Ornamentals Conference

Softwood Propagation of Ornamentals
‘Managing quality through the propagation process’

The Arthur Rank Centre, Stoneleigh Park, Kenilworth, Warwickshire
7 February 2017

Event Programme
Event Programme

Although there are several UK specialist plant propagators, and a number of production businesses take propagation material from their own stock plants or crops, the production of cutting material from stock plants is now an international trade with material being supplied from as far away as Africa and South America.

The successful and uniform rooting of bought-in or self-produced softwood cutting material is important for a wide range of crops including nursery stock, herbaceous plants, alpine plants, bedding and patio plants and pot plants. The selection of material, its transportation and preparation, the rooting and weaning environments provided and subsequent pest and disease control will all impact on the rooting percentage achieved and the quality of the rooted young plant.

This seminar focuses on these and other aspects which can impact rooting percentage and plant quality and provides information about optimising the various processes involved.

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<td>Refreshments and registration</td>
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<td>Welcome from the event chairperson</td>
<td>Martin Emmett, HNS Panel Chairman</td>
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<td>10.00-10.30</td>
<td>Stock plant management to improve cutting quality and speed of rooting</td>
<td>Paul Dyer, New Place Nurseries</td>
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<td>10.30-11.00</td>
<td>Management of bought-in cutting material to retain quality</td>
<td>Dr Jill England, RSK ADAS</td>
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<td>11.00-11.20</td>
<td>Refreshment break</td>
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<td>11.20-12.00</td>
<td>Current understanding of environmental and internal key factors determining the survival and rooting of ornamental cuttings</td>
<td>Dr Uwe Druege, Leibniz-Institute of Vegetable and Ornamental Crops, Germany</td>
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<td>12.00-12.30</td>
<td>The art of rooting difficult plant subjects</td>
<td>Dr Ross Cameron, Department of Landscape, University of Sheffield</td>
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<td>12.30-13.00</td>
<td>Managing the cutting environment to maximise rooting and minimise wastage</td>
<td>David Hide, Fargro</td>
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<td>13.00-14.00</td>
<td>Lunch</td>
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<td>14.00-14.30</td>
<td>Lighting stock plants and cutting material with LEDs, the physical and economic benefits</td>
<td>Dr Phillip Davis, Stockbridge Technology Centre</td>
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<td>14.30-15.00</td>
<td>Managing the potential of quarantine pests and diseases on bought-in cutting material</td>
<td>Jonathan Hazelwood, PHSI</td>
</tr>
<tr>
<td>15.00-15.30</td>
<td>The practical options for integrated pest and disease control during propagation</td>
<td>Neil Helyer, Fargro</td>
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<td>15.30 onwards</td>
<td>Closing remarks from the event chairperson</td>
<td>Martin Emmett, HNS Panel Chairman</td>
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<td>The practical options for integrated pest and disease control during propagation – Neil Helyer</td>
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AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board (AHDB)
Stock plant management to improve cutting quality and speed of rooting

AHDB Horticulture Oramentals Conference
Paul Dyer, New Place Nurseries

Contents
1. Growth control and trimming stock plants to manage plant juvenility and cutting habit.
2. Growing environment for stock plants.
4. Weed, pest and disease control around and on stock plants (especially prior to cutting collection).
5. Stock plant renewal.
7. Own stock plants v bought-in cutting material.
Stock plant management to improve cutting quality and speed of rooting
Stock plant management to improve cutting quality and speed of rooting
Stock plant management to improve cutting quality and speed of rooting
The management of bought-in cutting material to retain quality

Dr Jill England

Overview

1. Background
2. ‘Post-shipping cutting dips to improve cutting rooting and survival’
3. ‘Improving cutting success’

1. Background

Temperature

Cold tolerant
Chrysanthemum, Carnation 0-2°C

Cold intolerant
NG Impatiens, Poinsettia 10°C

Geranium 4°C, 5 days

Respiration rate

As low as possible to extend storage life without causing chilling / freezing injury

Water

Balance

Desiccation

Free water

Leaf abscission
Necrotic tissue
Reduced rooting

Disease

Pathogens

Balansa

Grey mould
Botrytis cinerea

Bacterial soft rot
Erwina spp.

Warmth
Moisture
Free water

Botrytis cinerea

Erwina spp. (Source: Brian Whipker)
Treatments – Year 1

- Nutrition
  - Urea

- Growth regulator
  - K-IBA (water soluble IBA)
  - Configure® (BA)

- Disease control
  - Pageant (pyraclostrobin + boscalid)
  - Fascination®: (GA + BA)
  - Fascination® + K-IBA

- Carbohydrate
  - Sucrose
  - Fructose: 0, 1.0, 4.0%
  - Glucose: 0, 1.0, 4.0%

- All treatments: +/- CapSil 30®
- Water or water + CapSil 30®
- Control (dip and spray)

Carbohydrate level

Endogenous highest at harvest

Depletion starch glucose, fructose, sucrose

Effect limited root development

Affected by nitrogen feed light level

Post-shipping cutting dips to improve cutting rooting and survival – Year 1

- Plant varieties (from on-site stock plants)
  - Zonal Geraniums ‘Rocky Mountain Violet’ and ‘Tango Dark Red’
  - New Guinea Impatiens ‘Fanfare Orchid’ and ‘Super Sonic White’
  - Poinsettia ‘Prestige Red’ and ‘Whitestar’

- Storage: 20°C
- Timing: 24 hrs, 48 hrs (slight and moderate post harvest stress)
- Treatments: 30 min dip, spray

2. Post-shipping cutting dips to improve cutting rooting and survival

- Professor John Dole, Ingram F McCall and Weiwen Guo (NCSU)
- Jim E Faust (Clemson University)

Results - Year 1

- Overall, increased post-harvest stress reduced rooting of all three species
- Dips generally more effective than sprays
- Exceptions: treatments including Configure (all species) and Pageant (Impatiens), where sprays were more effective than dips
- Impatiens – spray treatments were more effective
- Dip treatment: positive effect even for water control and unstored cuttings
Results – Year 2

- Again, post-harvest stress reduced rooting of all three species
- Greatest rooting: treatments that included K-IBA (400 mg/L)
- Water + CapSil 30® dip improved rooting compared with untreated control

**Results – Year 2, Geranium**

Geranium cuttings dipped into solutions with various compounds for 30 min: C=CapSil, K=K-IBA (400 mg/L), P=Pageant (900 mg/L), F=fructose (1%), B/K=Configure (BA, 2.5 mg/L) + K-IBA (100 or 400 mg/L). For the CapSil + K-IBA + Pageant + fructose treatment, cuttings were dipped for either 0 or 30 min. (All other treatments were applied as 30 min. dips). Data from both cultivars are combined.

