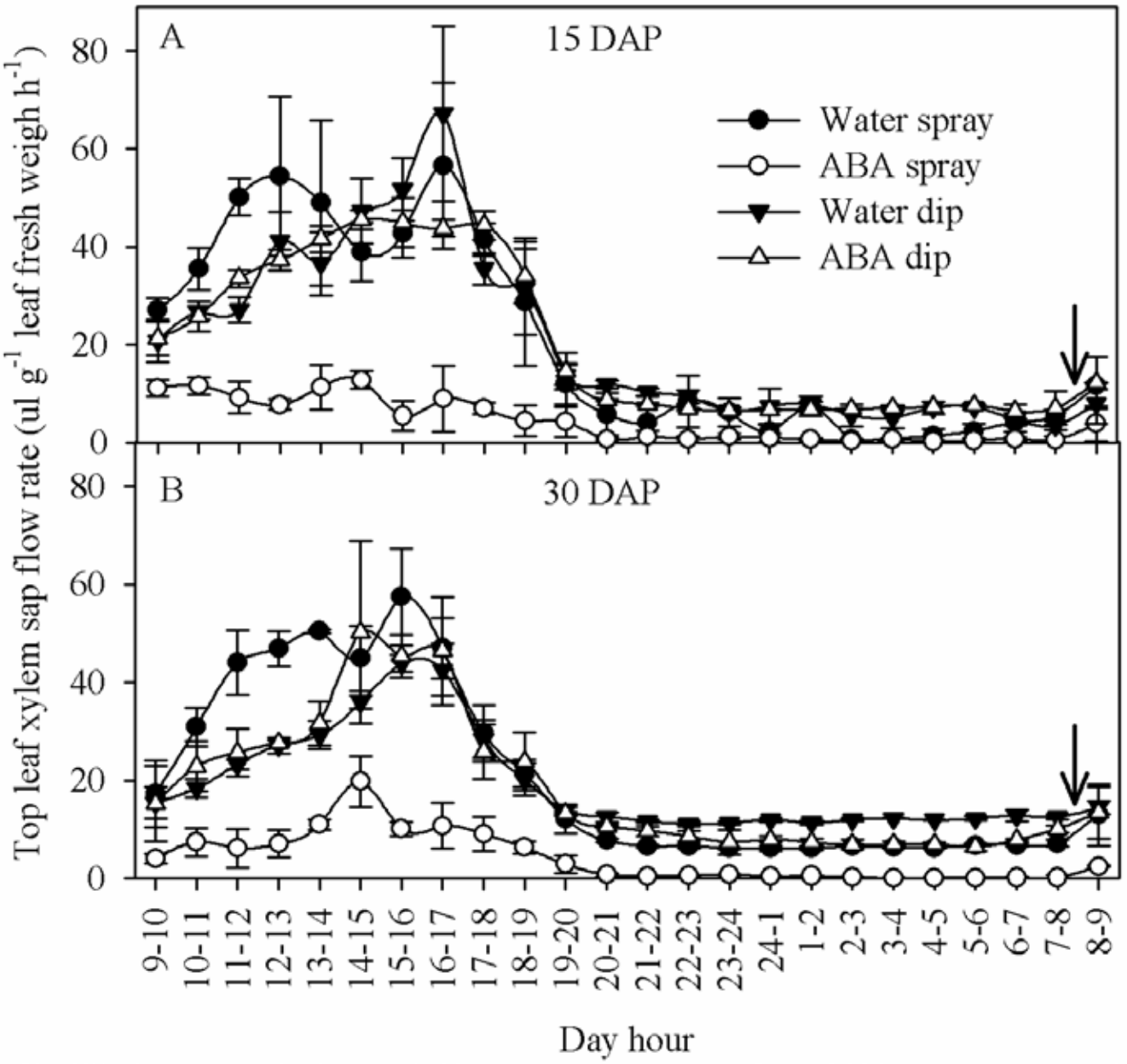


ABA had both whole plant and fruit specific effects

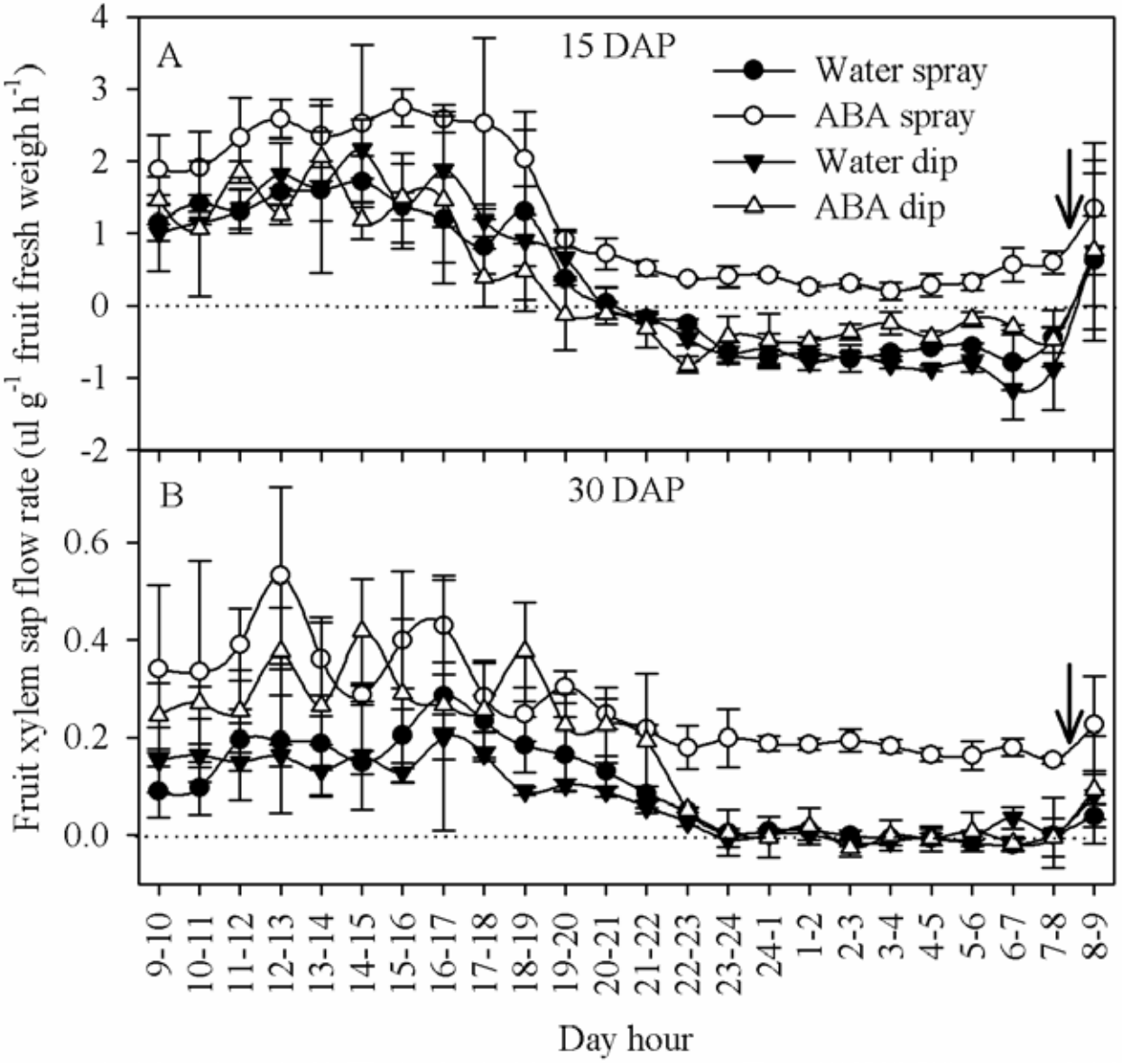
Leaf Specific Effects of ABA







ABA Spray Reduced Sap Flow to Leaves



ABA Spray Increased Sap Flow to Fruit

Fruit Dip also had a smaller increase in sap flow

There were also fruit specific effects on reducing BER, unrelated to spray effects

Influence of ABA on Blossom End Rot

1. Water stress increases BER because more water goes to leaves than fruit

2. Plants with greater production of ABA under stress will close the stomates and increase water flow to the fruit.

3. May explain variable susceptibility among varieties.

Plant Responses to its Environment Result in Shifts in Hormone Levels that can Promote Blossom End Rot

How can this knowledge help?

1. Information used to breed resistant varieties
2. Develop better management practices

Factors that Influence Blossom End Rot Development Fruit

1. Calcium uptake to the fruit
    a) Not enough calcium in soil
        a) California soils generally have enough
        b) Calcium sprays may help
    b) Plant cannot take up enough Ca
        a) Mg, K, ammonia nitrogen compete with calcium for uptake
