Welcome!

Branching Out with PGRs

Pesticide Applicator Recertification Credit

The following states offer credit for this session:

<table>
<thead>
<tr>
<th>State</th>
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<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>California</td>
<td>Colorado</td>
<td>Indiana</td>
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<td>Kentucky</td>
<td>Michigan</td>
<td>Ohio</td>
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<td>Tennessee</td>
<td>Virginia</td>
<td>West Virginia</td>
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Check in at the table in the back of the room for special instructions.

WEBSITE ADDRESS: cultivate.cnf.io

Step 1: Enter website URL
Step 2: Choose a Session
Step 3: Click to Evaluate

Today’s Presentation

- 2:45 pm – 2:50 pm: Introduction and What PGRs are available – Brian Whipker (5 minutes)
- 2:50 pm – 3:05 pm: Best Management Practices use of PGRs to improve rooting and growth of plugs
  - FAL 1786 Research – Brian Whipker (5 minutes)
  - K-IBA usage – Roberto Lopez (10 minutes)
- 3:05 pm – 3:25 pm: Best Management Practices use of Ethephon to improve plant growth
  - Ethephon Basics – Roberto Lopez (5 minutes)
  - Improvement of results – Roberto Lopez (10 minutes)
- 3:25 pm – 3:40 pm: Best Management Practices use of Configure to improve plant growth
  - Configure Basics – Joyce Latimer (5 minutes)
  - Improvement of results – Joyce Latimer (10 minutes)
- 3:40 pm – 3:45 pm: Questions

PGR TOOLBOX

WHAT PGRS ARE AVAILABLE?
PGR Guide: Fine/GrowerTalks

- 2019-2020 — Greenhouse PGR Guide by Brian Whipker of NC State University

PGR Types

Table 1. The wide assortment of plant growth regulators available for ornamental crops.

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>PRODUCTS</th>
</tr>
</thead>
</table>

PGR Attributes

PGR ToolBox

Growth Control
- Ancymidol
- Chlormequat
- Daminozide
- Dibutylate Sodium
- Ethephon
- Flurprimidol
- Paclobutrazol
- Uniconazole

Improved Branching
- BA (benzyladenine)
- BA + GA
- Dibutylate Sodium
- Ethephon

Flower Enhancement
- BA (benzyladenine)
- BA + GA
- GA (gibberellic acid)

Flower Control
- Ethephon

Growth Enhancement
- BA (benzyladenine)
- BA + GA
- GA (gibberellic acid)
IMPROVING CUTTING ROOTING AND PLUG GROWTH

BRIAN WHIPKER

FAL 1786

• Plant growth stimulant
• Contains
  – Kinetin
  – IBA
  – GA₃

Control 1786

Experiment

• Objective: To determine if FAL 1786 would promote growth of vegetatively propagated annuals when applied as a pre-transplant plug liner soak.
• The goal was to stimulate increased rooting and plant growth.

Experiment

• Species Used (Dümmen Group)
  – ‘Michigan Avenue’ Coleus
  – ‘XXL Veracruz’ Dahlia
  – ‘Parfum d’Ethiopia’ Artemisia dranunculus
  – ‘Sweetie Pink’ New Guinea Impatiens
  – ‘Pinata Pink’ Pentas
  – ‘Comet Pink Shades’ Argyranthemum

• Unrooted cuttings were stuck into 128-cell plug flats on 14 March 2017
• Plants rooted and the FAL 1786 treatments were made on 12 April 2017 (0 to 100 mL/L)
• Rooted cuttings then transplanted into 3 oz. (88.7-mL) clear plastic cups with four drainage holes on 13 April 2017.
  – Cups filled with Fafard 1; Sun Gro Horticulture.
Greenhouse Uses & Rates

- FAL 1786 can be used in watering programs or as foliar sprays to reduce apical dominance and to promote bud differentiation, cell division, root induction and growth.

- **Propagation of Cuttings**: Dip cuttings in rooting hormone powder or solution and stick in rooting medium. Spray or mist cuttings with a solution of 1 fluid ounce FAL 1786 per 4 gallons of water (1 quart/100 gallons) at weekly intervals until roots initiate. Then spray at 2-4 week intervals.

- **Transplanting**: Add 1 fluid ounce FAL 1786 per 4 gallons of transplant solution (fertilizer-water). Use the necessary amount of solution to drench the root zone for that cropping situation. Then either apply a foliar spray or add through irrigation system at 2-4 week intervals at the rate of 1 quart per 100 gallons.