### Treatment Comparison

<table>
<thead>
<tr>
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<th>Geranium</th>
<th>Impatiens</th>
<th>Poinsettia</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-IBA (water soluble IBA): 400 mg/L</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pageant (pyraclostrobin + boscalid): 400 mg/L</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose @ 1.0%</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose @ 4.0%</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose @ 1.0%</td>
<td>Dip</td>
<td>Dip</td>
<td></td>
</tr>
<tr>
<td>Fructose @ 4.0%</td>
<td>Dip</td>
<td>Dip</td>
<td></td>
</tr>
<tr>
<td>Urea @ 0.4%</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure® (BA) 2.5 mg/L</td>
<td>Spray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure® (BA) 2.5 mg/L + K-IBA 400 mg/L</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-IBA 400 mg/L</td>
<td>Dip</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post-shipping cutting dips to improve cutting rooting and survival – Year 2

- Urea: 0, 0.1, 0.2, 0.4%
- Pageant (pyraclostrobin + boscalid): 600, 900 mg/L
- Fructose: 1.0%
- K-IBA (water soluble IBA): 400 mg/L
- Configure® (BA) 2.5 mg/L
- Configure® (BA) 2.5 mg/L + K-IBA 400 mg/L
- All treatments: +/− CapSil® 30: 0.3 ml/L

### Post-shipping Cutting Dips to Improve Cutting Rooting and Survival – Year 2

- **Plant varieties**
  - Zonal Geraniums ‘Rocky Mountain Violet’ and ‘Tango Dark Red’
  - New Guinea Impatiens ‘Fanfare Orchid’ and ‘Super Sonic White’
  - Poinsettia ‘Prestige Red’ and Whitestar’
- **Storage:** 20°C
- **Timing:** No or 48 hrs (moderate) post harvest stress
- **Treatments:** 30 min dip; 0 and 30 min dips (CapSil 30® + K-IBA + Pageant + Fructose)
- **Control:** untreated; dip (water or water + CapSil 30®)

### Results – Year 2, Geranium

- **Geranium:**
  - K-IBA plus fructose and/or Pageant
  - 30 min dip slightly better than 0 min dip

Geranium ‘Tango Dark Red’. 30 min dip into water + CapSil (left) and water + CapSil + K-IBA + Pageant + fructose (right). Copyright John Dole
1. Set up

- Geranium Green Leaf Series ‘Bianca’
- 5 days in transit
- Set up: 25 March (T1) and 29 March (T2) (4 days cold storage)
- 72-cell plug half tray, 15 cuttings per tray
- Growing medium: Peat + 20% perlite propagation medium (Tref)
- Heated glasshouse, heated bench
- White propagation film cover

Results – Year 2, New Guinea Impatiens

New Guinea Impatiens cuttings dipped for 30 min: C=CapSil; K=K-IBA (400 mg/L); P=Pageant (600 mg/L); F=fructose (1%) or sprayed: B=Configure (BA, 2.5 mg/L) + K-IBA (100 or 400 mg/L). For the CapSil + K-IBA + Pageant + fructose treatment, cuttings were dipped for either 0 or 30 min. (All other treatments were applied as 30 min dips). Data from both cultivars are combined.

Results – Year 2, Poinsettia

Poinsettia cuttings dipped for 30 min: C=CapSil, K=K-IBA (400 mg/L), P=Pageant (900 mg/L), and F=fructose (1%) or treated with sprays of B=Configure (BA, 2.5 mg/L) + K-IBA (100 or 400 mg/L). For the CapSil + K-IBA + Pageant + fructose treatment, cuttings were dipped for either 0 or 30 min. (All other treatments were applied as 30 min dips). Data from both cultivars are combined.

3. BPPC. Improving cutting success

To investigate the use of a range of products to increase the success rate and decrease rooting time when striking un-rooted cuttings

<table>
<thead>
<tr>
<th>Products</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omex SW7 (0.5 L/ha)</td>
<td>Spray</td>
</tr>
<tr>
<td>Signum (1.35 L/ha)</td>
<td>Quick dip (5 secs)</td>
</tr>
<tr>
<td>Fructose (1%)</td>
<td>Long dip (30 min submersion)</td>
</tr>
<tr>
<td>Rhizopon AA (6 tablets/L)</td>
<td></td>
</tr>
<tr>
<td>Serenade ASO (10 L/ha)</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
</tbody>
</table>

Assessments

- No. of cuttings with visible roots on plant (sample of 5)
- Plant quality (sample of 5)
  - T1 – first assessed 8 days after treatment
  - T2 – first assessed 10 days after treatment
  - Further weekly assessments until week 18 (6 WAT)

Plant quality scale

0 1 2 3 4

Set up

Pelargonium 'Bianca' (Copyright Dümmen)
Summary of results

Root development – most promising
T1: Rhizopon (QD), Omex (LD) and Serenade ASO (LD)
T2: Signum (QD), Omex (QD / LD) and Serenade ASO (LD)

Plant quality
Generally similar, but poor scores in:
T1: Rhizopon (QD, LD) and slightly in Signum (LD)
T2: Rhizopon (QD, LD)

Root development and plant quality scores generally lower for spray application (T1 and T2) than dips

Improving cutting success
To evaluate a range of products alone or in combination, to increase the success rate and reduce rooting time when striking unrooted cuttings. This is a continuation of work carried out in 2016

Variety
Geranium Green Leaf series ‘Bianca’

Products
Omex SW7 (0.5 L/ha)
Signum (1.35 L/ha)
Rhizopon AA (6 tablets/L)
Serenade ASO (10 L/ha)
Water

Treatments
x 29, including controls

Timing of sticking (x2)
Day of receipt
3 days post day of receipt (i.e. after 3 days of cold storage)

Application method
5 second quick dip
30 minute total immersion
Overhead spray
Further information

Bedding and Pot Plant Centre:

- Blog: https://ahdbbppcblog.wordpress.com
- Report: March 2017
- AHDB Horticulture News articles
- 2017 open days:
  - Spring Open Days - 29th March and 5th April
  - Summer Open Day – 20th June

Acknowledgements

- Professor John Dole, NCSU
- Will Lamb and Jack Olds, Baginton Nurseries
- Roundstone Nurseries / Newey Group
- Lovannia Nurseries
- Pöppleman

BPPC - Ideas for future work?

