EFFECT OF HORMONES AND GROWTH REGULATORS ON VEGETATIVE GROWTH OF CITRUS

HOS 6545 – ADVANCED CITRICULTURE I
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Plant hormones and growth regulators

- Plant hormones: naturally occurring organic substances which influence physiological processes at low concentrations*

- Plant growth regulators (PGR’s): typically denote synthetic substances. PGR’s might be analogues of plant hormones or substances that alter the plant’s ability to produce plant hormones

The Five “Classical” Plant Hormones

- **Abscisic Acid**: Induces stomatal closure, inhibits shoot growth. Synthesized in roots and mature leaves, particularly in response to water stress.

- **Auxin**: Inhibits growth of lateral buds. Encourages root development, delays leaf senescence. Synthesized in leaf primordia and young leaves.

- **Cytokinin**: Stimulates cell division, stimulate growth of lateral buds, stimulates leaf expansion and delays leaf senescence. Synthesized in root tips.

- **Ethylene**: Stimulates abscission of organs, fruit ripening, flower induction. Synthesized in most tissues.

- **Gibberellin**: Stimulates cell division and elongation, fruit set and growth, delays peel senescence in Citrus. Synthesized in young shoot tissue.
Newer plant hormones

- Polyamines –
- Jasmonic acid –
- Salicylic acid –
- Active in small amounts - ?
- Do plant hormones differ than co-factors in function?
- Role in gene regulation

- Plant hormones in citrus were not known, but assumed to be similar to those reported for other plants.
  - Growth of citrus different, levels of hormones could be also.
- Need to evaluate in several tissues since production may be tissue specific
- PURPOSE: Determine hormones in tissues
Vegetative shoots contain auxin and GA, not cytokinins or ABA at detectable levels.
Fig. 2. Well watered and wilted leaves of Shamouti orange tested for ABA

Chromatographic zone of ABA shows in wilted tissue.
DISCUSSION & CONCLUSIONS

• Citrus demonstrated to have standard hormones in tissues and respond to stress by producing ABA
Effect of Gibberellic Acid on Growth and Dormancy in Citrus

Background

• Between citrus shoot flushes are periods of quiescence or “dormancy”.
• Gibberellic acid (GA₃) stimulated growth in young growing shoots of citrus and caused renewed vegetative growth of grapefruit trees.

Objective (implied):
• To test whether exogenous GA₃ application hastens vegetative growth of quiescent grapefruit trees.
Effect of Gibberellic Acid on Growth and Dormancy in Citrus

Materials and Methods:

- 2-4 year old Red Blush grapefruit on sour orange rootstock
- $\text{GA}_3$ was applied at various concentrations and during various seasons
GA did not stimulate shoot growth overall, average length similar

<table>
<thead>
<tr>
<th>Tree age and concentration of gibberellic acid</th>
<th>Treatment dates (1957)</th>
<th>Observation date (1957)</th>
<th>Length of new shoots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>cm.</td>
</tr>
<tr>
<td>3-year-old trees:</td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>0 p.p.m.</td>
<td>Mar. 1, Apr. 8</td>
<td>May 21</td>
<td>9</td>
</tr>
<tr>
<td>100 p.p.m.</td>
<td></td>
<td>May 21</td>
<td>10</td>
</tr>
<tr>
<td>3-year-old trees:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 p.p.m.</td>
<td>Mar. 1, Apr. 8</td>
<td>July 15</td>
<td>18</td>
</tr>
<tr>
<td>100 p.p.m.</td>
<td>and May 9</td>
<td>July 15</td>
<td>19</td>
</tr>
<tr>
<td>1000 p.p.m.</td>
<td>May 9</td>
<td>July 15</td>
<td>14</td>
</tr>
<tr>
<td>2-year-old trees:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 p.p.m.</td>
<td>May 9</td>
<td>July 15</td>
<td>14</td>
</tr>
<tr>
<td>50 p.p.m.</td>
<td></td>
<td>July 15</td>
<td>15</td>
</tr>
<tr>
<td>100 p.p.m.</td>
<td></td>
<td>July 15</td>
<td>17</td>
</tr>
<tr>
<td>1000 p.p.m.</td>
<td></td>
<td>July 15</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 2.—Effect of 100-p.p.m.-gibberellic acid treatment during fall, winter and spring on length of the dormant period of young Red Blush grapefruit trees.