- **Production**: To increase growth rate, improve quality and resilience of nursery and greenhouse crops, add 1 fluid ounce per 4 gallons (1 quart/128 gallons) of fertilizer or water solution and apply through the irrigation system or via foliar spray.

---

**Rooting Hormones**

- Rooting hormones contain auxin (IAA, IBA, KIBA or NAA) that are involved in cell elongation and adventitious root formation.

- Are not required for the majority of species to achieve nearly 100% rooting success.

- Difficult- or slow-to-root species and cultivars are often treated to increase:
  - Uniformity of rooting
  - Speed of rooting
  - Root mass

- Liquid or powder rooting hormones can be applied to the basal end of cuttings
  - generally range between 1,000 and 1,500 ppm for annuals
  - generally range between 50 and 300 ppm for perennials
  - Labor intensive
  - Dipping can spread diseases

- Overhead rooting hormone application after cuttings have been stuck.

- Can increase leaf yellowing by increasing the export of sugars from the leaves.

---

**Rooting Hormones**

- Osteospermum received a 200 ppm IBA overhead rooting hormone application.

---

**2b**

**IMPROVING CUTTING ROOTING AND PLUG GROWTH**

ROBERTO LOPEZ
**Rooting Hormones Beneficial**
- Species in this category will root without using rooting hormones, but will generally root faster or more uniformly with their use.

<table>
<thead>
<tr>
<th>Rooting Hormone Beneficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternathera</td>
</tr>
<tr>
<td>Angelonia</td>
</tr>
<tr>
<td>Argyranthemum</td>
</tr>
<tr>
<td>Begonia</td>
</tr>
<tr>
<td>Begonia 'hibemalis, reinger, rex'</td>
</tr>
<tr>
<td>Bidens</td>
</tr>
<tr>
<td>Campanula</td>
</tr>
<tr>
<td>Cuphea</td>
</tr>
<tr>
<td>Diascia</td>
</tr>
<tr>
<td>Fuchsia</td>
</tr>
</tbody>
</table>

**Rooting Hormone Essential**
- Species in this category are slow or difficult to root, and there is higher value of using rooting hormones.

<table>
<thead>
<tr>
<th>Rooting Hormone Essential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracteantha</td>
</tr>
<tr>
<td>Calibrachoa on certain cultivars</td>
</tr>
<tr>
<td>Crossandra</td>
</tr>
<tr>
<td>Dahlia</td>
</tr>
<tr>
<td>Dracaena</td>
</tr>
<tr>
<td>Gazania</td>
</tr>
<tr>
<td>Heliotrope</td>
</tr>
<tr>
<td>Hibiscus</td>
</tr>
<tr>
<td>Heuchera</td>
</tr>
</tbody>
</table>

**Spray Application after sticking**
- Can also be applied as an overhead coarse spray that allows some of the solution to run down the stem toward the base of the cutting.
- The potassium-salt formulation of IBA is often used as it is water soluble
  - 20 to 500 ppm KIBA (3-5 day 1 or 2 after stick)
- Some leaf curl response can occur at higher rates, but the plants will normally grow out of it prior to shipping.

---

**Scaevola ‘Brilliant’**
2 weeks after the following rooting hormone treatments:
- Fine Americas Foliar Sprays
- Hortus Foliar Sprays

<table>
<thead>
<tr>
<th>Root dry mass (mg)</th>
<th>Medium Light 11.9 ± 1.5 mol m⁻² d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.006 b</td>
<td>0.01 ab</td>
</tr>
<tr>
<td>0.01 ab</td>
<td>0.02 ab</td>
</tr>
<tr>
<td>0.02 a</td>
<td>0.02 a</td>
</tr>
<tr>
<td>0.01 ab</td>
<td>0.02 a</td>
</tr>
</tbody>
</table>

**Dahlia ‘Passion Fruit’**
2 weeks after the following rooting hormone treatments:
- Fine Americas Foliar Sprays
- Hortus Foliar Sprays

<table>
<thead>
<tr>
<th>Root dry mass (mg)</th>
<th>Medium Light 11.9 ± 1.5 mol m⁻² d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03 b</td>
<td>0.05 a</td>
</tr>
<tr>
<td>0.05 a</td>
<td>0.05 a</td>
</tr>
<tr>
<td>0.03 b</td>
<td>0.05 a</td>
</tr>
<tr>
<td>0.05 a</td>
<td>0.05 a</td>
</tr>
</tbody>
</table>