- Contact:
  - Jill.England@adas.co.uk
  - Chloe.White@adas.co.uk
  - David.Talbot@adas.co.uk
Current understanding of environmental and internal key factors determining the survival and rooting of ornamental cuttings

Dr. Uwe Druege

1. The global young plant production chain
2. Pelargonium: when ethylene meets sensitivity
3. Nitrogen, storage, carbohydrate metabolism and rooting (Pelargonium and others)
4. Light and temperature, carbohydrate metabolism and rooting (Pelargonium)
5. When storage improves rooting – molecular control of adventitious root (AR) formation in Petunia
6. Explanatory model: What makes the difference?
7. Current projects and outlook

Leibniz Institute of Vegetable and Ornamental Crops (IGZ)
Erfurt, Germany

www.igz.de

Group “Adventitious root formation and development”

Objective:
• Improve the understanding and the use of environmental and endogenous control of cutting survival and adventitious root formation

www.igz.de

2. Pelargonium: when ethylene meets sensitivity: Ethylene production

Example Pelargonium: Problems:
1. Cutting production: low latitude sites, usually high light intensity
2. Storage: post-chilling, coldroom, darkness, low temperature
3. Transport: truck → airplane → truck darkness, variable temperature
4. Rooting: Central Europe: often low light intensity
   a) Leaf senescence, decay, total loss

b) insufficient root formation

Environmental key factors?
Endogenous key factors?
Processes controlling survival and adventitious root formation in cuttings?
2. Pelargonium: when ethylene meets sensitivity: Leaf senescence

- Ethylene blockers reduced leaf damage and drop out by ca. 50%

2. Interim summary: ethylene and senescence of Pelargonium

1. Wound and (post-)chilling ethylene can contribute to ethylene production and accumulation in packages of Pelargonium cuttings.

2. Constantly low current temperatures (below 5°C) reduce current ethylene production.

3. Dark-storage induced leaf senescence in Pelargonium cuttings is partially caused by ethylene action and can be reduced by application of MCP.

4. Dramatically enhanced ethylene production in response to blocking the ethylene receptor indicates a negative feedback loop (autoinhibition) in the vegetative tissues of the cuttings.

5. Blocking the ethylene receptor can reduce adventitious root formation in cuttings (shown for Pelargonium, petunia).

2. Pelargonium: MCP and ethylene production during storage at 20 °C

- Ethylene blockers dramatically enhance ethylene production

3. Nitrogen and dark storage: carbohydrate metabolism?

I. Nitrogen level supplied to stock plants:
- Nitrogen assimilation needs carbon skeletons

II. Storage: Cuttings usually kept under darkness and cooled:
- No photosynthesis
- At low temperature: respiration and metabolism is slowed down but not prevented!

→ Decrease in carbohydrate content of the cutting!

2. Pelargonium cuttings: Regulation ethylene biosynthesis

- Ethylene blockers obviously interrupt negative feedback of ethylene biosynthesis!

3. Nitrogen, dark storage → carbohydrates in Pelargonium

- High N-supply to stock plants:
  - Low starch levels at harvest
  - Low sugar levels after storage

- Low N-supply to stock plants:
  - High starch levels at harvest
  - High sugar levels after storage

Nutrients in P. × hortorum

Amino acids, etc.
Cuttings rooted at low light: PPFD: 22 µmol m⁻² s⁻¹ per 16h, DLI = 1.3 mol m⁻²d⁻¹
Cuttings produced at high light: PPFD 1) of 281 µmol m⁻² s⁻¹ per 16h, DLI 2) = 16.2 mol m⁻²d⁻¹

3. Nitrogen content at harvest → AR formation in Pelargonium

Obviously a general principle: nitrogen limits rooting, if there is no predominant limitation by carbohydrates: chrysanthemum, pelargonium, poinsettia, petunia

3. Storage: Leaf sugars at time of planting → AR formation in Pelargonium

Rooting under low light: sugar levels at time of sticking limit subsequent root formation!

3. Initial leaf sugars → basal stem sugars → AR formation

NITROGEN IN CUTTINGS [mg g⁻¹ DM]

Number of roots per cutting

NITROGEN IN CUTTINGS [mg g⁻¹ DM]

Number of roots per cutting

NUMBER OF ROOTS PER CUTTING

Glucose in leaves, day 0 [mg g⁻¹ DM]

Glucose in leaves, day 0 [mg g⁻¹ DM]

Glucose in leaves, day 0 [mg g⁻¹ DM]

3. Nitrogen at harvest → nitrogen compounds

A) TOTAL AMINO ACIDS

B) ASPARAGINE

Nitrogen level in cuttings determines amine acid levels in the stem base at harvest

Initial leaf sugars limit subsequent sugar accumulation in the stem

Day 5

Day 10
3. Interim summary: nitrogen, storage, carbohydrates and rooting

1. Nitrogen content in cuttings is one important endogenous factor limiting adventitious root formation in cuttings.

2. Nitrogen content in cuttings limits the level of amino acids in the stem base.

3. But high nitrogen supply to stock plants induces lower carbohydrate reserves, particularly of sugars after storage.

4. Under particular conditions (for example: stored high-light adapted Pelargonium cuttings rooting under low-light) the induced lower carbohydrate levels can become a predominant role and inhibit root formation.

5. Considering carbohydrate reserves in cuttings at time of sticking, the sugar levels in leaves are most important for subsequent root formation.

4.2 Light supplied to cuttings and carbohydrates

More light during rooting

Pelargonium

<table>
<thead>
<tr>
<th>PPFD (µE)</th>
<th>Unstored root number</th>
<th>Stored root number</th>
</tr>
</thead>
<tbody>
<tr>
<td>188 µmol m-2 s-1 (3.2 mol m-2 d-1)</td>
<td>6.4 a</td>
<td>5.5 a</td>
</tr>
<tr>
<td>100 µmol m-2 s-1 (1.8 mol m-2 d-1)</td>
<td>3.2 b</td>
<td>5.4 a</td>
</tr>
</tbody>
</table>

Question: Can carbohydrate levels be enhanced by reduction of air temperature?

Example Pelargonium

More light enhances sugar reserves in cuttings at harvest and after storage

Mean PPFD 3 weeks before harvest (µmol m-2 s-1)

Sucrose in basal stem (mg / g fresh mass)

Shifting the harvest day time from morning to afternoon:
- enhanced carbohydrate levels
- reduced damage and losses during storage

(1) Rapaka et al. (2007a,b)

Storage for 4 days: d1: 5 °C, d2: 15 °C, d3-4: 8 °C

4.3 Air temperature during rooting → carbohydrates

Pelargonium cuttings have a low photosynthetic activity when rooting under low light PPFD (100 µmol m-2 s-1, DLI: 3.6 mol m-2 d-1), so that respiration should have a big influence on the carbon balance

Question: Can carbohydrate levels be enhanced by reduction of air temperature?

Sugar levels in leaves are most important.

More light during rooting: 42 – 207 µmol m-2 s-1 (9h), DLI: 1.4 – 6.7 mol m-2 d-1

But

During rooting: 188 µmol m-2 s-1 (3.2 mol m-2 d-1), DLI: 5.5 klx

Higher photosynthetic photon flux density, ** daily light integral

Higher air temperature:
- increased sugar levels in cuttings
- promoted replenishment of storage-depleted sugar pools

Example Pelargonium

More light enhances sugar reserves in cuttings at harvest and after storage

Mean leaf sucrose level in leaves during the first week of rooting determined the number of roots!

Leaf sucrose (mean of days 0+7) (mg g-1 FM)
4.3 Temperature-mediated sugar levels → leaf damage and rooting

Druege: Environmental & endogenous control of rooting

1. When Pelargonium cuttings rooted at temperatures of 18 °C – 21 °C, raising the PPFD from ≤ 100 to > 150 µmol m⁻² s⁻¹ or the DLI from ≤ 3.2 to > 4.9 mol m⁻² d⁻¹
   - counterbalanced storage-induced carbohydrate depletion and drawback in rooting.

