The Black Pecan Aphid Elicits Localized Senescence in Leaves

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Understanding leaf senescence provides insight for managing the black pecan aphid (BPA).

Although not entirely similar, the injury imparted to pecan by the BPA likely follows some of the same pathways as do leaves changing color in the fall.

Leaf Senescence

- Nutrient re-mobilization from leaves to other parts of the tree.
  - A genetically controlled degenerative process leading to cell death.
  - A part of normal leaf development.
    - induced and controlled by endogenous factors operating during plant growth and maturation.
  - Can be prematurely induced by environmental stimuli.

Leaf Senescence & Environmental Stress

- The relationship of these two is brought about by plant hormones activating processes related to senescence and plant responses to biotic and abiotic stresses.
  - Ethylene, Jasmonic Acid and Salicylic Acid
    - Levels increase during senescence and induce the expression of specific genes.

Seasonal Changes in Nutrient Import/Export by Leaves

On many plant species, many aphid species feed on senescing leaves exploiting nutrients that are being remobilized out of the leaf.

manipulate leaf senescence to its benefit.

Leaf chlorosis is not a result of BPA feeding, rather it is necessary for the BPA to feed.

-initiates the breakdown of chlorophyll and feeds on the resulting catabolites.

Senescing Leaves

Nutrient Export & Remobilization

Senescence-Delaying Plant Bioregulators

- Auxins
  - In terminal buds, suppress side buds; stimulate root growth.
  - Affects cell elongation, apical dominance and fruit drop/rention. May reduce sensitivity of cells to ethylene.
  - Initiates roots in plant cuttings.
  - Suppresses abscission of fruits and leaves.

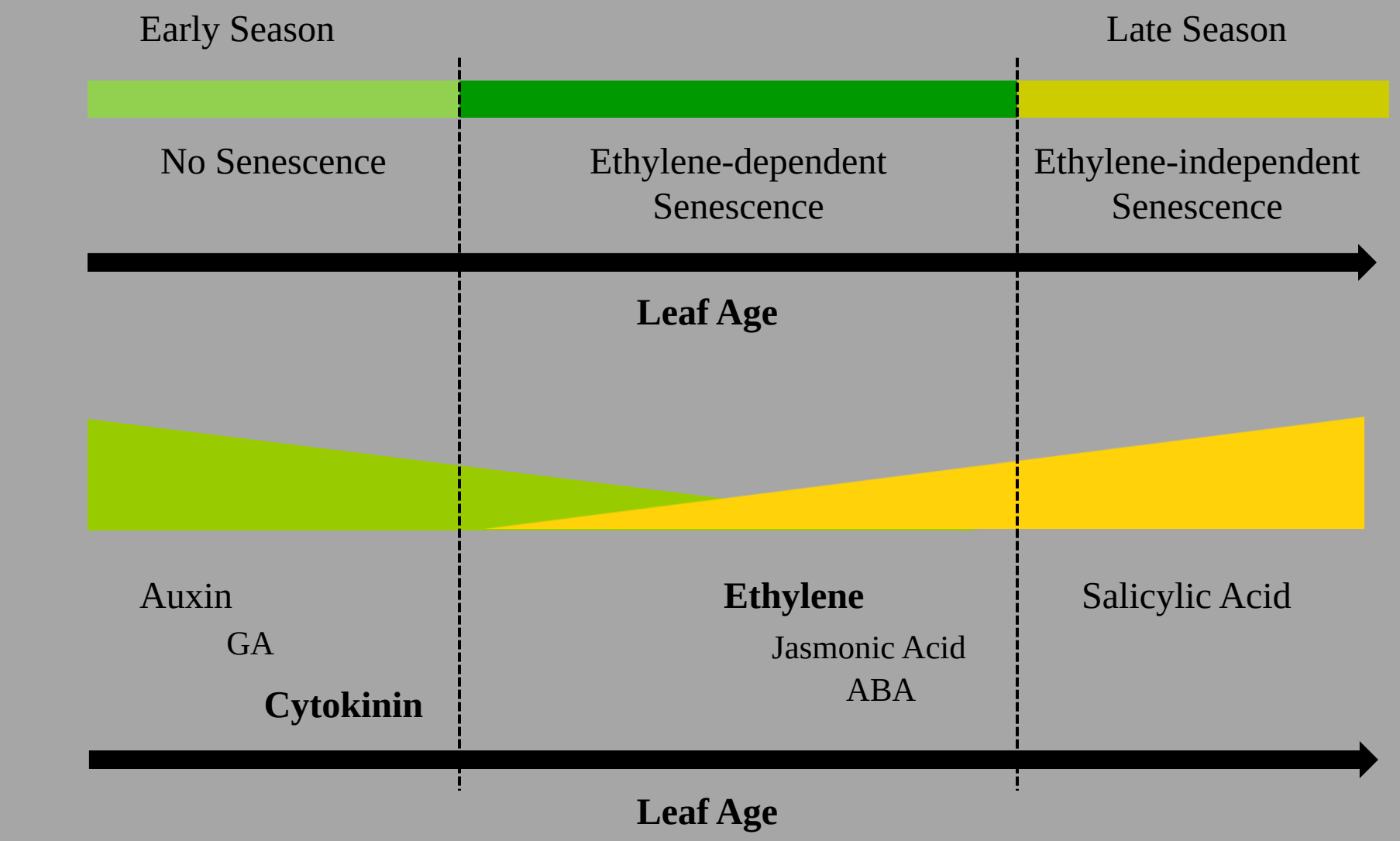
- Gibberellins (e.g., ProGibb 4%)
  - Promote stem and leaf growth.
  - Can delay protein and *chlorophyll degradation*.
  - Levels decline as leaf matures.

