Narcissus Growers Workshops

13 & 20 May 2015

Redruth & Spalding

In association with CABGA and EGBA

Optimising bulb treatments, post-lifting
### Programme - Wednesday 13th May

*Pool Innovation Centre, Trevenson Road, Pool, Redruth, Cornwall, TR15 3PL*

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30</td>
<td><em>Arrival, refreshments and registration</em></td>
</tr>
<tr>
<td>09:45</td>
<td>HDC update (Cathryn Lambourne and Gracie Emeny, HDC)</td>
</tr>
<tr>
<td>10:15</td>
<td>Optimising daffodil hot-water treatment: A summary of recent HDC-funded projects (Gordon Hanks)</td>
</tr>
<tr>
<td>11:30</td>
<td><em>Refreshments</em></td>
</tr>
<tr>
<td>11:45</td>
<td>Bulb drying and storage: Getting the detail right and minimising energy costs (Bill Basford)</td>
</tr>
<tr>
<td>13:00</td>
<td><em>Lunch</em></td>
</tr>
<tr>
<td>13:30</td>
<td>Minimising energy costs in the process of treating bulbs (Andrew Kneeshaw, FEC)</td>
</tr>
<tr>
<td>14:45</td>
<td><em>Refreshments and depart</em></td>
</tr>
</tbody>
</table>

### Programme - Wednesday 20th May

*Whaplode Manor, Washway Road, Spalding, Lincolnshire, PE12 8AZ*

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:15</td>
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</tr>
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<td><em>Lunch</em></td>
</tr>
<tr>
<td>13:45</td>
<td>Potential for living mulches in bulb production (Sarah Cook, ADAS)</td>
</tr>
<tr>
<td>14:30</td>
<td><em>Refreshments and depart</em></td>
</tr>
</tbody>
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<td>HDC crop protection update May 2015</td>
<td>7</td>
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<td>HDC update – BOF 074a: Evaluating potential new fungicides for the control of Narcissus basal rot in bulb and plant tests</td>
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<td>HDC update - FV 415: Molecular methods for detection of stem nematode (<em>Ditylenchus dipsaci</em>) in soil and predicting risk of damage to onions &amp; leeks</td>
<td>16</td>
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<td>Daffodil bulb dipping/hot water treatment: Where are we and where do we go from here? – Gordon Hanks</td>
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<td>Bulb drying and storage: Getting the detail right – Bill Basford</td>
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<tr>
<td>Energy Issues: Bulb Drying and Storage – Andrew Kneeshaw</td>
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<td>Potential for living mulches in bulb production – Sarah Cook</td>
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UK NARCISSUS GROWERS (CORNISH BULB GROWERS ASSOCIATION & EASTERN/GRAMPIAN BULB ASSOCIATION)

Please Note: All prospective research contractors to speak to the nominated CABGA or EGBA co-ordinator before submitting any concepts/proposals. Contact details for CABGA & EGBA co-ordinators at the end of the document.

Top CABGA & Lincs/Grampian priority issues:-
- Fusarium basal rot, Investigation of possible ClO2 effects, Fungal disease control, Storage, Large Narcissus Fly

Main cross sector issues:- Pests, Pathogens, Weeds,

**Objective 1: Ensuring adequate and sustainable crop protection measures are available for the key pests, diseases and weeds of each crop/category**

<table>
<thead>
<tr>
<th>Target</th>
<th>Initiative examples</th>
<th>Previous, current, or pipeline work</th>
<th>Priority (Low/med high)</th>
<th>CABGA or EGBA Co-ordinator</th>
</tr>
</thead>
</table>
| Control of key fungal pathogens |  - White mould (*Ramularia vallisumbrosae*)
  - Narcissus smoulder (*Botrytis narcissicola*)
    - decision support system | BOF 041: forecasting white mould and smoulder.
BOF 072.a: Narcissus- improved control of foliar diseases. Finished Dec ’13, ADAS | Low | CABGA | EGBA |
| | | BOF 041: forecasting white mould and smoulder. BOF 059 – Completed 2008, G. Hanks. BOF 072a – as above | Med | | PR (EGBA) |
| |  - Fusarium basal rot
  - resistance through the season
  - genetics
  - dip treatment (fungicides, cold dipping)
  - Biological control
  - Cool storage of bulbs July/August to control BR. Below 18°C does it ‘hold’ disease or prevent it?
  - Cool dipping post-harvest | BOF 061, a-c: Alternatives to Formaldehyde for basal rot control.
BOF 071: The use of FAM 30 disinfectant as a cold dip treatment for Fusarium basal rot.
BOF 074: In vitro screening of fungicides for control of basal rot of narcissus.
BOF 074a Potential new fungicides for the control of Narcissus basal rot. 2014
BOF 060: An on-line low cost non-invasive sensor of basal rot in narcissus bulbs.
BOF 069: Suppression of Fusarium basal rot using composts amended with biocontrol agents. Finished June ’12, EMR FV 219, a-b. Control of Fusarium basal rot and OWR in onions. 2013 In Pipeline – Cross-sector project being built (2014) | High | | |
| Control of key |  - Nematodes | In Pipeline – Chlorine Dioxide project (2015) | Low | | |

### Objective 1: Ensuring adequate and sustainable crop protection measures are available for the key pests, diseases and weeds of each crop/category

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<th>Priority (Low/med high)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>pests</td>
<td>▪ Root lesion (<em>Pratylenchus penetrans</em>)</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ Stem &amp; bulb (<em>Ditylenchus dipsaci</em>)</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ CIO2 rates/use/guidance/HWT</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ timing of treatments</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ Bulb scale mite</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ In-field control (chemical/biological CIO2?)</td>
<td>B0F 025,a, BOF 063, a,b: Integrated control of bulb-scale mite in Narcissus. 2013.</td>
<td>Low</td>
<td>CABGA</td>
</tr>
<tr>
<td></td>
<td>▪ Large Narcissus fly</td>
<td>BOF 001, a-c, 024, 037, 053, 055 BOF 075 Novel insecticides for the control of large Narcissus fly. 2014.</td>
<td>Med</td>
<td>AJ (EGBA)</td>
</tr>
<tr>
<td></td>
<td>▪ Need long term protection post-planting</td>
<td>BOF 001, a-c, 024, 037, 053, 055 BOF 075 Novel insecticides for the control of large Narcissus fly. 2014.</td>
<td>Med</td>
<td>AJ (EGBA)</td>
</tr>
<tr>
<td></td>
<td>▪ Slugs</td>
<td>In Pipeline – PhD ongoing.</td>
<td>Low</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td>Control of key weeds</td>
<td>▪ General weeds as crop emerges and throughout growing season</td>
<td>BOF 035: Herbicides for late-season weeds.</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td></td>
<td>▪ Willow-herb control post-emergence</td>
<td>BOF 046: The use of herbicides singly and in combination for the control of volunteer potatoes.</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOF 047: as above but winter wheat.</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOF 051b: Gladiolus – evaluation of herbicides.</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOF 58: Lily herbicide trials</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOF 065: Replacement for Dosaflou in Gladiolus.</td>
<td>Med</td>
<td>ME (EGBA)</td>
</tr>
<tr>
<td>New crop protection products (EAMUs)</td>
<td>▪ Fungicides</td>
<td>BOF 022 Minor use chemicals: off-label approval</td>
<td>High</td>
<td>DB (EGBA)</td>
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<tr>
<td></td>
<td>▪ Insecticides</td>
<td>In Pipeline – HDC Gap Analysis</td>
<td>High</td>
<td>DB (EGBA)</td>
</tr>
<tr>
<td></td>
<td>▪ Herbicides</td>
<td>In Pipeline – HDC Gap Analysis</td>
<td>High</td>
<td>DB (EGBA)</td>
</tr>
<tr>
<td></td>
<td>▪ Chlorine Dioxide</td>
<td>BOF 070a: Narcissus: Chlorine dioxide – daffodils treated in hot-water treatment</td>
<td>High</td>
<td>DB (EGBA)</td>
</tr>
</tbody>
</table>
UK NARCISSUS GROWERS (CORNISH BULB GROWERS ASSOCIATION & EASTERN/GRAMPIAN BULB ASSOCIATION)

**Objective 2. Increase returns on investment through efficient use of resources.**

<table>
<thead>
<tr>
<th>Target</th>
<th>Initiative examples</th>
<th>Previous, current, or pipeline work</th>
<th>Priority</th>
<th>CABGA or EGBA Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanisation, precision technology</td>
<td>Flower cropping- semi/full automation</td>
<td>BOF 011 Report on Dutch study tour on forcing techniques and mechanisation.</td>
<td>High</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
<tr>
<td></td>
<td>Improved foliar fungicide application technology</td>
<td>CP 103 (PhD) The application of precision agronomy to UK production of Narcissus. 2013-2016</td>
<td>Low</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
<tr>
<td></td>
<td>Reduced Fertiliser inputs</td>
<td></td>
<td>Low</td>
<td>CABGA or EGBA Coordinator</td>
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<tr>
<td></td>
<td>Improve fertiliser placement</td>
<td></td>
<td>Low</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
<tr>
<td></td>
<td>Use of desiccants pre-lifting or other crop retardants</td>
<td></td>
<td>Low</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
</tbody>
</table>