2. When stored Pelargonium cuttings rooted at low light (PPFD: 100 µmol m⁻² s⁻¹, DLI: 3.6 mol m⁻² d⁻¹) and high root zone temperature (20°C)
   - lower air temperature during rooting from 20 °C to 10°C
   - enhanced net photosynthesis and shoot dry matter production
   - raised (replenished) carbohydrate levels
   - reduced leaf senescence
   - improved rooting.

5. Storage-response and AR formation in Petunia

Environmental key factors and molecular physiological processes

4. Interim summary: current light and air temperature
→ carbohydrates → rooting of Pelargonium

1. When Pelargonium cuttings rooted at temperatures of 18 °C – 21 °C, raising the PPFD from ≤ 100 to > 150 µmol m⁻² s⁻¹ or the DLI from ≤ 3.2 to > 4.9 mol m⁻² d⁻¹
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   - lower air temperature during rooting from 20 °C to 10°C
   - enhanced net photosynthesis and shoot dry matter production
   - raised (replenished) carbohydrate levels
   - reduced leaf senescence
   - improved rooting.

5. Storage of Petunia: intensity of AR formation

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date of rating</th>
<th>Rooting parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>No storage</td>
<td>2 dpe</td>
<td>Number of roots</td>
</tr>
<tr>
<td>Cold dark</td>
<td>16</td>
<td>7.4 *</td>
</tr>
<tr>
<td>Warm dark</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Cold dark</td>
<td>16</td>
<td>Root length</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per cutting (cm)</td>
</tr>
<tr>
<td>No storage</td>
<td>16</td>
<td>8.3 *</td>
</tr>
<tr>
<td>Cold dark</td>
<td>16</td>
<td>20.2 *</td>
</tr>
<tr>
<td>Warm dark</td>
<td>16</td>
<td>25.7 *</td>
</tr>
<tr>
<td>No storage</td>
<td></td>
<td>33.7 *</td>
</tr>
</tbody>
</table>

dpe = days post excision of cuttings
dpin = days post insertion/sticking (rooting under light)

3+4. Principle of carbohydrate source limitation of AR formation

Obvious principle of carbon source limitation of AR formation in Pelargonium:
High and steady leaf sucrose level during rooting is
a) a function of initial leaf sugar levels and current photosynthesis
b) necessary for sufficient carbohydrate export and carbohydrate influx into the stem base
to meet the carbon demand of AR formation.

In case of weakly photosynthesizing cuttings:
Net carbon balance can be improved with lower air temperature, provided root zone temperature is maintained high.

5. Dark storage Petunia: anatomy of root development

Cold dark storage allows the initiation of root formation during the dark phase and accelerates subsequent root development and growth under light!
5. Storage of Petunia: carbohydrates during dark storage

**Petunia: carbohydrates after dark storage**

Strong accumulation in the stem base, reaching higher values than in the cuttings sticked immediately!

<table>
<thead>
<tr>
<th>dpe (days post excision)</th>
<th>Total carbohydrates (µmol g FW)</th>
<th>control (immediately sticked)</th>
<th>Dark pre-treated (10°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9.8 ± 3.4</td>
<td>3.6 ± 2.0 *</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>6.0 ± 1.5</td>
<td>8.8 ± 3.1 *</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6.9 ± 2.1</td>
<td>11.4 ± 3.1 *</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>17.1 ± 2.5</td>
<td>30.3 ± 8.1 *</td>
<td></td>
</tr>
</tbody>
</table>

5. Storage Petunia: dry matter production and partitioning

**Under darkness**

Cold dark storage causes an enhanced partitioning of dry matter towards the roots under subsequent light!

5. Storage of Petunia and nitrogen metabolism

**Under darkness**

Mobilization of amino acids (degradation of proteins)
7. Current projects/approaches

7.1. Near infrared spectroscopy (NIRS)

Nitrogen and carbohydrates in cuttings are important but how to measure and control under practical conditions?

NIR spectra are used for quality analysis of other agricultural products/crops but mostly with dried and milled samples. Principle: excision of OH-, NH-, CH-, CO-groups → reflectance spectrum

Newly published NIRS measurement of nitrogen fractions in cuttings and of starch and total non-structural carbohydrates in cutting leaves

7.2. Elucidating the role of hormonal pathways and genetic control

Cutting off from the basipetal auxin drain

IAA = indole-3-acetic acid, PAT = polar auxin transport

Wounding

Early IAA peak

Transcriptional regulation of auxin and ethylene pathways

7.3. Making use of the Petunia genome

Towards understanding the genetic diversity of AR formation and environmental responses
Can cuttings from *any* species root?

**PROPAGATION**

**THE ART (and Science) OF ROOTING DIFFICULT PLANT SUBJECTS**

Ross Cameron
Dept of Landscape
University of Sheffield
r.w.cameron@sheffield.ac.uk

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Successful propagation or successful production????

- What do we mean by success?
- A certain percentage of cuttings form roots
- *All* our cuttings root
- Individual cuttings form good numbers of roots

---

Difficult subjects

- ‘Difficult to root’ species – same principles as other species
- However, they are more sensitive to limitations/stress factors that other species may be more tolerant of
- As such, they require more specific care and attention to detail
- Is softwood cutting propagation the best method?

---

Successful propagation or successful production????

- High percentage of cuttings root, form good root systems, rapidly develop lateral branches / flower buds, are consistent in their shape and size and have minimal labour inputs
- All the cuttings / plants sell, make you a profit and you leave work happy!

---

Rooting (in general) gets more difficult as

- Annuals - herbaceous - shrubs - angiosperm trees - gymnosperm trees
- As plants age - phase
What happens when we take a cutting?

- Some 'cheat' and already have pre-formed roots – Salix, Populus, Ribes etc.
- Competence to root – organogenesis - the ability of tissues to form undifferentiated and then differentiated cells
- Plants in juvenile phase (non-flowering) root easier than those in mature (flowering) phase
- Competent cells may have greater potential to respond to external / internal signals e.g. auxin

Stock plant pruning

- Hard pruning can encourage 're-juvenation'
- Also encourages fewer, but stronger and longer growing shoots
- This tends to help rooting potential

The cutting needs ‘life support’

First aid for cuttings

- Water loss – effectively cut-off its life supply (collect in damp sacking / towelling, not polythene)
- Water immediately and keep watered on the propagation bench
- Raise humidity in preparation area
- Keep out of direct sunlight – still transpiring!
Most difficult large-leaved woody species favour

- Active growing points to synthesis auxin
- Good leaf area to maximise photosynthesis
- Enclosed polythene or fog to keep humidity high
- Open, aerated medium
- High wetting – frequent mist
- Sharp drainage – sand bed – to pull moisture away from cutting base

For difficult woody species there appears to be some advantage in retaining shoot tips and young expanding leaves:

- Helps xylem-transported *exogenous* auxin applied at the base to enter the cambium
- Generates *endogenous* auxin that helps retain the rooting signal

Life support = The great balancing act

- Light
- Wetting
- Humidity
- Drainage

These factors are closely inter-related

### High light
- More photosynthesis – more sugars to power growth
- Increases temperature and reduces humidity
- Required increase in wetting (cooling and water supply) and humidity (minimise water loss)
- More water requires better, sharper drainage – capillary sand to draw water away from base of module

### Low light
- Less photosynthesis – slower to root
- Less stress due to excessive dryness and heat
- Requires less wetting
- Less requirement for sharp drainage – module in contact with myplex or concrete floor
Rooting enhanced when more shoot tips present - the ‘pre-branched cutting’ – can speed up liner production?