- Cytokinins
  - Strongest effect of all bioregulators on delaying senescence.
  - Prevent chlorophyll degradation.
  - a drop in endogenous levels initiates senescence.

Senescence-Promoting Plant Bioregulators

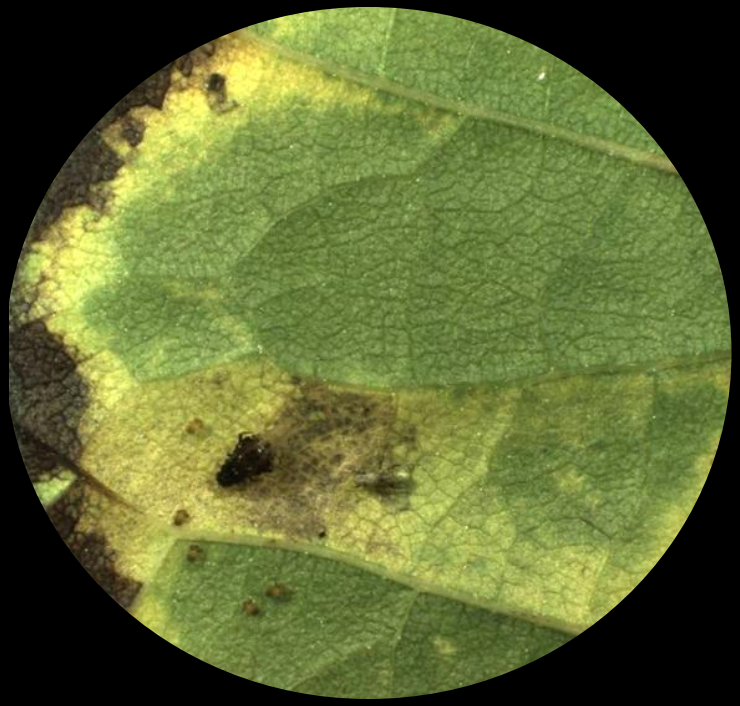
- Abcissic Acid
  - Can inhibit the action of other hormones to reduce growth when the plant is stressed.
  - Affect guard cells to close leaf stomata.
- Ethylene
  - Can be produced in response to plant injury
  - The aging/ripening hormone in plants
  - Can cause loss of chlorphyll
- Jasmonic Acid/Salicylic Acid
  - Regulate plant response to injury
  - Important regard SAR (systemic acquired resistance)

Seasonal Life of a Leaf Leading to Senescence



Black pecan aphid-elicited chlorosis

1st instar to Adult



Leaf Senescence and the BPA

- By understanding the processes controlling leaf senescence, the biological process used by the BPA to elicit senescence-like leaf injury can be mitigated.