**Objective 3: To supply consistent quality product and continuity and to achieve customer satisfaction**

<table>
<thead>
<tr>
<th>Target</th>
<th>Initiative examples</th>
<th>Previous, current, or pipeline work</th>
<th>Priority</th>
<th>CABGA or EGBA Coordinator</th>
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</thead>
<tbody>
<tr>
<td>Storage and transportation</td>
<td>Cooling of flower crops</td>
<td>BOF 004 Cool chain flower distribution</td>
<td>Med</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
<tr>
<td></td>
<td>Optimum storage conditions post-harvest to extend retail life</td>
<td></td>
<td>Med</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
<tr>
<td></td>
<td>Bulbs</td>
<td></td>
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<tr>
<td></td>
<td>Flowers</td>
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**Objective 4: Areas for further investigation**

<table>
<thead>
<tr>
<th>Target</th>
<th>Initiative</th>
<th>Previous or current work</th>
<th>Priority</th>
<th>CABGA or EGBA Coordinator</th>
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<tbody>
<tr>
<td></td>
<td>Diffuse pollution</td>
<td></td>
<td>Low</td>
<td>CABGA or EGBA Coordinator</td>
</tr>
</tbody>
</table>
LIST OF KEY INDUSTRY CONTACTS

Eastern/Grampian Bulb Association

Peter Ruysen
peter@drsimmons.co.uk
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Mob: 07951 435353

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Mob: 07974 458810

Mark Eves
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Mob: 07918 907486

Matthew Naylor
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Tel: 01205 260649

Cornish Area Bulb Growers Association

David Bond
david@jbondandson.co.uk
Mob: 07850 842140
## Current and recent projects relevant to Narcissus – May 2015

<table>
<thead>
<tr>
<th>Number</th>
<th>Project Title (report available for projects in bold type)</th>
<th>Start</th>
<th>Finish</th>
<th>Leader</th>
<th>Contractor</th>
<th>Industry Rep</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOF 074a</td>
<td>Evaluating potential new fungicides for the control of Narcissus basal rot.</td>
<td>01/06/13</td>
<td>31/08/14</td>
<td>John Clarkson Gordon Hanks</td>
<td>University of Warwick</td>
<td>Mark Cade &amp; Claire Taylor</td>
</tr>
<tr>
<td>BOF 075</td>
<td>Novel Insecticides for the control of large Narcissus Fly</td>
<td>01/02/12</td>
<td>30/04/14</td>
<td>Rosemary Collier</td>
<td>University of Warwick</td>
<td>Adrian Jansen</td>
</tr>
<tr>
<td>BOF 076</td>
<td>Understanding Physiological disorders in Narcissus</td>
<td>01/06/12</td>
<td>31/01/15</td>
<td>Gordon Hanks</td>
<td>University of Warwick, Agrovista, G. Hanks</td>
<td>Adrian Jansen</td>
</tr>
<tr>
<td>BOF 076a</td>
<td>Understanding physiological disorders in daffodil (BOF 76) – project extension to study the three-year-down crop</td>
<td>01/06/14</td>
<td>31/01/16</td>
<td>Gordon Hanks</td>
<td>University of Warwick, Agrovista, G. Hanks</td>
<td>Adrian Jansen</td>
</tr>
<tr>
<td>CP 048a</td>
<td>HDC Pest Bulletin</td>
<td>01/04/14</td>
<td>31/03/16</td>
<td>Rosemary Collier</td>
<td>WCC</td>
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<tr>
<td>CP 077</td>
<td>Sustainable Crop and Environment Protection – Targeted Research for Edibles (SCEPTRE)</td>
<td>01/10/10</td>
<td>30/09/14</td>
<td>Tim O'Neill</td>
<td>ADAS</td>
<td>John Sedgwick</td>
</tr>
<tr>
<td>CP 086</td>
<td>(Fellowship) Weed control in ornamentals, fruit and vegetable Crops – maintaining capability to devise sustainable weed control strategies</td>
<td>01/04/11</td>
<td>31/03/16</td>
<td>John Atwood,</td>
<td>ADAS</td>
<td>HDC Fellowship Governance Committee</td>
</tr>
<tr>
<td>CP 087</td>
<td>(Fellowship) Working with the industry to develop the next generation of technical staff for the UK horticulture industry through a Summer Research Programme</td>
<td>01/04/11</td>
<td>31/03/16</td>
<td>Jim Monaghan</td>
<td>Harper Adams University College</td>
<td>Fellowship</td>
</tr>
<tr>
<td>CP 089</td>
<td>(Fellowship) Maintaining the expertise for developing and communicating practical Integrated Pest Management (IPM) solutions for Horticulture</td>
<td>01/04/11</td>
<td>31/03/16</td>
<td>Jude Bennison</td>
<td>ADAS</td>
<td>Fellowship</td>
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<tr>
<td>CP 093</td>
<td>(PhD studentship) Field Vegetables: On-line measurement of selected soil properties towards the refinement of fertilisation management</td>
<td>01/11/12</td>
<td>31/10/15</td>
<td>Dr. Abdul M. Mouazen, student - Virginia Jimenez-Donaire</td>
<td>Cranfield University</td>
<td>Carolyn Coxe (Produce World)</td>
</tr>
<tr>
<td>CP 103</td>
<td>The application of precision agronomy to UK production of Narcissus (PhD)</td>
<td>01/10/13</td>
<td>30/09/16</td>
<td>Rob Lilleywhite student - James Syrett</td>
<td>University of Warwick</td>
<td>Adrian Jansen</td>
</tr>
<tr>
<td>CP 105</td>
<td>(PhD Studentship) Integrated protection of horticultural crops through enhancing endogenous defence mechanisms</td>
<td>01/09/13</td>
<td>31/08/16</td>
<td>Adrian Newton student - Daniel de Vega</td>
<td>JHI/SRUC</td>
<td>Neil Ward</td>
</tr>
<tr>
<td>CP 113</td>
<td>(Fellowship) Maintaining and developing capability in vegetable crop pathology</td>
<td>01/11/13</td>
<td>31/10/18</td>
<td>John Clarkson (Fellowship) Andy Taylor is fellow</td>
<td>WCC</td>
<td>Managed by Michael Gaffney, Teagasc, Ireland</td>
</tr>
<tr>
<td>CP 115</td>
<td>(PhD Studentship) Enhancing the soil food web to control soil dwelling pests of field vegetables (Walsh Fellowship)</td>
<td>01/10/13</td>
<td>30/09/16</td>
<td>Supervisor: Bryan Griffiths, Student: Celine Delabre</td>
<td>SRUC</td>
<td></td>
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<tr>
<td>CP 116</td>
<td>Exploiting next generation sequencing technologies for understand pathology and resistance in Fusarium</td>
<td>31/03/14</td>
<td>30/03/17</td>
<td>John Clarkson</td>
<td>U of Warwick</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>Project Title</td>
<td>Start</td>
<td>Finish</td>
<td>Leader</td>
<td>Contractor</td>
<td>Industry Rep</td>
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<tr>
<td>CP 119</td>
<td>(HDC Studentship) Sensor-based pre-symptomatic detection of pests and pathogens for precision scheduling of crop protection products</td>
<td>01/10/14</td>
<td>30/09/17</td>
<td>Martin McAinsh</td>
<td>Lancaster University</td>
<td></td>
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<tr>
<td>CP 126</td>
<td>Oomycetes Desk Review</td>
<td>01/05/14</td>
<td>28/02/15</td>
<td>Tim Pettitt</td>
<td>University of Worcester</td>
<td>Russ Woodcock</td>
</tr>
<tr>
<td>CP 127</td>
<td>Compendium of pest forecasting models</td>
<td>01/02/14</td>
<td>31/07/14</td>
<td>Rosemary Collier</td>
<td>WCC</td>
<td>CP 127</td>
</tr>
<tr>
<td>CP 128</td>
<td>Oomycete KT</td>
<td>01/08/14</td>
<td>28/02/15</td>
<td>Tim Pettitt</td>
<td>University of Worcester</td>
<td>CP 127</td>
</tr>
<tr>
<td>PCL 114R478 CP 129</td>
<td>Biofumigation for pest control</td>
<td>01/03/14</td>
<td>28/02/18</td>
<td>Profs. P. E. Urwin and H.J. Atkinson</td>
<td>University of Leeds</td>
<td></td>
</tr>
<tr>
<td>CP 134</td>
<td>“EyeSpot” – leaf specific herbicide applicator for weed control in field vegetables</td>
<td>01/10/14</td>
<td>31/03/18</td>
<td>Alistair Murdoch</td>
<td>University of Reading</td>
<td>CP 134</td>
</tr>
<tr>
<td>CP 135</td>
<td>Integrated Aphid Advisory Alerts</td>
<td>01/04/14</td>
<td>31/03/19</td>
<td></td>
<td>Fera/ Rothamsted</td>
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<tr>
<td>CP 136</td>
<td>Diagnostics: Development of Oomycete LFDs Development and testing of single and multiplex diagnostic devices for rapid and precise early detection of oomycete root and collar rot pathogens for disease avoidance, management and control</td>
<td>01/01/15</td>
<td>31/01/18</td>
<td>Alison Wakeham</td>
<td>University of Worcester</td>
<td>Gary Taylor</td>
</tr>
<tr>
<td>FV 363</td>
<td>HortLink: developing precision irrigation for field scale vegetable production, linking in-field moisture sensing, wireless network</td>
<td>01/04/10</td>
<td>31/03/14</td>
<td>Jerry Knox</td>
<td>Cranfield University</td>
<td>HDC</td>
</tr>
<tr>
<td>FV 415</td>
<td>Onions &amp; Leeks: Molecular methods for detection of stem nematode (Ditylenchus dipsaci) in soil and predicting risk of damage</td>
<td>01/04/13</td>
<td>30/04/15</td>
<td>Steve Ellis</td>
<td>ADAS</td>
<td></td>
</tr>
</tbody>
</table>
## HDC Crop Protection Update May 2015