<table>
<thead>
<tr>
<th>Date of termination of last period of growth prior to treatment</th>
<th>Date of treatment</th>
<th>Date new shoot growth initiated</th>
<th>Length of dormant period</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 15, 1956</td>
<td>December 12, 1956</td>
<td>February 1, 1957</td>
<td>109 Days</td>
</tr>
<tr>
<td>February 19, 1957</td>
<td>March 1, 1957</td>
<td>March 27, 1957</td>
<td>36 Days</td>
</tr>
<tr>
<td>April 19, 1957</td>
<td>May 9, 1957</td>
<td>June 15, 1957</td>
<td>57 Days</td>
</tr>
<tr>
<td>October 15, 1957</td>
<td>November 18, 1957</td>
<td>February 15, 1958</td>
<td>123 Days</td>
</tr>
<tr>
<td></td>
<td>December 2, 1957</td>
<td>December 16, 1957</td>
<td>62 Days</td>
</tr>
<tr>
<td></td>
<td>December 16, 1957</td>
<td>December 16, 1957</td>
<td>62 Days</td>
</tr>
<tr>
<td></td>
<td>December 30, 1957</td>
<td>December 30, 1957</td>
<td>76 Days</td>
</tr>
</tbody>
</table>

Treatments appear to shorten dormant period, not what authors say? No statistics
GA treated shoots and leaves in 2, 3, and 4. Terminal bud growth (2), thorns (3) and narrow leaves (4)
Effect of Gibberellic Acid on Growth and Dormancy in Citrus

Results and Discussion:

- The shoots of GA$_3$ treated trees were sometimes unusually long, thorny, and had long, thin leaves.
- GA$_3$ did not increase total shoot elongation because fewer buds grew on treated vs. non treated trees.
- GA3 hastened bud growth, particularly in the winter.
- Early GA$_3$-induced bud growth might make trees more susceptible to freeze injury in the winter.
Effect of Gibberellic Acid on Growth and Dormancy in Citrus

Strengths:

- Good observations and illustrations of GA$_3$ effects.
- Findings are still relevant since GA$_3$ is sometimes applied in the fall in areas prone to freezing.

Weaknesses:

- Objectives were not explicitly stated.
- Lack of statistical analyses limits comparisons among treatments.
- No data regarding the number of growing shoots.
- There was some “discussion” in the “results” section.

- Paclobutrazol appears to act as an anti-gibberellin for shoot and root growth.
- Does this compound alter assimilate production?
- Purpose: Measure growth of roots as a single sink when GA or Paclobutrazol applied. Determine effects
GA and PB effects on leaves and roots of citrus

GA and Paclobutrazol decreased leaf dry weight slightly, GA increased length and dia of taproot, while PB increased dia but decreased length. All treatments decreased lateral roots/plant and PB decreased their length over the control and GA. Overall root length decreased by GA, but more by PB.
GA and PB effects on dry weight of leaf and root parts

Little effect on mg/plant of leaves or roots. GA increased tap, but decreased lateral root weight/cm2. PB decreased both & therefore total. PB decreased tap/laterals, but GA increased & not reversed by PB
Root growth patterns from control (A), GA-10 (B) and PB-2 (C) or PB-10 plus GA-10.

Note stubby growth with more prominent lateral roots.

Like Swingle?
Discussion & Conclusions

• PB decreased root length growth, but little weight change effect.
• Author argues that GA restored length growth, but it appears to be only partial. Leaves not affected in growth, what about metabolism?
• Otherwise not a sink source effect.
• Shoot length is a big effect of GA, better place to measure?