HNS 69 – Developing the concept of the ‘Designer Liner’

<table>
<thead>
<tr>
<th>Species</th>
<th>Pre-branching response</th>
<th>Rooting stability</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forsythia</td>
<td>Typically only 2-4 laterals form after cutting rooted, requires re-tipping or later post-rooting pruning</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Cotinus</td>
<td>Excellent response; potential for taking very large cuttings, &gt; 5-6 laterals</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Magnolia</td>
<td>Pre-branching sometimes difficult; compatible with high humidity fog</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Garrya</td>
<td>Limited response; only 2-4 laterals form</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Populus</td>
<td>No response from tipping; shoots grow inapetently</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Photinia</td>
<td>Excellent response, established cuttings with 4-5 laterals</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Potentilla</td>
<td>Potential cuttings take rootings, high humidity fog required; large cuttings easy</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Viburnum</td>
<td>Large cuttings can almost result in the instant liner</td>
<td>√√</td>
<td>√√</td>
</tr>
<tr>
<td>Hebe</td>
<td>Pre-branching cuttings carry flower primordia</td>
<td>Rooted readily</td>
<td>√√</td>
</tr>
<tr>
<td>Cistus</td>
<td>Limited ability to form laterals</td>
<td>Rooted relatively easily in modules under mist</td>
<td>√√</td>
</tr>
<tr>
<td>Cornus</td>
<td>Limited ability to form laterals</td>
<td>Rooted relatively easily in modules under mist</td>
<td>√√</td>
</tr>
</tbody>
</table>

The devil in the detail
The importance of rooting environment for UK HONS

HNS 55

Rooting – environmental fingerprints

- Gradients by varying degree of fogging and degree of light

Controlled propagation environment
East Malling 1993-2002

‘Easy’ subjects
Easy species – broad range of environmental tolerances

*Acer palmatum ‘Aureum’*

Weigela

Copes well throughout

Challenging – active growth is key

*Weigela*

Interactions between light and wetting

*Ceanothus ‘Autumnal Blue’*

Wet and high light, but also moist and medium light

Most broad-leaved shrubs in active growth – *Cotinus coggygria*

Sometimes links to ecology - ecophysiology

*Convolvulus cneorum*
Tolerant to light variation, but dislikes wet – *Cryptomeria japonica*

*Narrow tolerance range* - *Garrya elliptica*

Don’t assume all genotypes need the same!

*Narrow tolerance range* - *Daphne ‘Somerset’*
If the environment can be optimised then cuttings can increase rooting potential over time, not see a reduction

• The case of *Anacardium* (cashew)
• Cuttings inserted in perlite within mist bed with enclosed polythene – timer control
• Apical cuttings 10cm long (0.5cm diameter at base) and 6-8 full leaves derived from pot grown stock plants
• Bases dipped in water (control) or 6.2 mM indole-3-butyric acid soln. (+IBA)
• Con = 90% rooted, +IBA=100% rooted

• Rooting potential actually *increased* with time in the propagation environment
• Photosynthates presumably were powering new root development
• Once the initial trigger to form adventitious roots has taken place, adventitious root development was not inhibited (possibly due to the removal of the initial roots)

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**Anacardium occidentale**

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Finally – the take home messages

• Economics of home propagation v buying-in
• Beware of inefficiencies - taking 300 to root 50!
• What is the market for difficult-species – economic justification – other ways – grafting?
• Attention to detail and proper facilities – investigate the specific requirements
• Stock plant – optimise potential to root
• Propagation – express that potential
• Weaning – ensure quality, saleable crop

---

Removing roots and reinserting the cuttings into pots – just encouraged the formation of more roots, e.g. clone AC10

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Thank you!

Questions?
References


Managing the environment to maximise rooting and minimise waste

Creating the right environments; humidity, light, temperature.

Watering, nutrition and weaning.

Controls.

How to make use of records to reduce waste.

Plant specific examples.

Humidity

Lowering humidity

ThermaProp polythene

ThermaProp Propagation Film
ThermaProp Clear or White films for low-cost propagation.

ThermaProp was produced by us after a demand from many of our colleagues in the UK. Originally produced in white for warmer propagation ThermaProp is made both with the new generation and with the older quality ThermaProp because it stops the condensate in the greenhouse and secures it gives a more even temperature around the plants. Non-thermal films give a bigger variation in temperatures. Secondly we made it anti-bip because the anti-bip solution used to be a coat of white paint. Trials at Kyara nurseries in Honduras showed us that we were on the right road with these materials.

You can see that the conditions inside the ThermaProp are almost the same as inside that very expensive poly house. Films on other nurseries also showed up to 15% improvement in rooting percentage, having proved the principle we then produced ThermaProp Clear so that new profession propagators have the advantages of ThermaProp for White propagation with the new films and better propagation with the white.
Heated matting

Humidity / keeping cool

Keeping cool

Watering

Shading materials

- Polythene
- Fleece
- Screens
- Netting
- Paints

Watering

- How often?
- How much?
- When?
How to make use of records to reduce waste

- Involve the team.
- Discuss and communicate change.
- Incorporate other people’s ideas.
- Recognise all of the skills within a team.
- Always seek improvements but remember that this isn’t football.

“Some people believe football is a matter of life and death. I am very disappointed with that attitude. I can assure you it is much, much more important than that.” Bill Shankly

Using biopesticides

Weaning and liquid feeding

Record keeping

Control systems

- Leaf
- Time clock
- Evaposensor
- Solar/ light

Successful management
Managing the environment to maximise rooting and minimise waste
Key stages of rooting

1) Post-excision dehydration
2) Root initiation
3) Cutting growth

How plants sense light quality

Post-excision dehydration

Highest blue light treatments caused *Eleagnus* cuttings to shed all leaves within one week resulting in high mortality.

Light treatments

Red, blue and far-red LEDs used to generate several different red:blue and red:far-red light mixtures ranging from 100% red to 100 blue.

All cuttings contained within tents to retain humidity.
Cutting growth

Rooting and growth of Iberis cuttings was more rapid under low blue treatments. This is less of an issue for node cuttings.