<table>
<thead>
<tr>
<th>Product</th>
<th>Active</th>
<th>Crop</th>
<th>Target</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EAMUs issued since last meeting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butryflow</td>
<td>bromoxynil</td>
<td>Outdoor ornamentals</td>
<td>Weeds</td>
<td>Application submitted to get approval for ornamental crops not covered by current EAMU</td>
</tr>
<tr>
<td>Springbok</td>
<td>dimethenamid-P +</td>
<td>Outdoor ornamentals</td>
<td>Weeds</td>
<td>This EAMU is for the new MAPP number product. Use of the old MAPP number product can still be used under LTAEU until November this year.</td>
</tr>
<tr>
<td></td>
<td>metazachlor</td>
<td></td>
<td></td>
<td>Use was dropped from LTAEU in Nov 2014. Protected uses can not be supported. The new EAMU comes with a restriction that workers wear gloves when re-entering a treated crop</td>
</tr>
<tr>
<td>Cuprokylt</td>
<td>copper oxychloride</td>
<td>Outdoor ornamental crops</td>
<td>Bacterial diseases</td>
<td></td>
</tr>
<tr>
<td>Goltix 70SC</td>
<td>metamitron</td>
<td>Outdoor ornamentals</td>
<td>Weeds</td>
<td>Pre-emergence and post-harvest application has been authorised</td>
</tr>
<tr>
<td>Galera</td>
<td>clopyralid + picloram</td>
<td>Outdoor ornamentals</td>
<td>Weeds</td>
<td>New EAMU issued - use previously covered by LTAEU. Latest application end of March</td>
</tr>
<tr>
<td><strong>EAMU applications currently with CRD for consideration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBC</td>
<td>acibenzolar-S-methyl</td>
<td>Ornamental crops</td>
<td>TBC</td>
<td>On-label application submitted to get approval for ornamental crops. Good results in MOPS trials</td>
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<tr>
<td>Betasana SC</td>
<td>phenmedipham</td>
<td>Outdoor ornamental crops</td>
<td>Weeds</td>
<td>Application has been submitted to allow growers access to a phenmedipham product.</td>
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<tr>
<td>Captan 80 WDG</td>
<td>captan</td>
<td>Outdoor and protected ornamentals</td>
<td>Various diseases</td>
<td>Application was re-submitted. Worker exposure issue have come up and HDC are putting additional information together to address concerns.</td>
</tr>
<tr>
<td>Custo-fume</td>
<td>Chloropicrin</td>
<td>Ornamental plant production</td>
<td>Soil disinfectant</td>
<td>New emergency authorisation application has been submitted.</td>
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<tr>
<td><strong>EAMU applications in discussion</strong></td>
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<td></td>
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<tr>
<td>Betanal Maxxim</td>
<td>desmedipham +</td>
<td>Outdoor ornamentals</td>
<td>Weeds</td>
<td>Potential for new EAMU being discussed</td>
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<tr>
<td></td>
<td>phenmedipham</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassiopeia</td>
<td>Dimethomorph/pyraclorobin</td>
<td>Ornamental plant production</td>
<td>Downy mildew</td>
<td>Good results in HNS 186. Discussing potential for EAMU with manufacturer. Initial assessments suggest there may be worker exposure issues.</td>
</tr>
<tr>
<td>Escolta</td>
<td>Cyproconazole/triflouxstrobin</td>
<td>Ornamental plant production</td>
<td>Black root rot</td>
<td>Good results in HDC project PO188. Application to be submitted</td>
</tr>
<tr>
<td>Kumulus DF</td>
<td>sulphur</td>
<td>Ornamental plant production</td>
<td>Powdery mildew</td>
<td>As Thiovet Jet has not been supported through re-reg a new application for this BASF product will be submitted for ornamental crops</td>
</tr>
<tr>
<td>Product Code</td>
<td>Chemicals</td>
<td>SCEPTRE Code</td>
<td>Market</td>
<td>Disease(s)</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>Mirage</td>
<td>procloraz</td>
<td></td>
<td>Ornamental plant production</td>
<td>Basal rot (narcissus)</td>
</tr>
<tr>
<td>Nativo 75 WG</td>
<td>Tebuconazole/trifloxystrobilin</td>
<td></td>
<td>Ornamental plant production</td>
<td>Black root rot</td>
</tr>
<tr>
<td>Product 10</td>
<td>TBC</td>
<td></td>
<td>Ornamental plant production</td>
<td>Powdery mildew, rust</td>
</tr>
<tr>
<td>Product 105</td>
<td>TBC</td>
<td></td>
<td>Ornamental plant production</td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>Product 130</td>
<td>TBC</td>
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<td>Ornamental plant production</td>
<td>Aphids</td>
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<tr>
<td>Product 179</td>
<td>TBC</td>
<td></td>
<td>Ornamental plant production</td>
<td>WFT, aphids</td>
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<tr>
<td>Product 207</td>
<td>TBC</td>
<td></td>
<td>Ornamental plant production</td>
<td>WFT</td>
</tr>
<tr>
<td>Product 77</td>
<td>TBC</td>
<td></td>
<td>Ornamental plant production</td>
<td>Powdery mildew, rust</td>
</tr>
<tr>
<td>Shirlan</td>
<td>fluazinam</td>
<td>TBC</td>
<td>Ornamentals - crocus, daffodil/narcissus, ginseng, hyacinth, iris, lily and tulip</td>
<td>Phytophthora</td>
</tr>
<tr>
<td>Sportak</td>
<td>procloraz</td>
<td></td>
<td>Ornamental plant production</td>
<td>Basal rot (narcissus)</td>
</tr>
<tr>
<td>Storite Super</td>
<td>Imazalil/thiabendazole</td>
<td></td>
<td>Bulb dip</td>
<td>Basal rot</td>
</tr>
<tr>
<td>Switch</td>
<td>cyprodinil + fluudochlol</td>
<td></td>
<td>Ornamental plant production</td>
<td>Basal rot (narcissus)</td>
</tr>
</tbody>
</table>
New herbicide. First authorisation expected within the next year. EAMU application will be submitted once first authorisation comes through.

Product currently approved in DE and DK. However, as the product is going through re-registration we are better off waiting until after re-reg before looking at submitting for new uses.

Application was refused. The only way to get an authorisation would be to lower the rate significantly. This is likely to compromise efficacy.

Crop Protection gap analysis
We have commissioned consultants to conduct a crop protection gap analysis across all our sectors to establish where the current gaps are but also looking at where regulatory developments in the near future may leave further gaps. This gap analysis will inform the EAMU programme and our R&D. Early conclusions will be presented to HDC ornamentals panels at the joint panel meeting in June.

Bolette P. Neve - May 2015
HDC BOF74a: Evaluating potential new fungicides for the control of Narcissus basal rot in bulb and plant tests

John Clarkson, Claire Handy and Gordon Hanks
john.clarkson@warwick.ac.uk

Warwick Crop Centre, University of Warwick

Background

- Basal rot of Narcissus bulbs caused by the fungal plant pathogen Fusarium oxysporum f.sp. narcissi (FON) is a major problem for the industry.

- Control relies on the fungicides thiabendazole (Storite / Tezate) and chlorothalonil (Bravo) which are compatible with hot water treatment (HWT).

- Projects BOF74 and BOF74a: identify new fungicide control options to:
  - Reduce the likelihood of resistance developing
  - Provide alternative products, should current actives be withdrawn
  - Identify more effective, cheaper, safer or reduced-rate actives
**F. oxysporum fsp. narcissi (FON)**

- **Fusarium oxysporum**
  - Large complex of fungi which cause disease on many plants
  - 'formae speciales' adapted to certain hosts.
  - Many non-pathogenic and others are beneficial.

- F. oxysporum fsp. narcissi (FON) affects daffodils causing a basal or neck rot.
  - Indistinguishable from other F. oxysporum f. spp. in culture
  - Identification relies on pathogenicity tests
  - Produces chlamydospores which survive for many years in soil.
  - Narcissus cultivars Carlton and Golden Harvest are particularly susceptible

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**Symptoms of Basal Rot of Narcissus**

Warwick Crop Centre
**BOF74: testing fungicides on agar for activity against FON**

- 154 FON isolates obtained from around the UK: 30 identified using molecular methods and pathogenicity confirmed.
- 14 fungicide products tested against 8 Fusarium isolates on agar including standards
- Two isolates showed resistance to thiabendazole but otherwise effective.
- Chlorothalonil less effective except at maximum doses.
- Prochloraz and tebuconazole very effective even at lower concentrations tested.
- Full details were presented in 2013 and available in HDC report.

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**BOF74a: testing fungicides in plant tests for activity against FON**

- Narcissus bulbs were treated with fungicides in hot water (HWT) and planted in compost infested with FON (4L pots, Oct 2013, ‘high’ and ‘low’ inoculum levels).
- Experiment placed in unheated glasshouse and assessed for basal rot symptoms in Feb / March 2014.
- Treatments tested
  - Thiabendazole: Storite (275 ppm – recommended rate)
  - Chlorothalonil: Bravo (500 ppm – recommended rate)
  - Prochloraz: Mirage (500 ppm)
  - Tebuconazole: Orius (500 ppm)
  - Biocontrol Agent: HDC F184 (applied to non-fungicide HWT bulbs pre-planting)
Small scale Hot Water Treatment (HWT) of bulbs

• Plant height was reduced in untreated control plants inoculated with FON and there was an increase in the number of chlorotic (yellowing) and necrotic (dead) leaves.
• Orius and Mirage were the most effective treatments in reducing chlorosis

Above ground symptoms of FON

- Plant height was reduced in untreated control plants inoculated with FON and there was an increase in the number of chlorotic (yellowing) and necrotic (dead) leaves.
- Orius and Mirage were the most effective treatments in reducing chlorosis
**Bulb infection by FON causing basal rot**

- After foliage had died down, narcissus bulbs were retrieved, cut open and assessed for basal rot. High levels of disease were observed in this inoculated system.

