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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

## **AUTHENTICATION**

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Andrew Hewson

Project Leader

ADAS UK Ltd

Signature ..... Date .....

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## ***Grower Summary***

### **Headline**

- A comprehensive guide to nursery stock propagation is now available

### **Background and expected deliverables**

The HDC has funded considerable research relating to HNS propagation and liner production over the last 20 years. There has also been a considerable programme of MAFF / Defra funded HNS R&D (e.g. various projects based at East Malling Research Station and Efford EHS), which has been complementary to the more applied aspects of HDC funded work. The principal findings from these research programmes are however widely scattered across numerous project reports, Open Day handouts and various fact sheets, and so are not readily accessible by growers. There is also a wealth of information from other sources, most notably the IPPS, which if critically reviewed would inform and add value to a propagation guide. Much of this information would be of direct value to growers (e.g. for solving current problems, reducing losses, increasing efficiency) were it to be researched, critically reviewed, edited and collated into single, practical publication which also brings together current commercial thinking, industry knowledge and best practice. This project was commissioned to achieve this aim.

### **Summary of the work**

This project has developed a practical propagation guide for HNS growers based on a critical review, current best practice and technical information, drawing on MAFF (now Defra), ADAS and HDC research along with other relevant sources of information, notably that of the IPPS (International Plant Propagators Society) and commercial experience; industry case studies were a key part of this work. The project has also identified current research and knowledge transfer needs in respect of HNS propagation, to help identify future HNS strategy and funding priorities.

The Guide will also form a training aid for students and (nursery) staff members new to propagation; as such, its development is timely and links well with the current Knowledge Transfer Partnership project (CP 76) developed by the HDC and HTA in collaboration with the University of Reading.

The basic structure and technical content of the Propagation Guide is as follows:

## 1.0 Propagation management

- Do it yourself or buy-in?
- Developing a propagation unit
- Planning, programmes and record keeping
- Stock-plants
- Clonal selection and plant health
- Rootstocks
- Collection and storage of vegetative propagation material
- Preparation and handling of cuttings
- Wounding, leaf stripping / trimming of cuttings
- Rooting hormones
- Propagation containers
- Propagation media and nutrition

## 2.0 Propagation techniques

- Seed
- Cuttings
- Micropropagation
- Budding and grafting
- Division
- Layering
- Stooling

## 3.0 Propagation environments and systems

- Influence of water, temperature and light
- Understanding environmental needs of cuttings
- The role of the Evaposensor
- Light levels and shading
- Mist and high humidity environments

- Polythene systems
- Cold frames with and without plastic
- Heated bins
- Cuttings in the open-ground
- Direct-sticking of cuttings

#### 4.0 Aftercare

- Crop protection
- Weed control
- Post-rooting nutrition
- Growth control
- Over-wintering of rooted cuttings and liners
- Aspects of liner production

#### 5.0 Case studies and top tips from the IPPS (International Plant Propagators Society)

- *Camellia* propagation, Margaret Scott
- Cracking *Photinia*, Geoff De La Cour-Baker
- Heathers the Kingfisher way, Pete Bingham
- *Hibiscus* grafting, Mark Howard
- Lavenders; rooting rotters, David Hide
- *Magnolia* chip budding, David Hide
- *Pieris* propagation, Brian Humphrey
- *Rhododendron* propagation, David Millais
- Success with *Hebe* cuttings, Karl O'Neill
- Success with herbaceous perennials, Paul Howling

Contributed by HNS propagators and IPPS members, this section comprises a short series of case studies with practical advice for the successful propagation of particular plants or plant groups.

## **6.0 Current research and knowledge transfer requirements**

An overview of current requirements identified, summarised and prioritised through the development of the Guide.

## **Appendices**

### **Appendix I**

A 'troubleshooting' guide to dealing with common propagation problems presented in table format.

### **Appendix II**

A ready reference summary of propagation methods for a range of woody HNS subjects, presented in table format

### **Appendix III**

References and further information

### **Appendix IV**

## **Glossary of terms**

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## **Written format**

Each section generally comprises an opening narrative introducing and summarising the subject matter together with accompanying research, followed by a science-derived bullet-point summary of 'action points'. Signposting to further sources of information and other relevant sections has been included throughout the main text. The Guide is widely populated with images, charts and tables to illustrate and highlight key points and research findings.

## **Industry Steering Group and priorities**

An industry steering group comprising industry representatives for the project, HNS growers, consultants and researchers convened and communicated regularly as the project developed. Its principal remit was to agree structure and content, and guide the project. An early priority was for the Guide to be practical, adaptable, well illustrated and clearly signposted to further sources of information.