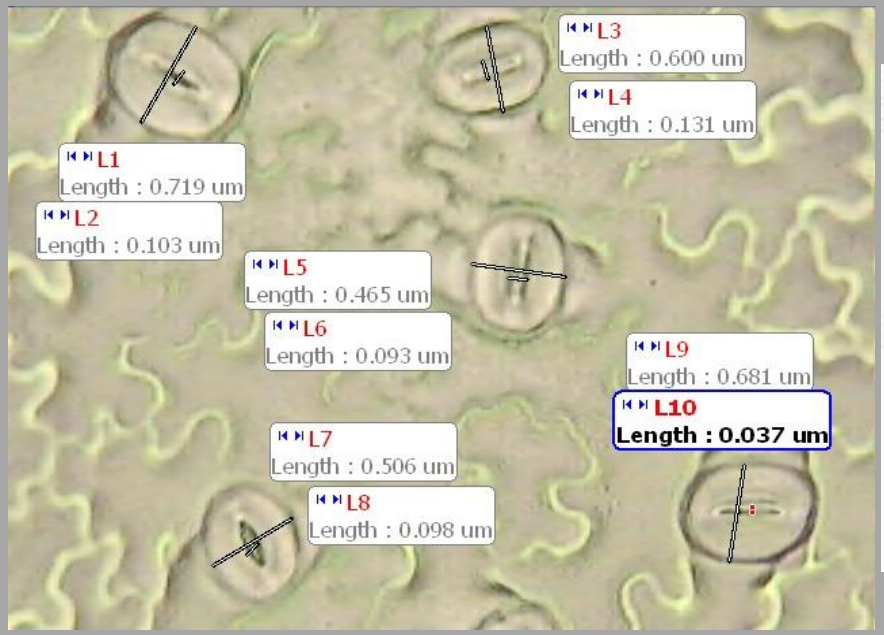
BPA can be affected through the application of certain plant bioregulators, e.g., gibberellic acid (GA_3) and forchlorfenuron, leading to:

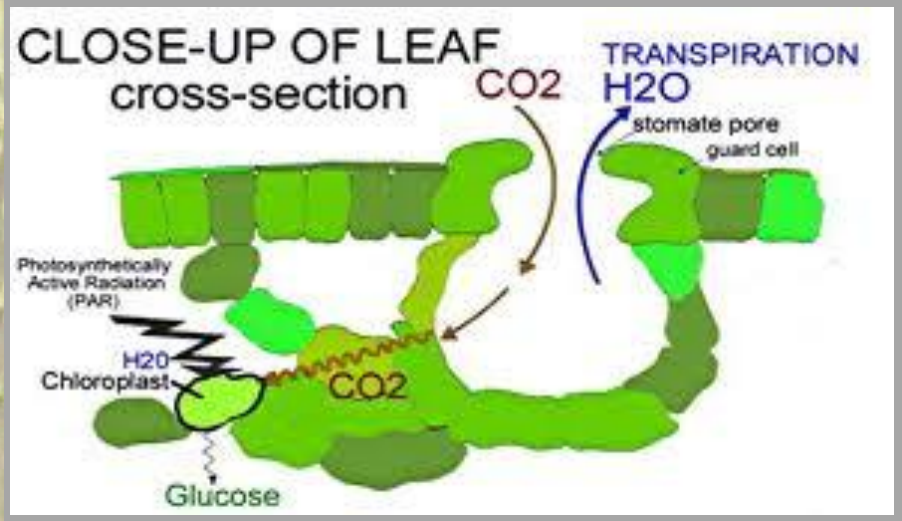
- **Increased time to develop**
  - **Increased opportunity for predation**
  - **Slower population growth**
- **Longer interval before onset of leaf chlorosis**
- **Overall decreased chlorosis**

- **What is the mechanism for elicitation of chlorotic feeding injury?**

Susceptibility of Pecan Foliage to BPA

- Plant bioregulators are a large part of the equation.
- Density of leaf stomata may be another part of the equation.