- Mirage and Orius had a higher proportion of bulbs with low severity of basal rot compared to the other treatments – comparable or better than Stortite. Bravo was less effective. Biocontrol agent HDC F184 was ineffective.

**Conclusions**

- We have developed efficient and robust methods for testing fungicides and other treatments against Fusarium basal rot both on agar and in plant tests.

- Orius (tebuconazole) and Mirage (prochloraz) gave good control of Fusarium basal rot when applied to Narcissus bulbs using standard hot water treatment.

- Both Orius and Mirage are equal to, or outperform the current industry standards; Storite (Thiabendazole) and Bravo (Chlorothalonil)

- Tebuconazole was the most effective and represents an effective alternative active to the currently approved chemistry.
Current situation and future work

- On the basis of this work, HDC pursued an EAMU for tebuconazole but it was rejected (bulb dip use not covered by the data which was submitted for the on-label use for tebuconazole). The only way to get an EAMU would be to reduce the rate significantly which would potentially compromise efficacy.

- Situation for prochloraz is being assessed by HDC.

- HDC may pursue an EAMU for Storite Super (thiabendazole+imazalil).

- Other future options might include Switch (cyprodinil+fludioxonil) and other triazoles which showed activity on agar in BOF74a. These would need to be tested in plant assays.

- Other non-HWT methods of fungicide application should be considered for Narcissus as well as alternative control options (e.g. biological control / cultural / green manures and biofumigation).

Related Work at Warwick

- A BBSRC HAPI project is investigating the genetic basis for pathogenicity of *Fusarium oxysporum* and resistance in onion.

- Results so far indicate that we can now distinguish isolates of *F. oxysporum* that affect different crops as well as non-pathogenic isolates using molecular approaches. This may form the basis for diagnostic tests using soil / plants.

- We are developing a general programme of more fundamental work on Fusarium with HDC that includes Narcissus.
FV 415 Molecular methods for detection of stem nematode (*Ditylenchus dipsaci*) in soil and predicting risk of damage to onions & leeks

- **Objectives**
  - Validate qualitative PCR for detection of stem nematode in extracts of FLN from UK soil
  - Determine effect of sample pre-treatment & DNA extraction on PCR analysis in a range of soil types
  - Investigate potential of PCR to distinguish races of stem nematode

**Testing PCR for detection of stem nematode**

- 25 tubes with one stem nematode
- 25 tubes with one stem nematode & other FLN species
- 25 tubes with other FLN species & no stem nematode
- Six tubes from onion soil spiked with four stem nematode
Results of preliminary analysis

- PCR detected stem nematode in 55 out of 56 samples (98.2%)
- PCR detected stem nematode on its own or in the presence of other FLN
- There were no false positives where no stem nematode were present
- There was no substantial PCR inhibition from English soil
Daffodil bulb dipping/HWT:
Where are we...
and where do we go from here?

HDC Bulb Growers’ Event, Cornwall, 13 May 2015
HDC Bulb Growers’ Event, Lincolnshire, 20 May 2015
Bulb dipping / hot-water treatment

1. Facilities
2. Preparations
3. The HDC process
4. Chemical additives

Facilities

Facility requirements... 1

- **Capacity** – adequate to carry out all required HWT in a four-week window, taking account of the tonnage of bulbs treated annually and the size and number of tank loads possible in that time
- **Construction** – usually mild steel painted with anti-corrosion paint, components should be resilient to all chemicals used, high level of thermal insulation
- **Health & Safety** – adequate ventilation, adequate PPE, ease of using tank doors, safe access for cleaning and maintenance
Facility requirements... 2

- **Heating** – capable of rapid initial heating, fine control of temperature during the process, range 40 to 50°C ±0.1°C, easy to read temperature monitoring and recording
- **Location** – outside or else well ventilated, away from and not downwind of infection sources, good vehicular access, easy to wash-down floors and surfaces, segregation of clean and dirty bulb areas
- **Size** – suitable for a water to bulb ratio of 3:1 (say, 3,000L water per tonne of bulbs) with bins covered by at least 1” of dip

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Facility requirements... 3

- **Pumps** – even flow of water through heat exchanger and treatment tank, usually through the back wall into the pallet bases of the bins, needs 8 to 10 pumped tank volumes per hour (24,000 to 30,000/hour for each tonne of bulbs); capable of handling some solids, sufficient head of pressure to cope with blockages, designed to achieve circulation without cavitation (which can lead to foaming and should be avoided)
Preparations

Bulb handling before HWT

- Bulb dipping should be part of a process involving good bulb handling and storage and maintaining hygiene around bulbs and equipment
- Clean bulbs and preferably grade out small bulbs – soil, debris and small bulbs can impede water flow and block filters
- Consider grading bulbs before HWT and treating in batches according to size
- Different storage temperatures before HWT will affect how quickly the bulbs reach the target temperature
Bulb storage before HWT

- Store at 17C and below 75% RH, and maintain a good air flow
- 18C is the best temperature to protect bulbs from the effects of late HWT
- Storage <17C increases HWT-damage and slows shoot growth
- Storage >20C encourages base rot, nematodes and mites
- If controlled storage conditions aren’t possible, at least try to avoid standing bins in the sun or rain or near possible sources of contamination

Pre-season jobs... 1

- Order in dip chemicals
- Clean and disinfect tanks and pipe-work well in advance, access to holding (slave) tanks can be a problem (pressure washer + disinfectant)
- Service tanks well in advance, check temperature accuracy and precision (calibrate against a certified thermometer)
- Clean and disinfect dipping shed and surroundings (vacuum cleaner, pressure washer, disinfectant), dispose of all trash hygienically

Pre-season jobs... 2

- Maintain and clean bulk bins
- Bins for drying walls should fit the letterbox openings and should be sound, with sides/floor intact and correct air-gaps (say, 1” gap from top planking to top of corner posts)
- Physically clean, then sterilize bins (short dip at 50C with disinfectant)
- Check supplies of adequate, clean foam closers and (if required) mesh lids to retain bulbs
The HWT process

Timing

• Ideally – when all the floral parts have been formed (‘Stage Pc’), but before the root initials in the base plate are in obvious growth; complete in the next 3 to 4 weeks, and in order poeticus – small cups – large cuts – trumpets
• In reality – to fit around the complexity of weather, susceptibility to base rot and narcissus fly infection, readiness to lift, shipping dates, storage space… etc.
• In practice – start late- to mid-July in west Cornwall, late-July to early-August in eastern England

Temperature and duration... 1

• Probably the most difficult issue to resolve – with the question of chemical additives running a close second
• Need to balance temperature and duration to optimize kill of stem nematodes (eelworm) with least damage to bulbs
• It’s important to understand that any HWT will cause some damage to bulbs… the damage has to be kept to tolerable levels (say, slight growth reduction and minor leaf-tip damage – see table on next slide)
Phytotoxicity after HWT (with no chemical added)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Phytotoxicity score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient (control)</td>
<td>0</td>
</tr>
<tr>
<td>3 hours at 44.4°C</td>
<td>3</td>
</tr>
<tr>
<td>4 hours at 44.4°C</td>
<td>6</td>
</tr>
<tr>
<td>3 hours at 46.0°C</td>
<td>6</td>
</tr>
<tr>
<td>2 hours at 44.4°C + 1 hour at 47.0°C</td>
<td>7</td>
</tr>
</tbody>
</table>

For years, 3 hours @ 44.4°C was the standard recommendation in the UK. This was used every time bulbs were lifted, irrespective of whether eelworm were known to be present or were suspected - we never embraced a shorter, cooler dip for ‘healthy’ bulbs and a longer, hotter one just for infested stocks.

Where pre-warming is required (for flower quality purposes), this alters the dynamics: storage at warmer temperatures dries out bulbs, causing stem nematodes to enter the ‘wool’ phase in which they are dormant and resistant to high temperature and desiccation.

Temperature and duration... 3

- Where pre-warming is used, pre-soak the bulbs (3 hours or overnight) to re-hydrate nematode wool before HWT, then treat for 3 hours @ 46.0°C (high temperature-HWT).
- There is still a desire to use longer, hotter HWT regimes to ensure a better kill of stem nematodes.
- Other high-temperature HWT regimes become possible if pre-warming and pre-soaking are used... but are unlikely to be advised – a case of try it and see, at your own risk!
Temperature and duration... 4

- What are the likely limits of HT-HWT? We need to avoid temp/time limitations on chemical approvals... 4 hours @ 49°C?
- But do we need higher temps and longer times? Or greater precision and accuracy in achieving the recommendations?
- (a) Ensure quick warm-up to target temperature after bulbs are immersed – e.g. by not bringing bulbs in from the cold, or by ‘surcharging’ the dip temperature before bulbs are immersed (trial and error)
- (b) Measure temperatures in the centre of bulbs?