- Paclobutrazol and other uniconazoles are gibberellin inhibitors that could reduce vegetative growth
- More long term studies needed to see if field responses are sufficient to justify use and if timing and method of application affect results
Materials and Methods

• Cleopatra mandarin seedling were treated with soil drench or foliar and then pruned back 4 times to observe long-term effects on citrus re-growth

• Mature Hamlin trees were treated with a trunk banding at the beginning of summer and again the next spring
Results

• No statistics

• Both products reduced growth if applied at 10 or 100 mg/pot – Table doesn’t explain if affect was less by 4th cutting

• Field treatments – spray worked on first flush, while trunk banding worked for both flushes
  – Spray reduced 40 to 60 %, trunk 20 % 1st flush and at most 20 % in spring
Summary

- Treatments did not reduce # of flush shoots
- Changed branch angle, more drooping growth reduced canopy size
- Internode length was reduced
- Shoot length affect for one flush, angle effect for up to 2 years

- Little work on GA carried out on woody plants, especially citrus
  - GAs generally stimulatory to growth
  - Growth retardants also known
- GA does appear to effect citrus growth and could have applications in nursery production
- PURPOSE: Compare compounds on growth of young seedlings for effects and possible use.
Shoot elongation of sweet-lime seedlings after treatments

**Table 2. Elongation rates (mm/day) during 3 successive growth periods (average of longest branches of seedlings)**

<table>
<thead>
<tr>
<th>Treatment (ppm)</th>
<th>Aug. 12–Aug. 28</th>
<th>Aug. 29–Sept. 28</th>
<th>Sept. 29–Oct. 26</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA 1600</td>
<td>7.60</td>
<td>4.50</td>
<td>6.21</td>
<td>6.16</td>
</tr>
<tr>
<td>800</td>
<td>6.56</td>
<td>4.50</td>
<td>5.97</td>
<td>5.68</td>
</tr>
<tr>
<td>400</td>
<td>3.97</td>
<td>3.59</td>
<td>5.63</td>
<td>4.40</td>
</tr>
<tr>
<td>200</td>
<td>2.33</td>
<td>3.76</td>
<td>5.34</td>
<td>3.81</td>
</tr>
<tr>
<td>100</td>
<td>1.39</td>
<td>3.44</td>
<td>6.33</td>
<td>3.72</td>
</tr>
<tr>
<td>50</td>
<td>1.26</td>
<td>2.55</td>
<td>3.42</td>
<td>2.41</td>
</tr>
<tr>
<td>Average GA</td>
<td>3.88</td>
<td>3.72</td>
<td>5.48</td>
<td>4.36</td>
</tr>
<tr>
<td>Control</td>
<td>0.93</td>
<td>1.33</td>
<td>2.52</td>
<td>1.59</td>
</tr>
<tr>
<td>AMO–1618 50</td>
<td>0.89</td>
<td>1.11</td>
<td>2.07</td>
<td>1.36</td>
</tr>
<tr>
<td>100</td>
<td>0.90</td>
<td>0.99</td>
<td>2.20</td>
<td>1.36</td>
</tr>
<tr>
<td>200</td>
<td>1.27</td>
<td>0.74</td>
<td>1.61</td>
<td>1.21</td>
</tr>
<tr>
<td>400</td>
<td>0.69</td>
<td>1.08</td>
<td>1.84</td>
<td>1.20</td>
</tr>
<tr>
<td>800</td>
<td>0.83</td>
<td>0.80</td>
<td>1.56</td>
<td>1.06</td>
</tr>
<tr>
<td>Average AMO–1618</td>
<td>0.92</td>
<td>0.94</td>
<td>1.86</td>
<td>1.24</td>
</tr>
<tr>
<td>AMO–1618 200 + GA 200</td>
<td>1.84</td>
<td>3.52</td>
<td>6.44</td>
<td>3.93</td>
</tr>
<tr>
<td>AMO–1618 200 + GA 100</td>
<td>2.24</td>
<td>2.99</td>
<td>4.48</td>
<td>3.24</td>
</tr>
<tr>
<td>AMO–1618 200 + GA 50</td>
<td>2.07</td>
<td>1.81</td>
<td>3.84</td>
<td>2.57</td>
</tr>
</tbody>
</table>

Elongation for different time periods after treatment with GA or AMO-1618
Effect of GA or Amo-1618 on avg. length of new growth or internode length

GA stimulated growth and Amo-1618 slightly decreased growth. Amo-1618 with GA like GA alone.
Area per leaf decreased by GA; slight decrease with Amo-1618 with GA like GA alone
Effect of GA or Amo-1618 on dry weight increases for leaves, shoots or roots and total.