Stomata

- The exchange of oxygen and carbon dioxide in the leaf (as well as the loss of water vapor in transpiration) occurs through stomata.

- Normally, stomata are open during the day and closed at night.

  - *But*…..Stomata may close at any time due to drought, cold, air pollutants, or high CO_2 concentrations in response to *in vivo* production of ABA.

  - *And*.....GA_3 can antagonize the action of ABA on closing stomata (i.e., the stomata open).

- Leaf stomata density can be influenced by CO_2, temperature, humidity and light intensity near the plant

BPA Susceptibility and Stomata Density

- **Supporting evidence:**
  - Senescence of excised foliage occurs faster in the dark (when stomata are normally closed) than in the light (when stomata are normally open)
    - Even when light, some reagents cause stomata to close and senescence occurs as if it is dark
    - In the dark, some reagents cause stomata to remain open and senescence is delayed
  - Shaded leaves have fewer stomata (less transpiration) than full sun leaves *and* BPA damage typically begins in the shaded interior of the pecan canopy.

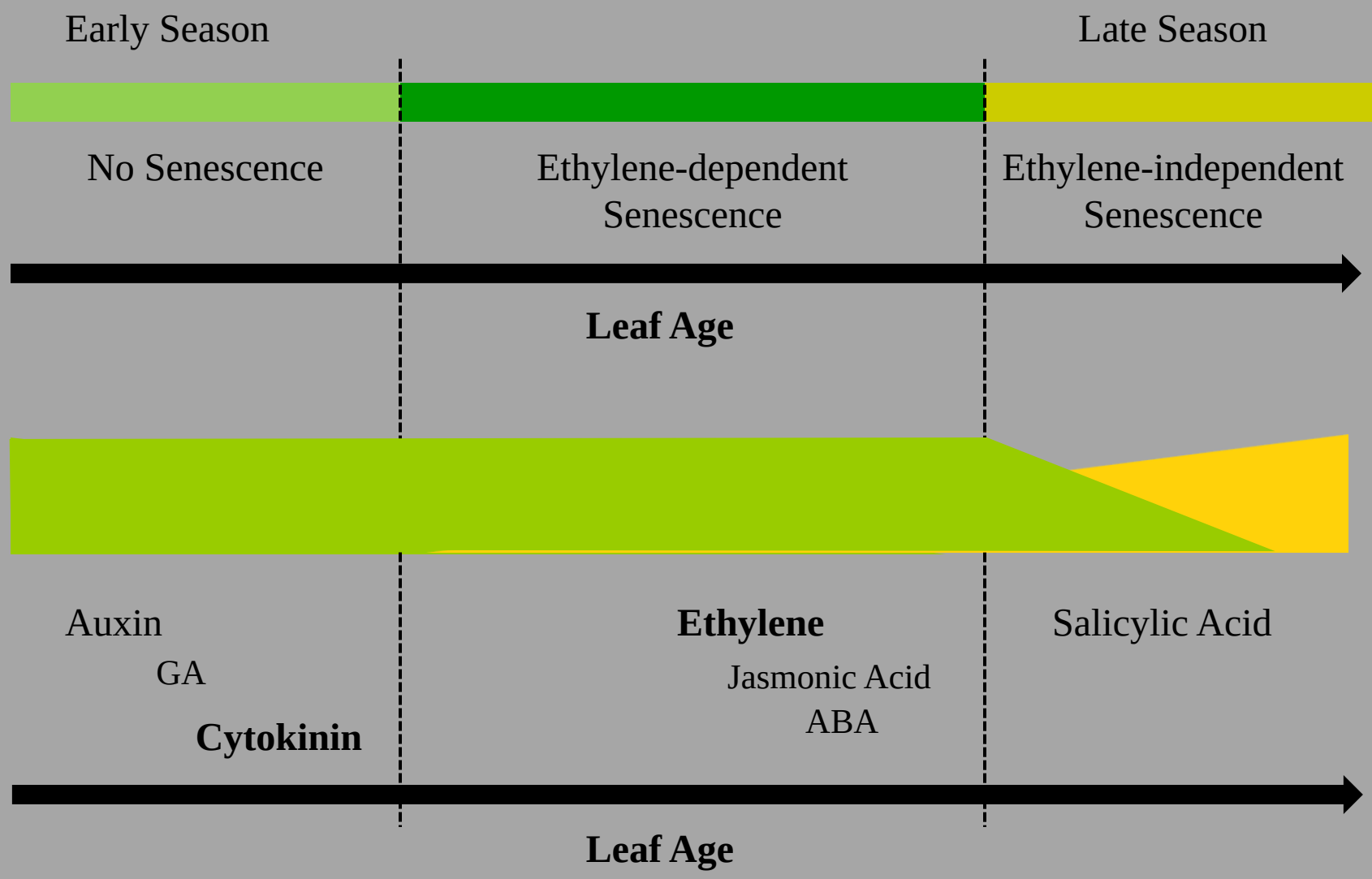
BPA Susceptibility and Stomata Density

- **Supporting evidence:**
  - The role of ABA as a promoter of senescence is well established (Giridhar & Thimann 1986).
    - *ABA causes stomata to close*

  GA_3 inhibits ABA signaling during stomatal closing (Goh et al. 2009)
    - *GA_3 causes stomata to remain open*
    - *GA_3 retards chlorophyll loss; does not stimulate ethylene production*
  - Ethylene production correlates with the onset of ripening or other symptoms of senescence (Aharoni and Lieberman 1979).
    - *Ethylene diffuses from the plant via open stomata*

  - As stomata density decreases, BPA damage increases
    - *Could it be as simple as BPA stimulating ethylene production when stomata are closed?*

If levels of senesce-retarding hormones remained high for a longer period, would there be a negative impact on the BPA?