Achieving the target HWT temperature

- In project BOF 63 Rosemary Collier studied the bulb-scale mite (BSM) with the aim of developing integrated management of this increasingly troublesome pest
- One finding was that bulbs which had recently received HWT contained many dead BSM – but also some live ones. Some mites apparently survived HWT (they weren’t re-invading the bulbs from elsewhere after HWT)
- Was the target temperature achieved during HWT in the centre of the bulb? Small thermistor probes were sealed inside 12-14cm grade bulbs and temperatures were logged throughout the process at a number of sites
- Assess the Accumulated Hot-Water Minutes = total number of minutes core of bulb was above 44.3°C (target = 180)

Bulb-core temperatures in HWT - example 1

Timing started too soon – but made up by leaving bins in situ at end
Bulb-core temperatures in HWT - example 2

Same site as before – but bins removed promptly from tanks at the end

Bulb-core temperatures in HWT - example 3

At correct temperature by start time – but fails to maintain target temperature throughout

Bulb-core temperatures in HWT - example 4

Fails to reach target temperature
Temperatures during HWT – farm survey

- The circulating dip took 20 to 100 minutes to reach the set temperature, reflecting the great differences between different facilities.
- Temperatures in the centre of bulbs lagged behind the dip, and reached the same temperature as the circulating dip 10 to 25 minutes later.
- Thereafter, the temperatures of the circulating dip and bulb centres remained very close (except during ‘re-heating’ periods).
- The dip temperatures achieved were not always what was set on the controller – need to check and calibrate temperatures.
- In some cases the controller started timing the HWT period (usually 3 hours) before the circulating dip was up to the set temperature.
- The temperature of the bulb centre kept hot while left in position in the tank after pumping out the water.

Temperatures during HWT – bulb grades, etc

- **Bulb grade** Larger bulbs naturally took longer for the bulb centre to reach the target temperature. Using grades of ≤10, 10-12, 12-14, 14-16 and 16+cm, as a rough guide about 6 additional minutes of HWT were needed for each increment in grade.
- **Bulb variety** Bulb varieties having different shapes or densities might be expected to warm-up and cool-down at different rates. But when 12-14cm grade bulbs of 8 varieties were tested, there were no significant differences between them in temperatures achieved. The tested included Actaea, which has looser bulb scales and a substantially lower density.
- **Position of bulb within the bin and Position of bin within the tank** Tests showed that there were no significant or substantial differences in the temperatures achieved.

Temperatures during HWT - conclusions

- All the facilities tested showed evidence of precise temperature control and uniformity around the tank. Nevertheless, have the temperature controller checked before the start of the season and double check the dip temperature using a good thermometer.
- Also check the controller starts timing the HWT period at the correct time; if it starts too soon you may not achieve the required period at 44.4°C.
- Allow an extra 15 minutes to allow the temperature of the bulb centres to come to the required temperature, i.e. 3½ hour @ 44.4°C. If treating only smaller or larger bulbs, the HWT period could be shortened or extended by 5 – 10 minutes.
- Establish uniform procedures at the start and end of the HWT period, e.g. standardise the ‘drain-down’ period before the bulbs are removed from the tank.
Chemical additives

The need for chemical additives in HWT... 1

- HWT developed specifically for daffodil bulbs 1914 to 1918. *Treatment was purely due to the high temperature, using water to conduct the heat to the bulbs*
- In 1930s found nematodes which escaped into the dip were resistant to high temperatures ('free-swimming' nematodes)
- Formalin was added to the HWT tank to control basal rot – found it also helped by killing FS nematodes
- Later, a fungicide was added for better basal rot control: mercury fungicides; later ‘Benlate’; then thiabendazole ('Tezate 220 SL' or 'Storite Clear Liquid')
- This state of affairs remained until 2008

The need for chemical additives in HWT... 2

- Formalin was not permitted after 2008 (carcinogenicity?)
- HWT without formalin could be unpleasant due to putrefaction by bacteria and fungi, a hygiene issue
- Also in 2008 the registration holder introduced a number of restrictions on the use of Storite/Tezate in bulb dipping (dip rate reduced by 75%; once use per year; not permitted on the Isles of Scilly)
- But... thiabendazole fungicides are expensive, strains of the basal rot pathogen resistant to it are known, and it is not sensible to rely on a single chemical
- Alternatives to formalin and thiabendazole were needed
### Fungicides – the current position for dips and HWT

<table>
<thead>
<tr>
<th>a.i.</th>
<th>Product</th>
<th>‘Use up by’ date</th>
<th>Use and problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiabendazole</td>
<td>Storite Clear Liquid</td>
<td>31/12/15</td>
<td>Bulb dip: 1.25L product/1,000L water, Tyteen, not on Isles of Scilly. Need to use an acidifier to prevent loss of a.i. Topping-up important. Approval for Storite Clear Liquid not being extended. HDC investigating future of Tezate 220 SL. Resistant strains not uncommon.</td>
</tr>
<tr>
<td></td>
<td>Tezate 220 SL</td>
<td>31/12/15</td>
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</tr>
<tr>
<td>Chlorothalonil</td>
<td>Bravo 900</td>
<td>30/04/20</td>
<td>Bulb dip: 0.5-1.0L product/1,000L water, Tyteen, Topping-up important. Future? (endocrine disrupter) Becoming difficult to source?</td>
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<tr>
<td></td>
<td>Life Scientific Chlorothalonil</td>
<td>30/04/20</td>
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</tr>
<tr>
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<td>LS Chlorothalonil</td>
<td>31/05/15</td>
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<tr>
<td>Tebuconazole</td>
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<td>HDC seeking EAMU – not successful.</td>
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<tr>
<td>Prochloraz</td>
<td>n/a</td>
<td>n/a</td>
<td>HDC pursuing EAMU but awaiting outcome of prochloraz re-registration.</td>
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<tr>
<td>Tebuconazole + prochloraz</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
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<tr>
<td>Copper oxychloride</td>
<td>n/a</td>
<td>n/a</td>
<td>HDC investigating potential for bulb dip EAMU following recent EAMU for outdoor ornamentals.</td>
</tr>
<tr>
<td>n/a</td>
<td>Switch</td>
<td>n/a</td>
<td>Unclear result, further trials may be needed.</td>
</tr>
</tbody>
</table>

### Insecticides and other chemical additives

<table>
<thead>
<tr>
<th>a.i.</th>
<th>Product</th>
<th>‘Use up by’ date</th>
<th>Use and problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorpyrifos</td>
<td>Alpha Chlorpyrifos 48 EC</td>
<td>31/12/21</td>
<td>Bulb dip: 10L product/1,000L water (15 minute cold dip) or 5L product/1,000L water (3 hour HWT) Tyteen</td>
</tr>
<tr>
<td></td>
<td>Cyren</td>
<td>31/12/21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyrinex 48 EC</td>
<td>31/12/21</td>
<td></td>
</tr>
</tbody>
</table>

- Wetted (non-ionic wetter)
- Anti-foam preparation (tank and pump design should not produce foam but when it occurs it potentially leads to a cooler layer of foam on top of the dip)
- Sodium bisulphate (acidifier, if using thiabendazole)

### Post-HWT bulb treatment

- Allow a standard drain-down time and reduce transfer of dip chemicals to floor of building
- Rapid cooling/drying/ventilation of treated bulbs in a clean area by high-output fans
- When surface-dry move bulbs back to appropriate storage conditions or plant immediately
- Towards the end of HWT successively reduce the amount of top-up or work with smaller loads to reduce amount of spent dip to be disposed of
Variations in HWT procedures

- Early HWT for improved P&D control (stocks with basal rot or stem nematode... the latter can lead to hygiene problems)
- Pre-warming when picking first-year flowers, bulbs must be surface-dry at the start to avoid soft rot development. E.g. 3 to 8 days at 30 to 35C; follow by pre-soaking at ambient temperature for 3 hours or overnight, then HT-HWT (3 hours at 46C). Adding FAM 30 (with or without a fungicide) to a 3 hour-cold dip should be effective against nematodes
- ‘Partial pre-warming’ – bulb storage at 18C will reduce damage due to late-HWT

Cold dips

- Some growers use cold-dipping of bulbs for 15 minutes soon after lifting, using formalin (with or without a fungicide); this was a useful treatment for basal rot
- Now that formalin is not available, such treatments with Storite, Bravo or FAM 30 are possible for basal rot management, but recent work has shown that they may be ineffective in dirty water, may need longer than 15 minutes, and would be ineffective against wool-stage nematodes

The future of pesticides use in HWT

- Recent experience has shown the problems of getting fungicide approvals for bulb dips / HWT
- Seems to be an urgent need to develop alternative delivery systems
Bulb drying and storage
Getting the detail right

Bill Basford

What’s coming?

• Handling criteria
• Pre storage
• Air condition
  – Drying
  – Cooling
• Box and system design
• Heaters / fans
• Faults / improvements
• Ethylene
• Dusts
• Clean up
• Safety

Harvesting / transport

• Machine improvements, low damage
• Electronics, hydraulics - speed control
• Long, low trailers, suspension
• Tyre improvements
• Hygiene - in coming routes, wheel dips?
Pre storage

• Clean - soil out, limits to airflow, moisture
• Pre - grading, size, relationship to airflow
• New grader types
• Adequate lighting
• Nets, Trays, Bulk, bins or boxes
• Design changes to assist airflow, heat distribution

Drying

• In field - simple, cheap, unpredictable, vulnerable contamination?
• In store - can be complex, costly but predictable and reliable with sound design & good management

New evidence?

• 1980’s Kirton work following letter box developments
• Fine tuning over 20 years, now accepted, no new work
• Airflows increasing – Dutch approach
• So continue with Best practice on reliable knowledge
Bulk on floor

- Probably most uniform - efficient
- 6 - 10 ft high
- Lateral duct or floor design critical
- Too shallow with ducts can lead to uneven drying
- Separation challenging

Drying - in store

<table>
<thead>
<tr>
<th>Type</th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>Bin / Box</td>
<td>450</td>
<td>175</td>
</tr>
<tr>
<td>Bin / Box -Dutch</td>
<td>1000</td>
<td>500</td>
</tr>
</tbody>
</table>

Pressure mm w.g.