GA decreased root and leaf DW, increased shoot & total with conc. to 0.4 and then decreased. Low conc. Amo-1618 decreased DW, then near normal at high conc.
Effect of GA or Amo-1618 on shoot (top) to root ratio

GA increased S/R to 0.8 g/l, while Amo-1618 had little effect.
Effect of GA or Amo-1618 on dry weight per fresh weight of different plant parts

Small changes only
Effect of GA or Amo-1618 on dry weight per chlorophyll or per leaf area.

GA caused dry weight increase per chlorophyll or per leaf area. Indicated thicker leaves with more cell or wall contents. Amo-1618 increased dry weight slightly.
Effect of GA or Amo-1618 on chlorophyll content per leaf area or per plant.

GA decreased chlorophyll/LA or/plant. Therefore need another measurement to see if increase in DW/chlorophyll was due to chlorophyll decline.
Peroxidase levels as affected by GA and Amo-1618.

General decline up to 0.4 Ga and increase up to 400 ppm solutions

Pn and respiration not affected
DISCUSSION & CONCLUSIONS

• Amo-1618 had little effect
• GA increased growth by most measurements but decreased leaf size
• Why was peroxidase measured.
• Why didn’t they show statistics for mean separations.
Cytokinins in *Citrus*. II. Fluctuations during growth in juvenile and adult plants


**Background**

- *Citrus* have a juvenility period where vegetative growth is dominant
- Young nucellar selections have more vegetative vigor than old clones
- Budded seedlings retain the age-condition of the scion
- Cytokinins may be involved in growth differences between juvenile and adult plants
Cytokinins in *Citrus*. II. Fluctuations during growth in juvenile and adult plants

**Objective:**
- To compare the growth of juvenile and adult budded nursery trees and to compare cytokinin levels of such trees during an induced, synchronized vegetative growth flush.
Cytokinins in *Citrus*. II. Fluctuations during growth in juvenile and adult plants

Materials and Methods:

- Adult (old line) and juvenile (nucellar) ‘Pickstone’ Valencia orange scion on ‘Troyer’ citrange rootstock
- 100 plants of each type (why so many?) were harvested monthly and shoot and root mass were determined
- Dormancy was induced in other plants (how many?) and cytokinin levels of shoot and root material was evaluated.
Cytokinins in *Citrus*. II. Fluctuations during growth in juvenile and adult plants

Results

- Plants with nucellar scions grew faster than plants with old line scions.
- Cytokinins levels differed according to scion type, tissue sampled, and time of sampling.
- Highest cytokinin activity was in buds
- nucellar bud extracts had greater polar cytokinin activity than old line bud extracts just prior to growth, but old line bud extracts had greater levels following bud break.
Dry weight accumulation for scion (A) and root (B) of Valencia nucellar Old line

**Graph A:**
- Y-axis: SCION DRY MASS (g)
- X-axis: TIME (month)
- Data points for Old line and nucellar

**Graph B:**
- Y-axis: ROOT DRY MASS (g)
- X-axis: TIME (month)
- Data points for Old line and nucellar
Bioassays for zeatin and ribozeatin (cytokinins) in juvenile or adult derived plant material

Fig. 2.

Fibrous roots (A), Tap root tips (B), lower leaves (C), upper leaves (D)
Changes in cytokinins, polar and non-polar, for fibrous roots (A), tap-root tips (B), lower leaves (C), and upper leaves.

Inconsistent patterns
Bud extract activities for juvenile (A) and adult (B) tissues
Changes in polar and non-polar cytokinins after dormancy broken by warm temperatures on juvenile (A) and adult (B) derived tissues.
Cytokinins in *Citrus*. II. Fluctuations during growth in juvenile and adult plants

**Strengths:**

- Unifying growth response by first inducing dormancy was a good approach

**Weaknesses:**

- Excessive replication of growth data but possibly little or no replication of cytokinin data?
- The number of plants used for cytokinin analyses not stated
- Cytokinin data were not subjected to statistical analysis (because no replication?)

What is juvenile factor? Is it cytokinin level?
Seasonal changes in endogenous ABA and IAA and the influence of applied ABA and auxin in relation to shoot growth and abscission in Valencia Orange (Citrus sinensis (L.) Osbeck)


Background:

- Cycles of shoot, leaf, flower and fruit growth are followed by cycles of organ abscission
- The role of hormones in regulating growth and abscission of Citrus organs is not well understood.
- Responses to exogenous PGR’s may provide indications of the roles of endogenous hormones in regulating flush growth and abscission
Seasonal changes in endogenous ABA...