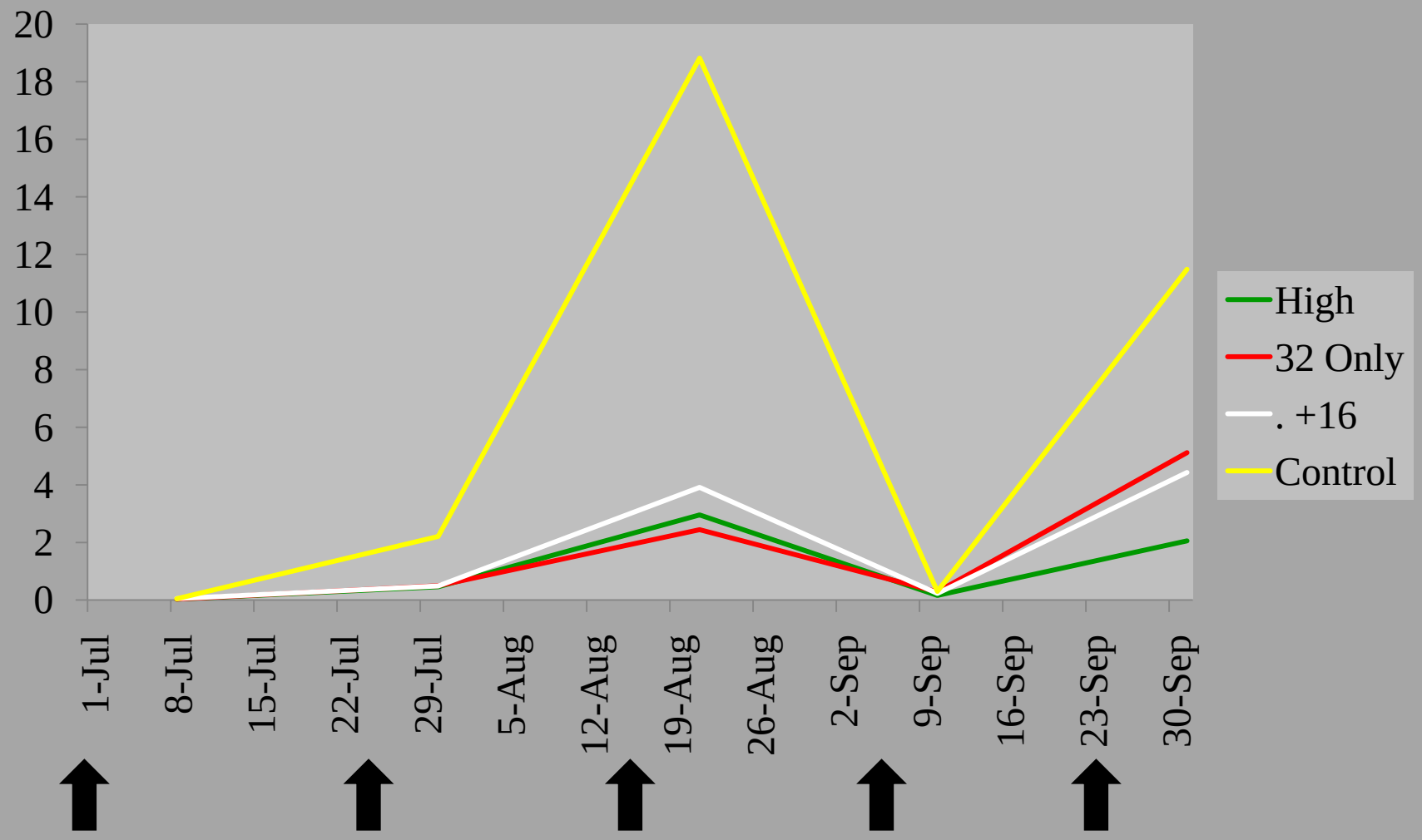


2014 ProGibb 4% Orchard Study

Can the natural decrease in endogenous levels of GA_3 in pecan foliage be augmented and affect the BPA?

	Treatment (oz/A) Application Dates				
Treatment	July1	July 24	August 14	September 4	September 22
“32 Only”	32	32	32	32	32
“+ 16”	16	32	48	64	80
High	32	32	64	64	80
Control	0	0	0	0	0

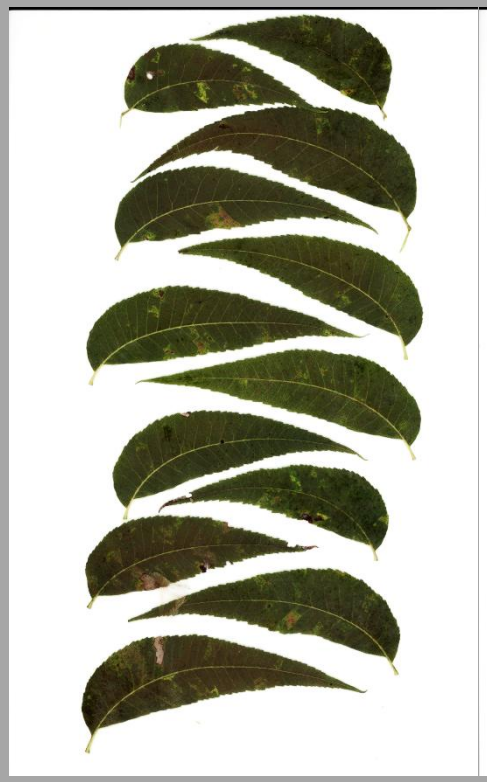
2014 ProGibb 4% Orchard Study
BPA Adults + Nymphs



BPA Injury with Gibberellic Acid (GA_3)