**Osteospermum ‘Lavender Frost’**
2 weeks after the following rooting hormone treatments:
- Fine Americas Foliar Sprays
- Hortus Foliar Sprays

<table>
<thead>
<tr>
<th>Root dry mass (mg)</th>
<th>Medium Light 11.9 ± 1.5 mol m⁻² d⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 c</td>
<td>0.08 abc</td>
</tr>
<tr>
<td>0.08 abc</td>
<td>0.06 bc</td>
</tr>
<tr>
<td>0.06 bc</td>
<td>0.06 bc</td>
</tr>
<tr>
<td>0.05 a</td>
<td>0.06 bc</td>
</tr>
</tbody>
</table>

---
Geranium ‘Lavender + Red Eye’
2 weeks after the following rooting hormone treatments:

**Overhead Rooting Hormone Conclusions**
- Spray applications are generally more effective than basal dip cutting applications at promoting rooting of the four species we tested.
- Generally, a low volume spray application (2 qts. per 100 ft²) at 150 to 300 ppm was effective at promoting rooting of geranium, Dahlia, and Osteospermum.

**Overhead Rooting Hormone Conclusions**
- Under lower light conditions (≤10 mol·m⁻²·d⁻¹), difficult to root species such as Scaevola may require a higher spray volume application.
- Daily light integral (DLI) and spray rooting hormone application interacted and resulted in improved rooting for Scaevola and geranium.

**Overhead Rooting Hormone Conclusions**
- Pending EPA registration, Fine Americas will have an IBA product labeled for overhead and basal applications in 2020.

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3

USE OF ETHEPHON TO IMPROVE PLANT GROWTH

**Branch Enhancement**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzyladine (BA)</td>
<td>Configure</td>
</tr>
<tr>
<td>Benzyladine (BA) + Gibberellin (GA₄+7)</td>
<td>Fascination, Fresco</td>
</tr>
<tr>
<td>Dikegulac sodium</td>
<td>Atrimmec (formerly Augeo)</td>
</tr>
<tr>
<td>Ethephon</td>
<td>Collate, Florel</td>
</tr>
</tbody>
</table>

- **Goal:**
  - Create better branched plants
- **Use:**
  - Annuals, Perennials
Why Ethephon?

- **Production goals:**
  - Compact plants, increased branching, and increased densities
  - Set the flowering clock to zero
- Ethephon (Collate® and Florel®) is mixed with carrier water to make a spray solution.
- After application, it is converted into the gaseous and active form ethylene.

Ethephon (Florel® and Collate®)

- **Applications:**
  - Sprays: 250 to 500 ppm
  - Generally inexpensive
- Achieving consistent results can be trickier than with other PGRs simply because ethylene is a gas.
  - Responses depend on the environment and water quality
  - Can be variable and less predictable

Effect of 2 sprays of ethephon products on Petunia ‘Wave Lavender’

Applications made 7 and 18 days after transplant

- **Control**
- **Collate**
- **Florel**
- **250 ppm**
- **500 ppm**
- **750 ppm**

Ethephon (Florel® and Collate®)

- Ethylene:
  - Suppresses stem elongation
  - Increases stem diameter
  - Reduces apical dominance causing an increase in branching and lateral growth
  - Induces abscission (abortion) of flowers and flower buds

Ethephon (Florel® and Collate®)

- Florel - 3.9 percent active ingredient (U.S.)
- Collate - 21.7 percent active ingredient

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Florel (3.9%) mL per 1 gallon</th>
<th>Collate (21.7%) mL per 1 gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>21.7</td>
<td>3.9</td>
</tr>
<tr>
<td>500</td>
<td>43.4</td>
<td>7.8</td>
</tr>
<tr>
<td>1000</td>
<td>86.8</td>
<td>15.6</td>
</tr>
</tbody>
</table>

- The evolution of ethephon to ethylene increases as the spray solution pH increases above 4.5.
- Therefore, if spray solution pH is high, ethylene is released before it is absorbed by the plant.
- If spray solution pH is too low, potential for leaf phytotoxicity in some species.
- Spray solution pH is affected by the **alkalinity** of your carrier water.
Plant damage with low pH

- Veronica ‘First Love’ 500 ppm Collate, pH 2.6
- Low alkalinity water can result in pH too low

Does Water Alkalinity affect Ethephon Efficacy?