Root initiation also correlates with blue light treatment.

Root initiation also correlates with blue light treatment.

Sensitivity to blue light varies between species.

But survival does not mean cuttings will root.

Root initiation also correlates with blue light treatment.

Root initiation also correlates with blue light treatment.

Influence of far:red on rooting

Chrysanthemums showed no negative responses to far-red so again there are differences in sensitivity between species.

Potential to remove or reduce the need for PGRs.
Benefits of lighting mother stock

- **Supplemental lighting**
- **No light**
- **Day length extension lighting**

- Cuttings lit with 0% BLUE (100% RED)
- Low stress

Survival and rooting poor if pre-excision lighting inappropriate

**Benefits of lighting mother stock**

- **Supplemental lighting**
- **No light**
- **Day length extension lighting**

- Cutting lit with 60% BLUE
- High stress

Survival and rooting high if pre-excision lighting appropriate even under stressed conditions

**Using tomato as a model system for rooting**

Rooting is fast

Rooting responses to light are similar to the other species examined

Regular supply of material available

Samples for hormone analysis collected at 2, 24, and 48 hours after collection

**First look at hormone data**

- Large changes in auxin concentration in the stem after cutting collection
- Light spectrum has large impact on auxin concentration in the stem 48 hours after collection

**Strong correlation between auxin concentration and number of roots produced**

\[ y = -1.5976x^2 + 12.883x + 7.6369 \]

\[ R^2 = 0.9551 \]
Summary of plant responses

- Low blue light (especially during the first few days) reduces dehydration
- Low blue light also helps rooting
- Increase the amount of blue light after rooting. This helps root growth and prevents shoot stretching
- Providing the correct light to mother stock plants greatly improved cutting quality and strike rate
- Changes in hormones are complex, but early studies indicate light quality alters hormone signalling. Future work may help identify the optimal light quality

Factors to consider when assessing use of LEDs

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Installation costs</td>
<td>• Potential increased strike rate</td>
</tr>
<tr>
<td>• Running costs of lights</td>
<td>• Increased speed of rooting</td>
</tr>
<tr>
<td>• The spectrum of the lights</td>
<td>• Improved quality of cuttings</td>
</tr>
<tr>
<td>• Area to be lit compared to the number of plants</td>
<td>• Reduce labour costs (due to increased strike rate and speed of rooting)</td>
</tr>
<tr>
<td></td>
<td>• May not need to use rooting powder</td>
</tr>
</tbody>
</table>

Some of the benefits may be achievable via other methods

Further information

- CP 125 reports available at the following link - https://horticulture.ahdb.org.uk/project/understanding-crop-and-pest-responses-led-lighting-maximise-horticultural-crop-quality-and
- LED4CROPS website - http://www.led4crops.co.uk/

Thanks to...
- Dr Rhydian Beynon-Davies
- Prof Ian Dodd (hormone analysis)
- Plants supplied by
  - Kernock park plants
  - New place nurseries
  - Micropropagation Services
Managing the potential of quarantine plant pests and diseases on bought-in cutting material
AHDB Horticulture Workshop
February 2017

What is a quarantine plant pest?

• Is it a regulated or non-regulated plant pest?

Who am I?

• Jonathan Hazelwood.
• Inspector for over 25 years.
• Based in Worcester since 1993.
• Responsible for work in Worcestershire, Gloucestershire and Oxfordshire.

What is a quarantine plant pest?

Regulated plant pest

• Pests listed in the EU Plant Health Directive and the UK’s Plant Health orders.
• Specifies the action required to control it.
• Directive can be slow to react to new pests but it does allow for emergency action to be taken by individual countries.

What is a quarantine plant pest?

Non-regulated plant pests

• The PHSI has the power to act on any pest that is considered to pose a risk to plants in the UK.
• The UK Plant Health Risk Register now lists nearly 1000 potential pests.
• This gives us the flexibility to look for and respond to new threats.
• https://secure.fera.defra.gov.uk/phiw/riskRegister/
What is the role of the industry in quarantine plant pest control?

- You have the main role in preventing the introduction and spread of pests into the UK.
- As a passport registered nursery it is YOUR legal responsibility to ensure that your plants are pest free.
- The establishment of a quarantine pest should be considered as a failure of the system.
  - It means the pest has evaded all the controls that have been put in place.
  - It has put the industry and possibly the wider environment at risk.

What is the role of the industry in quarantine plant pest control?

- EU cuttings
  - Is the production company aware of specific UK requirements for pest freedom?
  - Some quarantine pests and diseases of concern to the UK are present in parts of the EU.
    - UK is a protected zone for Bemisia tabaci so we impose tighter restrictions than parts of the EU.
  - Are the plants being correctly passported.
  - Is there a risk of cross infection from other plants being produced on the same site?

What is the role of the industry in quarantine plant pest control?

- UK production
  - Training staff in pest identification.
  - Can staff report issues back to supervisors?
  - Is your routine pest control programme sufficient to control quarantine pests?
  - Do you regularly monitor and record pest presence.
  - Do you have isolation between batches, glasshouses or different types of production.
  - Records of purchases and sales.
  - Liaison with your local PHSI about deliveries.

What is the role of the industry in quarantine plant pest control?

- Third Country cuttings
  - Think about quarantine risks when planning your supply of cuttings.
  - Is the production company aware of the risks and our requirements?
  - Are there quarantine pests naturally present in their environment?
  - Can they produce consistently pest free material?
  - Are they working with their Plant Health Service?
  - Is the plant genera you want to import subject to any specific restrictions or controls e.g. Solanaceae

What is the role of the industry in quarantine plant pest control?

- What to do if you suspect a quarantine pest?
  - Inform your local inspector immediately.
  - Failure to notify a suspect quarantine pest is an offence.
  - Don’t hide anything.
  - Start taking appropriate control measures.
  - Gather information.
    - Suppliers, dates consignments arrived, movements within the nursery, sales lists.
Examples of what to look for

Leaf miners

Very small threadlike mines on the oldest leaves.

Adult flies can have a distinctive yellow spot on their backs. Check yellow sticky traps.

Examples of what to look for

Something different

Look out for anything that looks different or odd. Leaf distortion, dieback on leaves or stems. Stop sticking and isolate.

Examples of what to look for

Whiteflies

Small scales on underside of leaves. Very hard to find and see.

Adult flies are often smaller and more yellow than the glasshouse whitefly. They can be trapped on the inside of plastic cuttings bag. Check yellow sticky traps.

Examples of what to look for

Caterpillars

Holes and damage to leaves. Frass on leaves or in the cutting bag. Very small early stages on cuttings or in bag.

More damage to leaves, frass, silk webbing and possibly rolled leaves. Often more active at night.

Examples of what to look for

Caterpillars

Holes and damage to leaves. Frass on leaves or in the cutting bag. Very small early stages on cuttings or in bag.

More damage to leaves, frass, silk webbing and possibly rolled leaves. Often more active at night.

What is the role of the PHSI in quarantine plant pest control?