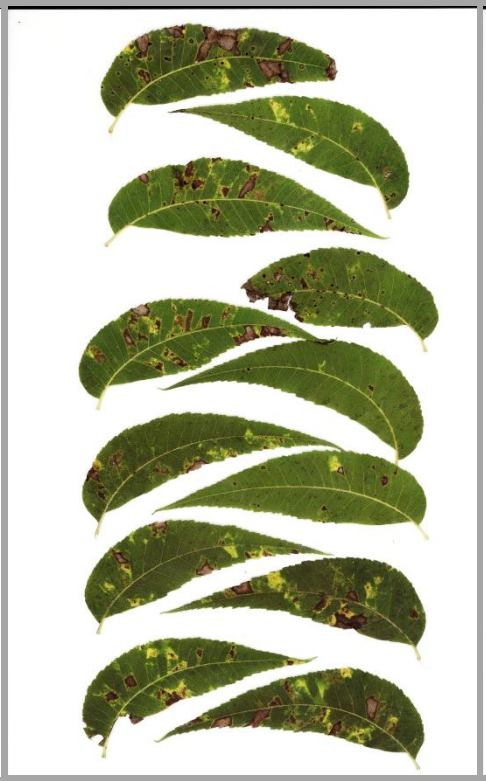
samples collected Aug. 29

(3 applications of ProGibb 4%)



32 Only

16, 32, 48



Control

32, 32, 64

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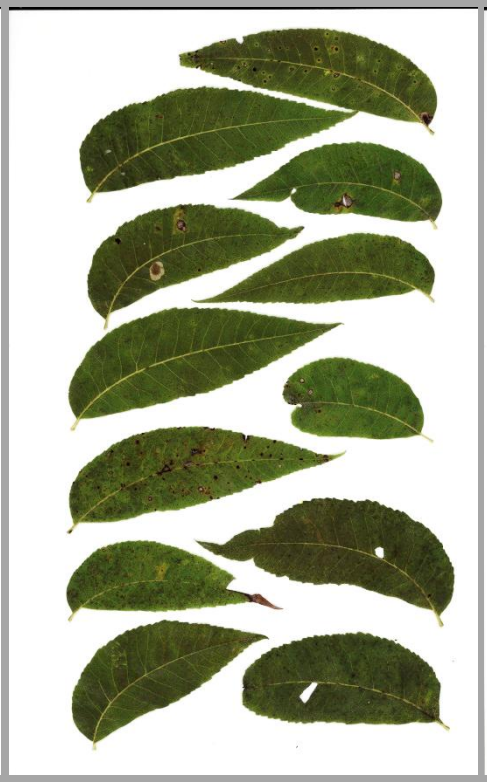

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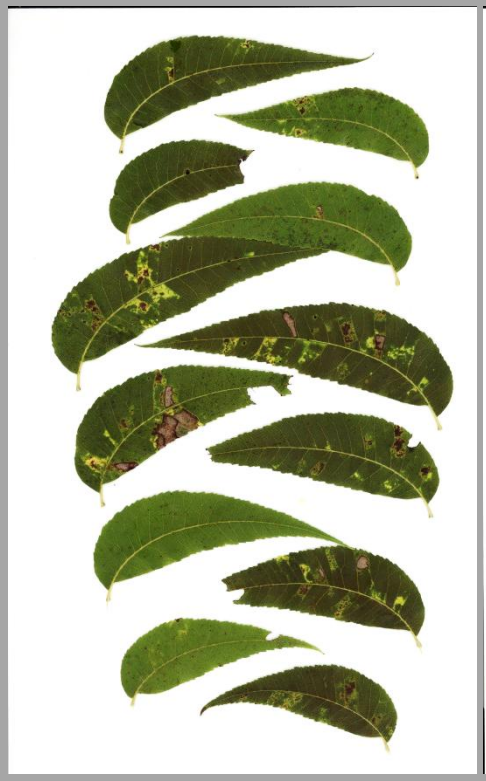

Control

32, 32, 64

- ProGibb 4% is not a stand-alone product for BPA - but it can help!
  - ProGibb + Prestige is better but Prestige is not labelled for pecan.

- Next step:
  - Examine effect of other senescence-retarding plant bioregulators on the BPA (e.g., cytokinins).
    - When applied singly
    - When applied in combination with ProGibb 4%

Acknowledgments

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