2. Calcium localization within fruit cells
    a) Hormone effects

Soil and Moisture Management

- Avoid extreme fluctuations in soil moisture
  - Don’t let soil get completely dry early in season
  - Irrigate before periods of high heat
  - Compost or mulch may help regulate soil moisture
- Test soil for salt, calcium, and other nutrients
  - Saline soils lead to more BER
- Avoid excessive nitrogen application
  - Use nitrate source instead of ammonia, ammonia reduces Ca uptake
- Limit cultivation to protect roots

Additional Resources

General BER practical reference:
Managing Blossom-End Rot in Tomatoes and Peppers. UCANR, Placer County. 2010.
http://ucanr.edu/sites/placernevadasmallfarms/files/86509.pdf

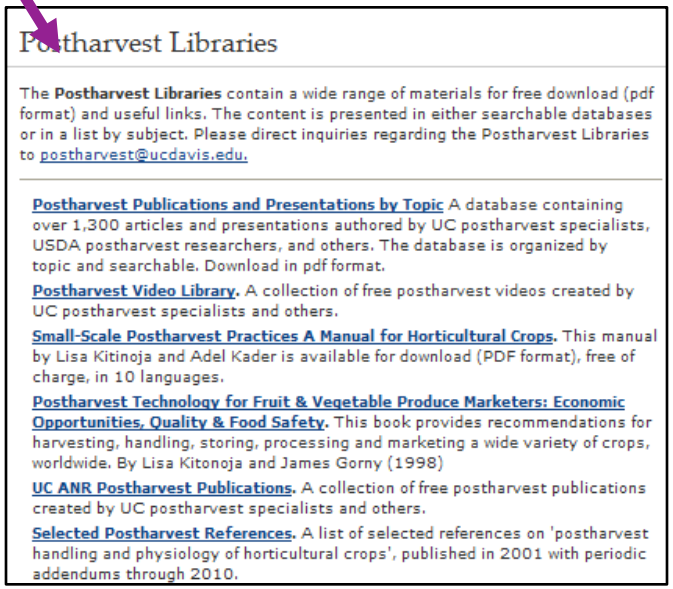
Other resources:
UC Small Farm Program http://sfp.ucdavis.edu/
- Soil testing recommendations/guidelines

UC Davis Postharvest Technology Center
http://postharvest.ucdavis.edu/
- Produce factsheets
- Workshops/short courses

The World's Premiere Source of Postharvest Information:

http://postharvest.ucdavis.edu

Produce Facts



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Questions?