• We are part of Animal and Plant Health Agency APHA.
• Which is part of DEFRA.
• Laboratory facilities at Fera, Sand Hutton, York.
• Our primary aim is to prevent the introduction and establishment of quarantine pests in England and Wales.
• If introduced our aim is to eradicate or control them as quickly as possible.
• PHSI Inspectors do the work on the ground.

Cutting inspection – a two stage approach

1. Point of entry inspections at airports.

• All plant consignments imported into the EU from Third Countries are held at the point of entry on arrival.
• It will have a documentary, identity and health inspection.
• If the consignment passes it will be released and will be free to move within the EU under a plant passport or a Plant Health Movement Document.
• Pre-notification to the PHSI of plants arriving in the UK from other member states is not currently required.
Interception or outbreak?

Interception

- An interception is when the pest is only found on the originally material.
- An interception can be made at the point of entry, pre-sticking nursery inspection, during sticking or on recently stuck material.
- The easiest way to deal with an interception is to destroy the material.
- Treatment and isolation may be an option.

Problems with point of entry inspections

- High volumes of plants can arrive in a very short space of time.
- Pressure to clear consignments as quickly as possible.
- Packages can be hard to open and examine.
- Small number of consignments are infected.
- Pests present at very low levels.
- Life stage of pest may be difficult to detect - eggs or early instars.
- Pests may not be uniformly spread within the consignment.

Outbreak

- An outbreak occurs when the pest has spread from the originally infected plants.
- The spread can be within the original batch of plants and/or onto adjacent batches.
- For insect pests it usually means at least one lifecycle has been completed.
- For fungi, bacteria or viruses it means they have reached a life stage where they can spread either directly or via a vector.

Dealing with the finding of a quarantine pest

Interception or outbreak?

- The first task of an Inspector will be to decide if a quarantine pest finding is an interception or outbreak.
- This will have a major effect how it is dealt with.
- It will also have a different impact on your business.
- Any finding of a quarantine pest will trigger official action.
  - One is enough!

What can you expect from PHSI?

Our responsibility is to

1. PREVENT PEST SPREAD TO OTHER SITES.
2. Identify any sites which may have received infected material and arrange follow-up inspections.
3. Identify the origin of the pest and prevent further introductions.
4. Prevent further spread within the nursery.
5. To eradicate the pest as quickly as possible.
What can you expect from PHSI?

What we will do if a quarantine pest is suspected
• Take samples to confirm the diagnosis.
• Serve Notices specifying the action required.
• Inspect the site to establish extent of infection
  - Is it an interception or outbreak?
  - Is it limited to one genera from one source or has it spread?
  - Is it contained within one area or the nursery?
• Gather records of deliveries in and sales out.
• Using the information obtained develop a control strategy, in co-operation with the nursery, to eradicate the pest.

Take home message
• The risk of a quarantine pest outbreak maybe low.
• Around 2-3 incidents per year.
• The implications for your business could be high.
• Stay vigilant and don’t become complacent.
• Minimise the risk by planning ahead.
• Work with your local Inspector - that’s their job.

Thank you

What can you expect from PHSI?

• From the moment that a quarantine pest is identified that information will be seen by all PHSI managers.
• A report is sent to the Commission in Brussels.
• Ministers receive weekly updates.
• Your Inspector will be under pressure to resolve the problem as quickly and efficiently as possible.
• We will try to work in co-operation with the nursery but we will be in control of the outbreak and eradication measures.

Timescales
– Every outbreak will be different so setting any time frame is difficult but as a guide:
  – Initial hold on movement.
    • Likely to be 5-7 days whilst a diagnosis is obtained and the severity and extent of the outbreak is ascertained.
  – Eradication action.
    • Minimum of 5 weeks. The time taken for the pest to complete a full lifecycle plus a buffer.
– Your Inspector will be visiting regularly to check for the pest and a period of no finds will be required before the pest can be declared eradicated and the restrictions lifted.

What can you expect from PHSI?

• From the moment that a quarantine pest is identified that information will be seen by all PHSI managers.
• A report is sent to the Commission in Brussels.
• Ministers receive weekly updates.
• Your Inspector will be under pressure to resolve the problem as quickly and efficiently as possible.
• We will try to work in co-operation with the nursery but we will be in control of the outbreak and eradication measures.
Integrated pest management

- Definition: A systems approach that combines different crop protection practices with careful monitoring and the use of natural enemies. Sustainable Use Directive: legal requirement as of 1 January 2014

Basics of IPM

- Cultural: general hygiene, ground cover materials, weed control, plant movement, monitoring, sticky traps
- Biological: parasitoids, predators and pathogens
- Environmental: disease control for plant and insect pathogens
- Pesticide backup with selective chemicals

Sustainable use of pesticides

IPM interactions

- Environment
- Side effects of pesticides
- Side effects of beneficials
- Intraguild predation / parasitisation
- Spray cocktails

Sticky trap orientation

100 / ha for monitoring, up to 1 per 2m² for mass trapping
Aphid control

*Aphidius*: parasitoid wasps, can be host specific, available as single or mixed species in tubes

*Aphidoletes*: predatory midge larvae, attacks majority of aphid species

**Broad spectrum arthropod control**

*Beauveria bassiana*

- Highly IPM compatible
- Spore activation
- Mix Naturalis-L in a bucket with a small amount of water and leave for 2-3 hours but no longer than 5 hours
- Application should be made early morning or late evening
- High relative humidity (optimum over 80%)
- Apply as high volume spray to just before run off
- Thorough coverage essential (contact activity)
- 1.5 lt/ha if water volumes between 500-1000 lt
- At 2000 lt of water use 3 lt/ha

**Environmental conditions for BotaniGard and Naturalis-L**

- **Temperature**: 18 to 32°C
  - Good activity from 20 to 27°C
  - Considerable reduction of viability of spores at temperatures exceeding 35°C
  - Spore germination stops at temperatures below 10°C
- **Humidity**: > 60%
  - Spore germination stops at RH levels below 15%
  - The higher the RH, the more the fungus is likely to sporulate

**Optimum conditions**: temperature 25°C, RH ≥ 80%

**Aphid control**

*Chrysoperla carnea*:
- Feed on most soft bodied prey
- Can be introduced to hedges to prevent pest migration

*Beauveria bassiana*:
- Min 60% RH, 80% at leaf surface
- Good curative, produces epizootic infection

**Sciarid flies**

Larvae feed on roots and damage cuttings.
Adults and larvae can transmit plant pathogens.
Yellow traps for adults

**Aphid control**

*Beauveria bassiana*:
- Registered bioinsecticide – MAPP 17526
- Control of whitefly
- Demonstrated control of spider mite and reduction of thrips with good activity against a range of other pests
- On-label: All edible crops (protected) and ornamental plant production (protected)
- EAMU: 20162195 issued 25/08/2016 exp 31/10/2021
- Protected forest nursery
**Sciarid and scatella larvae control**