- Collate® and Florel® acidic
- Not sufficient when:
  - Chemical is used at low concentrations
  - Spray water has a high alkalinity

Alkalinity

- Alkalinity is the capacity to resist pH change

Carrier Water + Ethephon

| pH 7 | Acidic |
| 250 ppm Ethephon Spray Solution |
| 300 mg L⁻¹ alkalinity carrier water | pH 6.3 |
| 750 ppm Ethephon Spray Solution |
| 300 mg L⁻¹ alkalinity carrier water | pH 3.9 |

Solution pH changes

- 0 ppm Ethephon
- 50 ppm Ethephon
- 150 ppm Ethephon
- 300 ppm Ethephon

Does Temperature affect Ethephon Efficacy?

- Recommended application air temperature of 60 to 95 ºF.
- At low temperatures ethephon breaks down slowly.
- At high temperatures ethephon breaks down quickly.

Collate Efficacy

- Veronica ‘First Love’ two weeks after 500 ppm Collate application
- No effect with high spray solution pH

Solution pH changes

- 0 ppm Ethephon
- 250 ppm Ethephon
- 500 ppm Ethephon
- 750 ppm Ethephon
**Objective**

- To determine if the efficacy of ethephon foliar sprays is affected by *carrier water alkalinity* and ambient *air temperature* at application.

---

**What did we do?**

- **Chemical structure**
  - $\text{Cl}_2\text{O}_7\text{PO}_4\text{OH}$
  - $[\text{Ca}^{2+}]\text{[CO}_3\text{]}^{2-}$

- **Table of treatments**
  - **Ethephon**
    - 0 ppm
    - 250 ppm
    - 500 ppm
    - 750 ppm
  - **Alkalinity (CaCO}_3\text{)**
    - 50 ppm
    - 150 ppm
    - 300 ppm
  - **Temperature**
    - 79°F
    - 73°F
    - 68°F
    - 63°F
    - 57°F

---

**Materials and Methods**

- Grown at 68 ºF and DLI of 10 µmol·m–2·s–1

- **Treatments**
  - High alkalinity reduces efficacy

<table>
<thead>
<tr>
<th>Alkalinity (ppm)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>79°F</td>
</tr>
<tr>
<td>150</td>
<td>73°F</td>
</tr>
<tr>
<td>300</td>
<td>68°F</td>
</tr>
<tr>
<td>350</td>
<td>63°F</td>
</tr>
<tr>
<td>400</td>
<td>57°F</td>
</tr>
</tbody>
</table>

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**Alkalinity and Air Temperature Treatments**

- Alkalinity of tap water adjusted with sulfuric acid
- Air temperature at application was changed 2 hours prior to spray application for 24 h
  - (It takes ~12 to 16 h to fully absorb ethephon)

---

**High alkalinity reduces efficacy**

<table>
<thead>
<tr>
<th>Alkalinity (ppm)</th>
<th>Efficacy</th>
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<tr>
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<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>
Alkalinity and ethephon concentration interact

Increase in Stem Length (in.), 4 weeks

<table>
<thead>
<tr>
<th>Alkalinity (ppm)</th>
<th>Ethephon (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0 250 500 750</td>
</tr>
<tr>
<td>150</td>
<td>4.1 3.7 2.2 1.7</td>
</tr>
<tr>
<td>300</td>
<td>3.9 3.7 3.3 2.4</td>
</tr>
</tbody>
</table>

Petunia ‘Easy Wave Neon Rose’ 57 ºF

<table>
<thead>
<tr>
<th>Alkalinity (ppm)</th>
<th>Ethephon concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0 250 500 750</td>
</tr>
<tr>
<td>150</td>
<td>4.1 3.7 2.2 1.7</td>
</tr>
<tr>
<td>300</td>
<td>3.9 3.7 3.3 2.4</td>
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</table>

Petunia ‘Easy Wave Neon Rose’ 68 ºF

<table>
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<th>Alkalinity (ppm)</th>
<th>Ethephon concentration (ppm)</th>
</tr>
</thead>
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<tr>
<td>50</td>
<td>0 250 500 750</td>
</tr>
<tr>
<td>150</td>
<td>4.1 3.7 2.2 1.7</td>
</tr>
<tr>
<td>300</td>
<td>3.9 3.7 3.3 2.4</td>
</tr>
</tbody>
</table>

Petunia ‘Easy Wave Neon Rose’ 79 ºF

<table>
<thead>
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<th>Alkalinity (ppm)</th>
<th>Ethephon concentration (ppm)</th>
</tr>
</thead>
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<tr>
<td>50</td>
<td>0 250 500 750</td>
</tr>
<tr>
<td>150</td>
<td>4.1 3.7 2.2 1.7</td>
</tr>
<tr>
<td>300</td>
<td>3.9 3.7 3.3 2.4</td>
</tr>
</tbody>
</table>