A further aim was to develop a high degree of 'industry buy-in', such that growers were encouraged to support and participate in the project as it developed. This became one of the unique and outstanding features of the project, lending a strong 'by growers, for growers' dimension to the work. The involvement and support of the IPPS has been especially welcome and invaluable.

Whilst initial discussions favoured a traditional hard copy format, the concept of developing the Guide as a more adaptable (e.g. for education and training purposes) web based tool became the preferred option as the project progressed.

## **Developing the narrative**

The narrative for the Guide was developed in three stages, although there was a degree of natural overlap as the work unfolded, notably with the development and integration of the case studies within the main text:

- 1) Research, describe and summarise best practice (signposting to more detailed references)
- 2) Critically review, summarise and integrate relevant research work (signposting to project reports and papers)
- 3) Undertake industry case studies and consultation to showcase good practice, illustrate the successful adoption of research to improve propagation outputs and identify research and knowledge transfer requirements to guide future HNS strategy and funding priorities

Six case studies covering propagation planning and how to develop a propagation unit, practical aspects of micropropagation, using the Evaposensor for improved control of rooting environments and integrated management aspects of crop protection were completed during the course of the project to complement those included in IPPS section.

### **The Propagation Guide**

The final draft of the Propagation Guide and accompanying images were submitted for final consultation on June 30<sup>th</sup> 2012 with a view to launching it to industry at this years IPPS conference at East Malling Research in September (25<sup>th</sup>–28<sup>th</sup>). A striking feature of the project has been the high degree of grower involvement, with many giving freely of their time to contribute images and check or even draft passages of text; the author is extremely grateful for this support and participation.

### **Research and Knowledge Transfer Requirements**

Current research and knowledge transfer requirements in HNS propagation identified during the project are summarised below.

### Current research and knowledge transfer requirements

Section	Subject	Work required	Priority
<b>Propagation management</b>	Stock-plant and cuttings nutrition	Research on micro-nutrient requirements of stock-plants (and rooting cuttings), particularly with more difficult to root subjects.	High
	Cold storage of leafy cuttings	Research linked with desk study to determine optimum storage times and temperatures to develop specific guidelines for HNS subjects.	High
	Lean management and its application to propagation work	A fact-sheet linked to workshops tailored to the needs of propagators to build confidence and raise awareness of benefits.	Medium
	Wounding of cuttings	Research to identify optimum wounding techniques for difficult to root subjects (link with new work on rooting hormones).	Medium
	Leaf removal from cuttings	New research with a wider range of subjects to substantiate and build on previous work as a basis for crop recommendations.	Medium
	Rooting hormones	Research to identify optimum formulations, combinations and rates for a range of HNS subjects.	High
<b>Propagation environments</b>	Water management under mist systems	<p>Research to compare rooting results on capillary beds under mist, using a range of systems, rooting media and plug trays.</p> <p>Find practical ways for growers to measure air/water content of media across a range of plug and media types.</p>	Medium

<b>The role of the Evaposensor</b>	Best practice	Systematic comparisons of different mist regimes to identify optimal set points for particular species and cultivars to enable nurseries to get the best from the Evaposensor mist control equipment.	High
<b>Aftercare</b>	Crop protection	Research to evaluate the benefits and role of microbial products in HNS propagation.	Medium
	Integrated Pest Management in propagation	Fact-sheet on getting the best from IPM in propagation situations, revised grower guide (ref. defra guide, Integrated Pest Management in Protected Ornamental Crops – A Best Practice Guide for UK Growers) and / or a DVD to promote best practice.	High
	Integrated Crop Management	Knowledge transfer to build confidence and promote best practice, (e.g. revise defra guide, Environmental Best Practice for the Ornamentals Sector, 2008) inc. e.g. propagation / maintenance of disease-free material.	High
	Liverwort and moss control	Research on potential products for control would be useful along with cultural control / non-chemical / ICM compatible control strategies (ref. HNS 185).	Medium
	Cold storage of rooted plugs and liners	Research on HNS requirements and firmer recommendations for growers.	High