*Hypoaspis miles*:
- Good in all growing media, preventive
- Live just below surface, dislike direct light

*Atheta coriaria*:
- Predatory beetle
- Feeds on sciarid larvae and pupae as well as scatella larvae

---

**Life cycle of sciarid flies**

- **Copulation on the soil surface during the first day after emergence**
- **Larvae pupate on the soil surface (3-5 days)**
- **Larvae hatch after 2 to 3 days at 18 to 20°C**
- **100-200 eggs per female in batches of 20-30**

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**Scatella fly (shore fly)**

*Scatella stagnalis and S. tenuicosta*
- Feed only on algae but can transmit plant pathogens
- Nuisance pest
- Rapid reproduction
- General hygiene very important

---

**Scatella flies**

---

**Predatory hunter flies: Coenosia atenuata**
**Sciarid fly control: pathogens**

*Steinernema feltiae:*
- Curative and preventive
- Min 10 - 12°C in moist substrate
- Disease control with fungicides, Prestop, Serenade and T34

**Prestop: Biofungicide**

- Synthesis of biostatic and antibiotic compounds: Prestop produces natural chemicals which are highly effective at killing disease causing pathogens
- Priming: Prestop activates the natural defence mechanisms of plants making them more resistant to pathogen attack (ISR or ASR)
- Root colonisation: Prestop grows around roots forming a valuable protective barrier against disease and also moves with the roots as they grow

**Application timing**

- First larval stage too small for nematodes to enter
- The 2nd to 4th instars of sciarid larvae are the most susceptible stages
- More nematodes recycle in larger larvae
- Nematodes infect best in soil/substrate with 70% water content, avoid overwatering as nematodes will drown
- Nematode numbers can decrease by 50% within one week, particularly in small plugs

*Match application with occurrence of larvae!*

**Serenade**

- Serenade is a highly effective, contact fungicide and bactericide with multiple modes of action for a broad spectrum of control with little potential for resistance
- Based on the proprietary active ingredient, *Bacillus subtilis* QST 713, a naturally occurring, rod shaped, aerobic, motile bacterium, not genetically modified
- *B. subtilis* QST 713 is unique in its production of both antifungal and anti-bacterial compounds and is patented
- MAPP 16139 / PCS 03847

**Prestop: Biofungicide MAPP 17223**

Prestop is a broad-spectrum biofungicide with several modes of action, with no chemical residue and little potential for resistance

For control of various root and foliar diseases such as *Fusarium, Pythium, Phytophthora, Rhizoctonia, Sclerotinia* etc. on ornamentals and vegetables. Also good control of *Botrytis* and *Didymella*

**Fungicidal metabolites – lipopeptides**

- Spore of botrytis; intact and germinating on leaf surface
- *Gliocladium catenulatum* J1446 root association
- *Pathogen spore attacked by Serenade*
- Pathogen spore destroyed and multiplication of *B. subtilis* cells
Inducer of systemic resistance (ISR)
Classical model for induced systemic resistance based on the dispersal of salicylic acid (SA)

Soil and substrate treatments
• Apply in the penultimate irrigation of the day, using sufficient water to thoroughly drench substrate; aim for at least 10% of pot volume

• Minimize the wash-out risk and guarantee suitable diffusion in the substrate, final irrigation is to washout lines

Drench – calculate the amount of T34 required to drench 15,000 X 2 lt pots  
Answer – 150g

Incorporation into substrate – calculate the amount of T34 incorporated into growing media used for 16,000 X 3 lt pots  
Answer - 480g

Foliar treatments
• Ensure full coverage of the crop

Application rates
Spray – calculate the amount of T34 required to spray 25,000 X 1 lt pots  
Answer - 250g

Compatibility: fungicides
Compatible
• azoxystrobin
• bupirimate
• chlorothalonil
• fosetyl-aluminium
• kresoxim-methyl
• metalaxyl-M
• propamocarb
• hydrochloride
• sulphur
• toclofos-methyl
• trifloxystrobin

Incompatible
• copper oxichloride
• cyproconazole
• difenoconazole
• iprodione
• myclobutanil
• penconazole
• prochloraz
• hexaconazol
• thiophanate-methyl

Allow at least 10 days

Majority of insecticides are safe
• **Compatible** fungicides can be used alongside the product. However, for absolute safety we do not recommend tank mixing with any fungicide.

• **Fungicides** that are not compatible should have a security period of at least 10 days before and after the use of **T34 Biocontrol**®

• **Insecticides** and the majority of **acaricides**, are compatible and can be tank mixed.

• **Fertilisers** are all compatible with **T34 Biocontrol**®

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**Spectrum of activity**

<table>
<thead>
<tr>
<th>CROP</th>
<th>PATHOGEN</th>
<th>RANKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td><em>Botrytis cinerea</em></td>
<td>****</td>
</tr>
<tr>
<td></td>
<td><em>Colletotrichum acutatum</em></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td><em>Sphaerotheca macularis</em></td>
<td>**</td>
</tr>
<tr>
<td>Stone fruits</td>
<td><em>Monilia spp.</em></td>
<td>****</td>
</tr>
<tr>
<td>Plums, apricots, peaches</td>
<td><em>Botrytis cinerea</em></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td><em>Rhizopus spp.</em></td>
<td>**</td>
</tr>
<tr>
<td></td>
<td><em>Sphaerotheca</em></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td><em>Podosphaera</em></td>
<td>**</td>
</tr>
<tr>
<td>Pears</td>
<td><em>Stemphylium spp.</em></td>
<td>****</td>
</tr>
<tr>
<td></td>
<td><em>Venturia pirina</em></td>
<td>**</td>
</tr>
<tr>
<td>Vegetables</td>
<td><em>Botrytis cinerea</em></td>
<td>***</td>
</tr>
<tr>
<td>Tomatoes, cucumbers, eggplants, lettuce, peas, beans, onions, pepper</td>
<td><em>Sclerotinia spp.</em></td>
<td>**</td>
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<tr>
<td></td>
<td><em>Ascochyta spp.</em></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td><em>Alternaria spp.</em></td>
<td>**</td>
</tr>
<tr>
<td></td>
<td><em>Leveillula, Erysiphe and Sphaerotheca</em></td>
<td>**</td>
</tr>
<tr>
<td>Ornamentals</td>
<td><em>Botrytis cinerea</em></td>
<td>****</td>
</tr>
</tbody>
</table>

*** = excellent; ** = good; * = side effect

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**Switch**

MAPP 15129

A prepack mixture of **fludioxonil** and **cyprodinil**, both of which have distinctly different modes of action, which infers good resistance management.

Switch means double action on the crop through long lasting protectant (fludioxonil) and systemic (cyprodinil) activity. PCS No: 03761 FRAC 9 + 12

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**Preventive and systemic protection**

Fludioxonil molecules remain on the leaf surface, providing excellent protection from infection.

While some cyprodinil molecules remain on the leaf surface, others enter and move within the plant.

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**Thank you for your attention**
Notes