- Objectives
- To establish correlations between patterns of shoot emergence and abscission and changes in the occurrence of endogenous ABA and IAA
- To observe the effects of exogenous auxin (NAA) and ABA on growth and abscission in Valencia orange
Seasonal changes in endogenous ABA...

Materials and methods

Growth and endogenous hormone levels

- Detailed records of shoot, leaf, flower and fruit growth of 15-year-old St. Ives Valencia Orange trees were recorded from 1/84 to 11/85
- Endogenous levels of IAA and ABA in shoots made monthly for one (IAA) or two (ABA) years
Seasonal changes in endogenous ABA...

Materials and methods:

**Applied PGR’s**

- ABA, NAA or malic acid (control) were applied to shoot bases via wicks placed under bark.
- PGR’s were applied to 2 leafless floral shoots and to 2 leafy floral shoots on 4 adult trees.
- Observations on leaf, flower, and fruitlet abscission were made over 3 months.
Shoot emergence followed by abscission at a slightly lower level.
ABA levels over time from leaves (dark), stems (hatched) and buds (open bars). Two peaks occurred, mainly in Sept.-Oct. when most abscission occurred.
Spring flush leaf extracts showing Sept.-Oct. peak again
**Table 1.** Comparison of endogenous ABA concentration (ng g⁻¹ d.w.) in one-year-old branches which produced floral shoots with those producing vegetative shoots. (*C. sinensis* collected 30 August 1983)

<table>
<thead>
<tr>
<th>Branch:</th>
<th>Leaves</th>
<th>Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Branches with floral shoots</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apical</td>
<td>26 ± 8</td>
<td>18 ± 1</td>
</tr>
<tr>
<td>Middle</td>
<td>26 ± 4</td>
<td>20 ± 1</td>
</tr>
<tr>
<td>Basal</td>
<td>20 ± 8</td>
<td>26 ± 4</td>
</tr>
<tr>
<td><strong>Branches with vegetative shoots</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apical</td>
<td>106 ± 11</td>
<td>64 ± 14</td>
</tr>
<tr>
<td>Middle</td>
<td>84 ± 6</td>
<td>50 ± 4</td>
</tr>
<tr>
<td>Basal</td>
<td>72 ± 12</td>
<td>66 ± 12</td>
</tr>
<tr>
<td><strong>Whole emerging shoots</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floral</td>
<td>162 ± 6</td>
<td>166 ± 4</td>
</tr>
<tr>
<td>Vegetative</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Increased ABA in branches with vegetative shoots
IAA in spring flush leaves
Retention of leaves after treatment with NAA, ABA or MA
Seasonal changes in endogenous ABA...

Discussion:

- Very high [ABA] peaks preceded organ abscission peaks, and ABA feeding experiments promoted leaf abscission, indicating that ABA is involved in abscission of *Citrus* organs (but probably interacts with ethylene).
- Auxin data are inconclusive, but high auxin levels generally coincided with shoot growth flushes as would be expected.
- Auxin did not seem to have much effect in the feeding studies, but methodology might be flawed (auxin is transported basipetally).
Seasonal changes in endogenous ABA...

Strengths:
- Growth data and endogenous hormone levels were similar two years in a row

Weaknesses:
- feeding technique might not approximate endogenous hormone delivery (especially auxin)
- Few replications for feeding study, and no statistics
Growth and dormancy cycles in *Citrus* bud cultures and their hormonal control


**Objective:**
- To describe characteristics of the development of *Citrus* buds cultured *in vitro* and their control by PGR’s.