## Science Section

### Programme of work

Work stage	Milestone (revised March 2011 and May 2012)	Progress
Agree and finalise basic structure of Guide to be used to develop first draft.	1 <sup>st</sup> April 2010	Completed.
Prepare and deliver a paper to the IPPS GB Regional Conference.	14 <sup>th</sup> September	Completed.
Identify and collate sources of information inc research reports and papers.	30 <sup>th</sup> September 2011	Completed.
Research, appraise and sort reference information.	30 <sup>th</sup> September 2011	Completed.
Interview HNS growers and undertake case studies.	31 <sup>st</sup> December 2011	Six case studies completed to schedule.
Source and collate image library to illustrate Guide.	31 <sup>st</sup> December 2011	Completed.
Write up case studies	31 <sup>st</sup> December 2011	Completed
Complete draft 1 and circulate to Steering Group.	31 <sup>st</sup> December 2011	Completed
Revise, complete and circulate draft 2 for comment.	31 <sup>st</sup> March 2012	Completed
Revise and submit final draft.	30 <sup>th</sup> June 2012	Final draft with images submitted 29 <sup>th</sup> June 2012.
Write promotional article for HDC News	30 <sup>th</sup> June 2012	Copy underway and scheduled for early July. Publication due as a promotional feature in the September issue of HDC News

		in lead up to industry launch (IPPS conference, September 25-28 <sup>th</sup> 2012).
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## Current research and knowledge transfer requirements

### Propagation management

**Stock-plant and cuttings nutrition** - little detailed work appears to have been done – or at least published - on the nutritional requirements of stock-plants to sustain their production of uniform, high quality propagation material, or on the effects conferred by supplementary feeding stock-plants (e.g. container grown plants under protection where nutrient status frequently changes) on the subsequent rooting of cuttings (especially uniformity of rooting). Research is needed to address this (e.g. use of liquid / foliar feeds, compost teas, potassium phosphites).

**Cold storage of leafy cuttings** – whilst the HDC Grower Guide, HNS Cold storage – How to successfully cold store hardy nursery stock, published in 2009, helped address current knowledge gaps on how to get the best from cold storage, research is needed to provide a better understanding of the cold storage requirements of leafy cuttings and in turn, enable the development of more specific guidelines for optimum storage times, temperatures and conditions for a range of HNS subjects.

Such information would help enable growers to cold store cuttings to optimum effect and further exploit the benefits of controlled temperature storage as a propagation management and scheduling tool (ref. HNS 113, The feasibility of using low temperature storage as a scheduling aid in nursery stock production).

**Lean management and its application to propagation work** – Lean Management is a set of techniques that can be used to help reduce costs and add value to businesses. It can do this by improving productivity, reducing plant losses and removing wastage.

Some propagators appear unaware of the wider benefits of ‘Lean’ and how its principles and practices can be applied to HNS propagation (e.g. collection, preparation and handling of cuttings, seed sowing, transplanting / liner potting, budding and grafting). A fact-sheet linked to a programme of KT workshops tailored to the needs of propagators would be useful to build confidence and raise awareness of the considerable savings that may accrue from the use of Lean in propagation situations.

**Wounding of cuttings** – wounding cuttings increases the quantity and quality of roots as new sites for root initiation are triggered when basal stem tissue is exposed. It is a particularly useful technique to ‘coax’ roots from difficult or slow rooting subjects, especially where the wood is quite lignified. Much of the current knowledge base is empirical rather than research based. New work should consider and trial different methods of wounding, linked with the use of hormone rooting aids. Such work should be preceded by a simple desk study to establish present knowledge (wounding and rooting hormones), as a baseline for future work.

**Leaf removal from cuttings** – avoiding the need to remove or ‘strip’ leaves from large numbers of cuttings saves considerable time. Past research to investigate leaf removal with a range of species found that many woody HNS subjects rooted better when their lower leaves were retained (although *Hebe* cuttings rooted better following leaf removal). Whilst this work highlighted scope for considerable time – and so cost - savings for growers by not removing leaves, further trials work with a wider range of subjects is required to substantiate its initial findings before firm recommendations can be made.

**Rooting hormones** - following the commercial withdrawal of Seradix products (a range of dustable powder formulations based on varying concentrations of IBA) and Synergol (a ready to dilute hormone solution based on IBA and NAA) during 2011, Rhizopon (based on IBA or NAA and available as ready-to-use powders or water soluble tablets dissolved for use as dips or sprays) is now the standard product approved for use and a useful rooting guide to accompany the product range is available to growers ([www.rhizopon.com](http://www.rhizopon.com)).

Whilst quick-dip rather than powder applications have been shown to improve rooting in some difficult HNS species, growers no longer have easy access to the higher strengths required to achieve high rooting. Currently, it appears there are no approved liquid rooting hormones available for sale to the UK market containing high concentrations IBA for the rooting of cuttings – presently, it appears that the only product containing IBA for making liquids in water are the Rhizopon AA 50 mg water soluble tablets and the maximum concentration approved and made with tablets in water is 1500 ppm. New research to evaluate different hormones, formulations, timings, combinations (e.g. powders or dips + leaf sprays) and rates for a range of HNS subjects would help growers optimise their use and identify current product gaps.