Bin / box limitations- number of boxes out when drying

<table>
<thead>
<tr>
<th>Void height</th>
<th>4 inch</th>
<th>6 inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>4-5</td>
<td>7</td>
</tr>
<tr>
<td>Dutch</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Keep airspeed below 1000 fpm or 5 m/s
Box design

• vents in side - top lids?
• sufficient to vent i.e. 900 kg per box
  25 mm x 900 mm each side

or from wall split blowing up and down
but 2 times air quantity entering voids

Airspeed?

Temperature

• Stage 1
• Drying air 35 °C achieved with variable base
  temperature - Often 10% of energy wasted on small
  detail
• Lower temps promote basal rot
• Large heat input, mixing / separation within ducts
• Linked to uniform airspeed within and from drying
  walls
• Temperature not above 17°C for storage

Drying wall distribution

• End ventilation - mixing thorough or
  from multiple fans - recirculation
• Top ventilation - high speed air from
  small diameter fast rotation fans –
  issues with:
    heat input
    recirculation
Airflow variation

Airflow variation - corrected

Psychrometric Chart
### Table:

<table>
<thead>
<tr>
<th>Dry bulb deg C</th>
<th>Wet bulb deg C</th>
<th>RH %</th>
<th>Moisture content g/kg air</th>
<th>Difference g</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>28.5</td>
<td>60</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>35</td>
<td>100</td>
<td>34</td>
<td>11.8</td>
</tr>
<tr>
<td>20</td>
<td>15.3</td>
<td>60</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>100</td>
<td>12.8</td>
<td>4.2</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>60</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>100</td>
<td>7.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>

>4 x

### Images:

- **Size does matter!**
- **Dutch system**
  - Large fork voids to handle 2 x UK drying airflow.
Controls

- Generally temperature, desired and ambient to maintain set point
- Temp and humidity around set limits
- Humidity – computer control over air valve and temperature
- Now can control fan speed – possible inverter use
Dehumidification

- Removes water from air by cooling past dew point
- Replaces extracted heat to give warmer, drier air
- ‘Clean’ air though crop
- Drying speed similar to HT system
- Recirculation good
Simple box cooler

Common problems

• Not enough heat
• Not enough air
• Poor air distribution / heat
• Air losses – leaks, floor angles
• High speed air
• Loading / grading
• Poor controls

Hazards / Health & Safety

• Combustion products
• Ethylene ?
• Dusts - bulb shale
  -soils / pesticides?
• Fire
• Guards / electrical, PAT’s
Ethylene

- From some rots
- Releases dormancy, twists and may inhibit root and shoot
- Flower opening / senescence
  - 0.1 ppm is biologically active
    - 0.2cc per box!!
  - Burners and vehicle exhausts?
  - what are levels?
  - Measurement systems
- 10-15 x air changes / hour to counter infected store

Dusts

- Mainly H & S issue
- < 10 mg / m³
  - measure with pump / filter
- Contaminant? across equipment / bulbs
- Enclose graders - prevailing winds etc.

Post HWT Actions

- Cool bulbs rapidly to ambient
  - minimum Stage 2 airflow
    - Do not recontaminate
      - Sterilise boxes/bins
        - HWT - 50 °C
        - Thoroughly cleanse all equipment
Summary

- Well established knowledge
- Design detail simple
- Avoid simple pitfalls
- Ensure adequate air and heat
- Controls now can give improved performance
- Monitor and record
Energy Issues
Bulb Drying and Storage

Andrew Kneeshaw
Farm Energy Centre
(FEC Services Ltd)

Subjects

• Overview of the current energy market
• Energy management pertaining to
  – ventilation/drying
  – cooling
  – worker accommodation
• The 7 c’s
• Renewable energy incentives

Why worry about energy?

Energy costs
Commodity cost
Taxation
Demand for “Low Carbon” produce?
Your customer might be concerned
Sustainable business?
Minimising energy costs in the process of treating bulbs - Andrew Kneeshaw

Efficiency – 7 C’s

- Cost
- Consuming equipment
- Control
- Containment
- Counting
- Care
- Create

Are energy prices high?

C1 - Cost

Energy price trends
The long view

Cut energy costs – pay less

- Change supplier
- For interruptible load go for a ‘price reflective’ tariff GSP price (Grid Supply Point)

GSP Price

- Commodity say 5p/6p kWh

<table>
<thead>
<tr>
<th>Code</th>
<th>Time</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>17:00 to 19:00 (weekdays)</td>
<td>20.51p</td>
</tr>
<tr>
<td>Amber</td>
<td>07:30 to 17:00 – 19:00 to 21:30</td>
<td>0.361p</td>
</tr>
<tr>
<td>Green</td>
<td>rest</td>
<td>0.129p</td>
</tr>
</tbody>
</table>

- Avoid red period to reduce costs by about 15%
C2 - Consuming equipment

- Fans
- Heating
- Lighting

Ventilation efficiency
- survey example
Efficiency

\[ \text{volume} \times \text{pressure} \times \text{e-factor} = \text{kW} \]

Double the pressure - double the power

Use of heat

- Direct gas heating is 97% efficient at point of use
- Indirect heating of any sort introduces inefficiencies

Lighting

Minimising energy costs in the process of treating bulbs - Andrew Kneeshaw
C3 - Control – vent and heat

- Multi point temperature and humidity control
- Multi-media processing and feedback
  - Computers, mobile devices
  - Recording and analysis of performance
  - Include energy
- Speed control

Why?
- Cut speed by 10%
  - Cuts air volume by 10%
  - Cuts pressure development by 19%
  - Cuts energy by 28%

Why not?
- Fans can stall
- Air can short circuit
C4 - Containment

- For cooled produce
  - Insulation
  - Air leakage

Insulation levels

Doors and louvres
In energy terms, ducts are more important for bulbs than for grain.

Floors

- Floors and ducts
  - Clean
  - Enough voided area

C5 - Counting – measuring use

- Most people have no accurate idea of
  - How much energy they use
  - Where it's going
- They use £ spent as a measure of effic
- Read meters
  - Record
  - Sub-meter
- Know where your energy is going
Smart metering value

http://www.energy-analysis.co.uk/Default.aspx?t=t

Cooling and storage – do sites vary?

- Sept to April average = 93kWh/t
- Lowest = 38kWh/t
- Highest = 113kWh/t

C6 - Care
C7 Create - Renewable energy

- Electricity generation by
  - Wind
  - Solar
  - Biomass
  - AD

- Economics revolutionised by feed in tariffs and RHI

Options

- Solar
- Wind
- AD
- Biomass Boiler

Feed in Tariff

FIT paid on all of this

Solar
- Generate 25,000kWh
- Used on site 10,000kWh
- Export to mains 15,000kWh
- FIT paid on all of this

Mains import 15,000kWh

Export payment on all of this
### Generation prices (FITs)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Scale</th>
<th>Tariff level for new installations (p/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic digestion</td>
<td>≤250 kW</td>
<td>10.13</td>
</tr>
<tr>
<td>Anaerobic digestion</td>
<td>250 - 500 kW</td>
<td>9.36</td>
</tr>
<tr>
<td>Anaerobic digestion</td>
<td>&gt;500 kW</td>
<td>8.68</td>
</tr>
<tr>
<td>PV</td>
<td>≤4-10 kW</td>
<td>12.13</td>
</tr>
<tr>
<td>PV</td>
<td>&gt;10-30 kW</td>
<td>11.71</td>
</tr>
<tr>
<td>PV</td>
<td>&gt;30-100 kW</td>
<td>9.98</td>
</tr>
<tr>
<td>PV</td>
<td>&gt;100-250 kW</td>
<td>9.54</td>
</tr>
<tr>
<td>PV</td>
<td>&gt;250 kW</td>
<td>8.16</td>
</tr>
<tr>
<td>Wind</td>
<td>≤100 kW</td>
<td>14.45</td>
</tr>
<tr>
<td>Wind</td>
<td>&gt;100-500 kW</td>
<td>12.05</td>
</tr>
<tr>
<td>Wind</td>
<td>&gt;500 kW - 1.5 MW</td>
<td>6.54</td>
</tr>
<tr>
<td>Wind</td>
<td>&gt;1.5MW - 5MW</td>
<td>2.77</td>
</tr>
</tbody>
</table>

### Financial benefit comes from

Feed – in tariff
All generated energy
Displacing own use
Export

### Changing economics

[Graph showing displacement component and FITs component]
The next 20 years

Use it yourself?/export

Self sufficient?
Renewable fit with worker accommodation -

- Solar – electricity
- Wind - electricity
- Biomass - hot water
- Load management

Smooth load and avoid peaks

- Avoid
  - Electric showers
  - Electric heaters
  - Electric cooking
- Use
  - Hot water storage (with staggered timing)
  - Fuel fired heating via centralised /biomass boiler
  - Gas cooking and microwaves
  - Low energy lighting

Alternative energy?