**Materials and Methods:**
- Buds collected from spring flush of ‘Shamouti’ orange
- Cultured on media to which various PGR’s were added.
- Grown under 16 hour days (fluorescent light) at 27°C
Growth and dormancy cycles in Citrus bud cultures and their hormonal control

Materials and Methods:

- 25-30 cultures per treatment (PGR mix)
- Buds assigned “elongation rating”
- New protein synthesis in buds was measured using radio-labeled leucine. The average of 3 replicates was reported.
- Statistics?
<table>
<thead>
<tr>
<th>Growth substance, $M$</th>
<th>TRS days</th>
<th>Relative elongation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal medium (control)</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>+IAA, $10^{-5}$</td>
<td>14</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$10^{-6}$</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>+GA, $10^{-5}$</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$10^{-6}$</td>
<td>3–4</td>
<td></td>
</tr>
<tr>
<td>+Benzyladenine, $10^{-8}$</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$10^{-6}$</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>+ABA, $10^{-8}$</td>
<td>50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$10^{-6}$</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

TRS = days to sprout
Control vs GA after 15 days

Control vs BA after 15 days, not buds
GA + 15 days
Control
Protein synthesis in buds total in A and specific activity in B. Basal media (open circles), IAA (open triangles), GA (open squares), kinetin (closed circle) and ABA (closed square).
Change in days to sprout for season and effect of PGRs on TRS
Growth and dormancy cycles in Citrus bud cultures and their hormonal control

Results and Discussion:
• Auxin delayed sprouting 5-9 days but had little effect on shoot extension
• Gibberellin slightly hastened sprouting and enhanced shoot extension
• BA and kinetin (synthetic cytokinins) were similar to control except they stimulated adventitious buds (photo).
• Abscisic Acid dramatically inhibited sprouting.
Growth and dormancy cycles in *Citrus* bud cultures and their hormonal control

Results and Discussion:

- Total protein and specific activity of protein decreased during sprouting and early growth, as reported with recently excised buds (data not shown).
- Effect of PGR’s on time required for sprouting varied according to the season, possibly because the endogenous level of plant hormones responded to environmental variables.
Growth and dormancy cycles in *Citrus* bud cultures and their hormonal control

Strengths:

- *In vitro* method allows manipulation of hormone levels and environmental conditions

Weaknesses:

- Endogenous hormone levels of buds on trees could have been evaluated when buds were collected for *in vitro* experiments.
- Growth chamber conditions were the same regardless of season (long, warm days)
- Statistics?

• Anti-gibberellin action?
• Reported reduction in root growth
• Sprays and soil treatments in the field to evaluate potential to reduce canopy development
Materials and Methods

- Minneola trees 4\textsuperscript{th} year after top working
- Treated in spring or summer
- Used morphactin (auxin inhibitor) at 250, 500 ppm or paclobutrazol 500 or 1000 ppm sprays
- Used paclobutrazol as soil application at 0.4 or 0.8 g/m sq
Results

- Morphactin caused branching & ^ growth
- Paclobutrazol in summer decreased growth if sprayed, but not if soil treated
- Spring foliars did not reduce growth
- Spring soil reduced total length about 70 % and shoot internodes about 15 %
Summary

• Unexplained time of year effect
• Unexplained application x season effect
• Effect short term
• Possible benefits today due to desire to shorten growth periods
Ethylene is considered to be a natural hormone and is used as a PGR
It affects fruit and vegetative plant parts
Vegetatively, it stimulates abscission
A small amount can stimulate additional production in fruit and some leaves
The mechanism of this is reported
Methods and Results

• Ethylene (12 ul/l) applied to citrus leaf discs caused ethylene and ACC to be produced
• ACC, ethylene precursor, required for system
• Stimulation of ethylene production started within 30-60 minutes and lasted about 3 to 4 hours
Summary

• Most plant tissues produce ethylene if injured or stimulated by exogenous C2H4
• System is useful for degreening fruit or loosing fruit for harvest
• But this additional production in leaves is problem with using ethylene generating products as leaf abscission is also stimulated
Overall conclusions

- Plant hormones and PGR’s offer great potential for manipulation of plant growth and development, but a better understanding of their role in *Citrus* physiology is needed.
- Much of citrus hormone research has involved isolating, characterizing, and quantifying endogenous hormone levels in response to changes in growth or environmental conditions, but the meaning of such results is not entirely understood.
- “Spray and pray” studies are common and they sometimes yield valuable results even if the physiological basis for response is not known.
Future needs

- To fully understand the role of plant hormones in citrus growth and development, a molecular genetic approach is desirable, but requires technological advances.

Measurements of all hormones at same time would be valuable.