Ambient temperature at application influences efficacy

<table>
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<tr>
<th>Temperature (ºF)</th>
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<th>63</th>
<th>68</th>
<th>73</th>
<th>79</th>
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</thead>
<tbody>
<tr>
<td>Dors to Flower</td>
<td>45</td>
<td>45</td>
<td>46</td>
<td>45</td>
<td>41</td>
</tr>
<tr>
<td>Branches (no)</td>
<td>63</td>
<td>64</td>
<td>67</td>
<td>67</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature (ºF)</th>
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<th>49</th>
<th>47</th>
<th>51</th>
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<tr>
<td>Dors to Flower</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Branches (no)</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
**Ethephon Tips**

- If your carrier water has high alkalinity, add a buffering solution to reduce pH before adding ethephon to the spray tank.
  - acid (i.e., sulfuric acid)
  - adjuvant (i.e., Indicate 5)
- Apply ethephon when greenhouse temperatures are below 75 °F
- Maintain high relative humidity or VPD of 0.7 kPa.
- Use spray solution within 24 hours of mixing.

**Ethephon Tips**

- Allow the solution to dry slowly over 4 hours to enhance uptake.
- Relative absorption time of foliar applications is 12 to 16 hours.
- To extend growth regulation or to maintain plants in a vegetative state, ethephon may be applied at two- to four-week intervals.
- Species and cultivars vary in response, thus you have to conduct your own rate trials.

**Ethephon Tips**

- Must manage application timing to avoid flowering delay (allow 6 to 8 weeks prior to desired market date).

**Ethephon Tips**

- Ethephon is a minor eye and skin irritant.
  - It has a longer restricted entry interval (REI) of 48 hours.
  - In addition, eye protection is required, along with protective gloves, coveralls, apron, shoes and headgear for overhead applications.

**Ethephon Tips**

- Avoid applications to stressed plants.
  - Ethylene is a natural plant hormone that influences fruit ripening, senescence, branching and growth.
  - Ethephon can enhance the stress.

**Phytotoxicity on Angelonia 'Serena Lavender Pink'**

- Floret 500 ppm
- Collate 500 ppm

Cathy Whitman, MSU
Configure (Fine Americas, Inc.)
- Active ingredient: 10% BA (benzyladenine)
- Stimulates but does not cause branching or flowering
- Short period of activity (~1 week). Complete spray coverage required

Configure Improves Branching/Pot Fill

Configure on Perennial Liners
- May reduce root dry weight – NO effect on finished plants
  - Apply after rooting, just after liners are removed from mist
- Generally improves branching during liner production; may persist in finished plants [Echinacea, Gaura]
- BA has short-term activity in most crops
  - What if we made multiple applications?

 increased branching, but reduced liner root dry wt of ~one-third of crops tested
Multiple Applications of Configure

_Sedum ‘Autumn Joy’_

**Tank Mix on Liners: Configure with IBA**

- Some of the same crops that showed reduced root growth:
  - Agastache ‘Tutti Frutti’
  - Lavandula x intermedia ‘Provence’
  - Leucanthemum x superbum ‘Snowcap’
  - Rosmarinus ‘Hill Hardy’
- Spray applications when rooted liners came off mist
  - Untreated control
  - 500 ppm BA (Configure)
  - 1000 ppm IBA (Hortus IBA Water Soluble Salts 20% IBA, Hortus USA)
  - 500 ppm BA plus 1000 ppm IBA

**Results**

- BA increased branching on liners; reduced root dry weight of Leucanthemum
- BA + IBA reduced root dry weight of Agastache and Leucanthemum

**Conclusions Tank Mixing BA and IBA**

- The addition of IBA to BA applications did not reduce BA’s negative effects on rooting
- IBA or IBA in combination with BA did not increase branching
- Reductions in root dry weight did affect growth of finished plants

**Tips on Using Configure**

- Generally improves branching during liner production
- Rates 100 to 600 ppm (higher on hosta)
- For liners, apply after rooting (plants coming off mist)
- Multiple applications recommended
- For liners, make second applications shortly after transplanting liners to finished containers
- Allow a minimum of 2 weeks between applications to reduce chances of phytotoxicity
For more information
Joyce Latimer
540-231-7906; jlatime@vt.edu

Questions
Thanks for Attending!

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