- Heat recovery from product refrigeration for hot water and heating
- Water available at 55°C
Daily profile

Renewable energy

- Electricity generation by
  - Wind
  - Solar
  - Biomass
  - AD

- Economics revolutionised by feed in tariffs

The Renewable Heat Incentive

- Free heat?
- Pays a tariff on heat generated
- Similar structure to FITs
  - Banded rates based on technology
### RHI rates

<table>
<thead>
<tr>
<th>Technology</th>
<th>Scale</th>
<th>Tier 1</th>
<th>Tier 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid biomass</td>
<td>Up to 200kW</td>
<td>5.87p</td>
<td>1.56p</td>
</tr>
<tr>
<td>Solid biomass</td>
<td>To 1002kW</td>
<td>5.18p</td>
<td>2.24p</td>
</tr>
<tr>
<td>Solid biomass</td>
<td>Over 1000kW</td>
<td>2.03p</td>
<td></td>
</tr>
<tr>
<td>Ground source heat pumps</td>
<td>All</td>
<td>8.84p</td>
<td>2.64p</td>
</tr>
<tr>
<td>Air source heat pumps</td>
<td>All</td>
<td></td>
<td>2.54p</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>Less than 200kW</td>
<td>10.16</td>
<td></td>
</tr>
</tbody>
</table>

### Energy cost reduction – 7 C’s

- Cost
- Consuming equipment
- Control
- Containment
- Counting
- Care
- Create

### Information resources

- TIPS (The Interactive Potato Store)
- Also http://www.growsave.co.uk/
Store auditing – Storecheck

- Structured store audit including an air leakage test
Potential for living mulches in bulb production

Dr Sarah K Cook
ADAS UK Ltd

Living mulch/cover crops/green manures

Cover crops can be:
• used on fallow land,
• grown between cash-crop rotations,
• intercropped with other crops, as green manure or as a living mulch.

What do you want them to do?

<table>
<thead>
<tr>
<th>Function</th>
<th>Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green manures</td>
<td></td>
</tr>
<tr>
<td>Nitrogen production</td>
<td>Legumes – red clover, peas, vetch</td>
</tr>
<tr>
<td>Nitrogen scavenging</td>
<td>Brassicas, rye, wheat</td>
</tr>
<tr>
<td>Biomass</td>
<td>Big fast growers – oat, oilseed</td>
</tr>
<tr>
<td>Weed suppression</td>
<td>Smothering – oats, rye</td>
</tr>
<tr>
<td>Allelopathy</td>
<td>Oats, buckwheat</td>
</tr>
<tr>
<td>Soil structure</td>
<td>Fibrous roots – wheat rye, red clover</td>
</tr>
<tr>
<td>Compaction reduction</td>
<td>Tap roots – radish, clovers</td>
</tr>
<tr>
<td>Erosion protection</td>
<td>Good cover – rye, wheat, oats</td>
</tr>
<tr>
<td>Nematode suppression</td>
<td>Species dependant</td>
</tr>
</tbody>
</table>
Natural living mulch in action

- Danish scurvy grass (Cochlearia Danica)
- Tolerates high levels of salt
- Low growing (20cm)

Green manures

- Cover crops grown primarily to add nutrients and organic matter to soil
- Typically grown autumn to late winter (4-5 months) & destroyed while still green

Green manures: N uptake

<table>
<thead>
<tr>
<th>Year</th>
<th>1991 (Dry Autumn)</th>
<th>1993 (Wet Autumn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Crop Species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volunteer Wheat</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Forage Rape</td>
<td>-</td>
<td>48</td>
</tr>
<tr>
<td>Winter Barley</td>
<td>20</td>
<td>51</td>
</tr>
<tr>
<td>Winter Rye</td>
<td>22</td>
<td>55</td>
</tr>
<tr>
<td>Phacelia</td>
<td>25</td>
<td>39</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>White Mustard</td>
<td>30</td>
<td>57</td>
</tr>
<tr>
<td>Mustard Turnips</td>
<td>-</td>
<td>63</td>
</tr>
</tbody>
</table>

- Species and over-winter weather influence N retention by green manures
Types of green manure

- Cereals (e.g. w. barley, w. rye)
- Legumes (e.g. clover, vetch)
- Brassicas (e.g. OSR, mustard, oil radish)
- Forage turnips (e.g. in stubble)

Nutrient value of green manures

N uptake & availability to spring crop depends on:
- species & seed rate
- sowing date
- over-winter weather
- destruction date
- chemical composition at destruction
- destruction method (flail, spray, cultivate?)
- post-destruction weather

Potential benefits of green manures

- Over-winter cover suppresses weed growth;
- Suppression of weed germination?
- Potential for discouraging soil-borne pests/diseases;
- Fixation of atmospheric N (legumes);
- Improved wildlife habitat (inc. natural pest predators);
- Soil structure - soil AWC and porosity;
- Reduced risk of run-off, erosion and loss of nutrients;
- Increased N retention & reduced NO₃ leaching;
  - can increase SMN & N supply to next crop.
Effect on weeds

Benefits of cover crops
Life cycle of an annual weed

1. Micro-environment
   - Soil moisture
   - Soil temperature

2. Natural enemies
   - Seed predators
   - Pathogens

3. Physical suppression
   - Mulch
   - Incorporated residues

4. Allelopathy
   - Chemical inhibition

5. Competition
   - Space
   - Nutrients
   - Light

6. Control
   - Mowing
   - Herbicide
   - Tillage

---

Allelopathy - Impact of buckwheat extract on weed seed germination (% reduction after treatment)

<table>
<thead>
<tr>
<th>Weed Type</th>
<th>T1 (chopped)</th>
<th>T2 (liquidised)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black-grass</td>
<td>0-20</td>
<td>0-30</td>
</tr>
<tr>
<td>OSR</td>
<td>0-20</td>
<td>0-30</td>
</tr>
<tr>
<td>Winter wheat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Liquidised plant material most effective

Defra project OF0367

After incorporation buckwheat suppresses some weed species

- Cut-leaved crane's bill
- Black nightshade
- Scentless mayweed
- Common chickweed
Impact of cover treatment on soil condition – grower field trial Rugeley, Staffs

Field assessments - 03 Feb, 2012

Bare stubble

Oil radish

Potential limitations of green manures

• Rotations limit use to before spring-sown crops;
• Residues - effects on spring cultivations/crop establishment?
• If destroyed late, can delay N supply or moisture available to next crop;
• May increase slug risk;
• Persistence (e.g. clover);
• Best suited to light and medium soils;
• Cost

R444 cultivations and cover crops

1st season:
Cover crops prior to potatoes

Cover crops drilled - 21 September 2011;
Incorporated with Discs - 24 February 2012;
Potatoes planted with full N response plots - 29 March 2012
ADAS site, drilled 21 Sept 2011

Winter rye
Radish
Mustard

Cover crops on 30 January 2012

Cover crop at destruction 24 Feb 2012
Cover crop nitrogen uptake at destruction – 24 Feb 2012

Topsoil SMN Feb to May 2012

Potato N offtake at canopy closure
Green manures: effect on potato yield

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stubble control</td>
<td>29.1</td>
<td>37.0</td>
</tr>
<tr>
<td>Winter rye</td>
<td>30.6</td>
<td>44.5</td>
</tr>
<tr>
<td>White mustard</td>
<td>34.6</td>
<td>42.6</td>
</tr>
<tr>
<td>Oil radish</td>
<td>36.8</td>
<td>44.8</td>
</tr>
</tbody>
</table>

- Results suggest green manures release c.50 kg N/ha to potato crop
- No effect on defects

Fertiliser N response (no green manures)

<table>
<thead>
<tr>
<th>N/ha</th>
<th>Yield (t/ha)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil N</td>
<td>30.9</td>
<td>38.4</td>
</tr>
<tr>
<td>20 kg N/ha</td>
<td>30.0</td>
<td>39.5</td>
</tr>
<tr>
<td>40 kg N/ha</td>
<td>33.8</td>
<td>40.7</td>
</tr>
<tr>
<td>60 kg N/ha</td>
<td>37.1</td>
<td>45.6</td>
</tr>
<tr>
<td>80 kg N/ha</td>
<td>44.3</td>
<td>51.0</td>
</tr>
<tr>
<td>120 kg N/ha</td>
<td>48.9</td>
<td>55.9</td>
</tr>
<tr>
<td>150 kg N/ha</td>
<td>56.5</td>
<td>62.2</td>
</tr>
<tr>
<td>180 kg N/ha</td>
<td>60.3</td>
<td>64.9</td>
</tr>
<tr>
<td>240 kg N/ha</td>
<td>69.0</td>
<td>75.0</td>
</tr>
<tr>
<td>280 kg N/ha</td>
<td>73.2</td>
<td>79.2</td>
</tr>
<tr>
<td>320 kg N/ha</td>
<td>77.4</td>
<td>85.4</td>
</tr>
<tr>
<td>380 kg N/ha</td>
<td>81.6</td>
<td>91.6</td>
</tr>
<tr>
<td>440 kg N/ha</td>
<td>85.8</td>
<td>97.8</td>
</tr>
<tr>
<td>500 kg N/ha</td>
<td>90.0</td>
<td>104.0</td>
</tr>
</tbody>
</table>

Companion planting in oilseed rape - Agrovista

- Sown with oilseed rape in autumn
- Killed by frost or by clopyralid
- 3rd year of trials

Companion planting

- Common Vetch, Purple vetch, Barseem clover
- Drilled separate to rape at 20 kg/ha
- Straw removed or incorporated

- Common vetch, Barseem clover
- Drilled in the row with oilseed rape at 1.75 kg/ha
- Subcasting or high trash levels
Companion planting in oilseed rape

• Produce organic matter
• Improve establishment through rooting synergy
• Reduce pest and weed pressure
  • Flea beetle, slug
• Take up autumn nutrients and release in the spring (40 kg/ha N)
• Increase yield improve soil structure

Effect on soil structure

Direct drilled Barseem clover

Vetches

Living mulches in apple orchards

• Sown between the rows
• Weed suppression
• Erosion control
Species investigated

- White clover (Trifolium repens)
- Black medic (Medicago lupulina)
- Birdsfoot trefoil (Lotus corniculatus)
- Creeping red fescue (Festuca rubra)
- Birdsfoot trefoil (Lotus corniculatus) + Red fescue (Festuca rubra)

June 2014

- Herbicide
- Clover
- Untreated
- Creeping Red fescue

Preliminary conclusions

- Creeping red fescue alone and in combination with Birds foot trefoil is as suppressive as a herbicide treatment
- The greatest proportion of apple yield was within the commercially acceptable grade range
- No significant effects on yield or extension growth
Contrasting ground cover and establishment techniques for maize production systems

John Williams
Soil Scientist
ADAS Boxworth

Background

• Maize cropping has increased significantly in recent years
• Often grown on steep slopes
• Bare soil over winter increases risks of:
  – Nitrate leaching
  – Sediment/phosphorus losses
  – Runoff/flooding risks
• Concern over reduced bio-diversity in maize cropping systems

Treatments

1. Conventional plough-based cultivation
2. Strip tillage: over-sown perennial ryegrass (June 2012) (sowing rate 35 kg/ha)
3. Strip tillage: over-sown biodiverse seed mix (June 2012) Black medick, sanfoin, alsike clover, crimson clover, birds foot trefoil, musk mallow
4. Sub-soil and non-inversion cultivation
**Fakenham: cover (broadcast June 2012)**

- Biodiverse mixture
- Ryegrass

**Bow: sediment loss (over-winter 2012/13)**

- Conventional
- Ryegrass
- Biodiverse mix

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sediment loss (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>1200 ± 100</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>400 ± 10</td>
</tr>
<tr>
<td>Biodiverse mix</td>
<td>600 ± 10</td>
</tr>
</tbody>
</table>

P < 0.01

I = standard error

**Strip tillage**
Conclusions

- Over-sown ryegrass and biodiverse mixture established ‘well’, in moist soil conditions
- Ryegrass reduced (compared with the conventional treatment):
  - Soil mineral-N (November and April)
  - Overwinter sediment losses (c. 70-85%)
  - Overwinter NO₃-N losses (c. 50%)
- Maize yields reduced - when strip tilled into well established growing cover crop

PCN trap crops for potatoes

Funded by Potato council (AHDB) and CRD

Aim

Investigates the potential of both native and non-native Solanum species as trap crops for potato cyst nematode (PCN)
- Identify the most likely species as potential trap crops for PCN under UK conditions
- Quantify some of the key agronomic requirements for growing and destroying the trap crop
Key findings

- Black nightshade reduced PCN eggs by 46-76%
- Other solanum species reduced numbers by up to 46-70%
- Established best from April to July
- Tolerant of clomazone, metribuzin, rimsulfuron and MCPA

Where will they fit in?

- Periods where soil is bare
  - Prevent erosion
  - Prevent soil splash
- As an inter row cover – suppress weeds
- As a trap crop for nematodes
- To deter or confuse pests, or act as an alternative host
- As frost protection
- Reduce summer soil temperatures
Summary

• What do you want them to do?
• Widespread choice of species
• Getting them established
• Getting rid of them
• Are you sowing a weed problem?

Thank you

Any questions?
Progress and findings:

• Field experiments conducted investigating depth, density, bulb orientation etc. in Warwickshire, Cornwall, Lincolnshire, Aberdeenshire.
• First year flower data collected – this is still being digitised and analysed properly, so this presentation only includes complete datasets and preliminary results.
• Planting depth and density both appear to affect stem length at least some of the time.
• Planting bulbs upright does seem to improve stem length.
• Deep planting and inverted planting do seem to delay flowering time (by about a week – yet to be fully quantified).
• Fertiliser placement does not appear to have an effect on first year flowers (as expected).
• Irrigation – no results yet as irrigation has yet to start.

Scotland (Dutch Master 14-16)

‘Dutch Master’ is rather short, but showed a weak response to higher planting densities, resulting in longer stems on average.

(Thick black line is the median – half of the stems are above and below this.)

[Graph showing data distribution and statistical significance]

Not quite statistically significant. May well become so with more data.
Scotland (Dutch Master 14-16)

‘Dutch Master’ grown in Scotland responded well to depth – deeper planting produced taller flowers.

NB. 12” = 305mm, so few stems would still meet this grade without pulling/cutting the stems. This is due to the variety.

Cornwall (Dutch Master 12-14)

Cornish ‘Dutch Master’ (note different bulb grade) did respond well to density. Dense planting resulted in taller flowers.

Lower density (12t/ha) also gave taller flowers than the control (17t/ha). This is probably a fluke.

Somewhat unexpectedly, stem mass responded greatly to density – dense planting increased stem weight.

This was not observed in Scotland.

The proportion that meet retailer requirements (70g per bunch) is generally good for all treatments.
Inverted (I) and upright (U) planting produced a significant difference in stem length against industry-standard, random (R) planting, but only for Scotland (right).

Bulbs from two plots in Lincolnshire were excavated to see effects of orientation.

Bulbs planted inverted had done little to right themselves (by April, year 1). Shoots grew hooked and the bulbs showed contractile roots.

Bulbs had not yet pulled themselves much deeper than planted.

Scale bar: 10cm large divisions, 2cm small divisions.

Bulbs planted randomly (as done by mechanical planters) had also done little to right themselves. Again, shoots grew hooked and the bulbs showed contractile roots.

Bulb depth was also close to that at time of planting.

Scale bar: 10cm large divisions, 2cm small divisions.
Some bulbs had one or more leaves and flowers that never reached the surface.

None of this bulb’s shoots had reached the surface. This was planted inverted.

I decided to analyse the number of flowers per bulb planted, to see if any treatments affected the flower yield, but preliminary results showed no correlation.

(Approx 1.7 flowers/bulb for Dutch Master 14-16)

The effect on bulb yield could be great.

Next stage:

Volunteer growers wanted to allow me to excavate bulbs in situ as per previous slides. I would do these prior to lifting, without damaging the bulbs or removing any.

This will quickly provide data on bulb self-righting.

Please contact j.rsyrett@warwick.ac.uk or 07921374357.

Plans to set up a few more bulb experiments based upon first year findings, trying alternative bulb placement — general preference required for ‘Standard Value’ or ‘Tamara’ (show of hands in the room?)
Notes
Over recent years HDC has produced a wide range of factsheets and publications which you can order by putting a tick next to the publication(s) you require and returning this form to the address below.

### Factsheets

- ✓ 18/14 Getting the best from biopesticides
- ✓ 11/13 Weed control in narcissus
- ✓ 10/13 Hot Water Treatment of daffodil bulbs
- ✓ 01/13 Practical measures to prevent and manage insecticide, fungicide and herbicide resistance for horticultural crops
- ✓ 26/10 Green manures – implications of economic and environmental benefits on rotational management
- ✓ 25/10 Green manures – species selection
- ✓ 24/10 Green manures – effects on soil nutrient management and soil physical and biological properties
- ✓ 03/09 Biobeds for treatment of pesticide waste and washings
- ✓ 05/08 Management of large narcissus fly (BOF 53, 55 & Defra project HH1747TBU)
- ✓ 09/07 Soil disinfestation options for cut flower growers (PC 213, PC 213a, PC 249 & BOF 45)
- ✓ 08/07 Integrated management of stock fusarium wilt (PC 213, PC 213a, PC 249)
- ✓ 04/06 Guidelines for the post-harvest handling of cut tulips
- ✓ 03/06 Guidelines for the post-harvest handling of cut lilies
- ✓ 02/06 Guidelines for the post-harvest handling of summer cut flowers and cut foliage
- ✓ 04/06 Guidelines for the post-harvest handling of cut tulips
- ✓ 24/05 Guidelines for the post-harvest handling of cut flowers
- ✓ 07/05 Securing your water supply for the future
- ✓ 13/04 Acidification of ‘Storite’ in HWT for narcissus basal rot control (BOF 43 & BOF 43a)
- ✓ 14/03 Control of narcissus smoulder and white mould (BOF 41)
- ✓ 11/03 Control of powdery mildew diseases on cut flowers (BOF 44)

### Information Sheets

- Snapdragons (Antirrhinum majus) as a cut flower crop grown in polythene tunnels
- Lisianthus (Eustoma grandiflorum) as a cut flower crop grown in polythene tunnels
- The National Cut Flower Centre and Cut Flower Growers’ Association information sheet
Summary of the Cut Flower Centre (CFC) trial examining the susceptibility of a wide range of different varieties of column stocks (Matthiola incana) to fusarium wilt

Field- and tunnel-grown cut-flowers with potential for UK exploitation: A review of trials programmes and research on ‘novel’ subjects

Summary of Cut Flower Centre (CFC) trial results for a new range of Solomio and Star spray carnations from Hilberda Kooji (2012)

Summary of Cut Flower Centre (CFC) trial results for a new range of Breanthus annual dianthus from Hilberda Kooji (2012)

Annual dianthus (Dianthus barbatus hybrids) as a cut flower

Guides

- Narcissus Manual
- Ornamental plant quality – developing a whole business management system - a grower guide

Sector Review Magazines

- Ornamentals Review 2014
- Ornamentals Review 2013

DVD’s

- Best practice for outdoor flower harvesting – a training DVD – Out of Stock
- Health & safety in horticulture - an awareness DVD in ten languages (plus English)

Computer Programmes

- MORPH 4 download available from – www.warwick.ac.uk/go/morph/models

Your Order

Please fill in the form and return it to: Louise Arculus/Victoria Routledge, HDC, AHDB, Stoneleigh Park, Kenilworth, Warwickshire CV8 2TL, or email to: hdc@hdc.ahdb.org.uk.

Name………………………………………………………………………………………………………………………………………………………………………………
Address………………………………………………………………………………………………………………………………………………………………………………
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