#### Propagation environments and systems

**Water management** – striking the right balance between increasing mist to reduce water loss from leafy cuttings or decreasing it to avoid water-logging of the rooting medium can be difficult to achieve. Potentially, capillary sand-beds offer a solution although covering the

beds with membranes (as many growers now do) to control weeds, rooting-through and to keep pots clean may however impede good capillary contact and so drainage. Capillary matting is also sometimes used and further work is needed to evaluate ways of improving capillary drainage and beds.

Related to this is the nature of the rooting medium, type of plug and tray and how that may affect drainage of the media and rooting; there are now many different types, sizes and materials used in pre-prepared rooting plugs, trays and options for propagation media mixes. There is a need therefore for research to compare rooting results of different systems and find practical ways for growers to measure air/water content of media across a range of plug and media types.

### The role of the Evaposensor

**Best practice** – related to water management under mist, systematic comparisons of different mist regimes to identify optimal set points for particular species and cultivars are also needed to enable nurseries to get the best from the Evaposensor mist control equipment.

### Aftercare

**Crop protection** - there is interest in the use of various microbial products to aid preventative disease control, either incorporated into the growing medium or applied as drench treatments. Interest so far has largely centred on their use to control root / stem base fungal infections in specific crops, e.g. *Choisya* and *Phormium*. Such products link well with current moves towards greater use of Integrated Crop Management (ICM) and may have a wider role to play in propagation situations, where they are relatively safe (as compared to the use of synthetic pesticides which can scorch soft growth or check rooting).

There is a need to review and screen a range of these products to assess their effects. Also, building on HNS 125 (Hardy Ornamentals: the potential of compost teas for improving crop health and growth), the use of micro-feeding with compost teas in HNS propagation / liner situations, e.g. their safe integration (compatibility) with fungicides when the latter are used to spot treat disease outbreaks.

**Integrated Pest Management in propagation** - the (usually) higher temperature and closer humidity environments of propagation restrict the range of biological controls and release methods that can be used in such situations. Also, the usually rapid throughput of crops, which necessitates more frequent introductions of biological controls. It is often therefore necessary to adopt different 'tactics' when using IPM in propagation situations and not all growers appreciate how best to devise and adjust programmes accordingly (resulting

in poor levels of control and loss of confidence with IPM). The frequent arrival of new products (biological control and bio-pesticides) can also be difficult for growers to stay abreast of.

Further knowledge transfer would be timely, e.g. a fact-sheet dealing with the successful use of IPM in propagation situations, a broader grower guide to refresh and update growers of ornamental crops (perhaps a revised version of the popular Defra guide, Integrated Pest Management in Protected Ornamental Crops – A Best Practice Guide for UK Growers, published in 2006) and / or a DVD to demonstrate and reinforce best practice.

**Integrated Crop Management** – HNS 185 (Understanding and managing crop protection through Integrated Crop Management) found that many growers are aware of ICM and implement such measures (albeit to varying degrees), suggesting they should have little difficulty in meeting at least some of the requirements of the EC Sustainable Use Directive (SUD), which requires growers to reduce the use of pesticides, and demonstrate good ICM practice by 2014.

This work and that of HNS 183 (Propagation Guide) has however identified a need for further knowledge transfer on the more technical aspects of ICM, such as the propagation of disease-free material, including the use of on-site diagnostic tests and their utilisation with latent infections. A fact-sheet or best practice guide (e.g. revision of the Defra Grower Guide, Environmental Best Practice for the Ornamentals Sector, published in 2008) – or DVD – building on HNS 183 and HNS 185 which deals with these aspects and promotes best practice would be timely.

**Liverwort and moss control** – both of these weeds continue to pose problems to propagators and there is a need to reinforce the benefits of cultural control measures and good nursery hygiene linked to the use of alternative, non-chemical weed control options. The publication of HDC Fact-sheet 25/12 (Non-chemical weed control for container grown hardy nursery stock) which provides detailed guidance on non-chemical weed control (including moss and liverwort) is therefore timely. Linking with this, weed control workshops (propagation / liners) which raise awareness of alternatives to chemicals, underline the value of nursery hygiene and cultural weed control measures, and demonstrate application equipment (mulches and pot-toppers) would help reinforce best practice and should be considered.

Anecdotally, there are also a number of registered pesticides that provide good moss and liverwort control and these should be screened with a view, if effective, to appropriate approvals being sought.

**Cold storage of rooted plugs and liners** - the ability to 'hold' rooted cuttings in modules and pot liners for short periods until required was one of several benefits identified by HNS 113 (The feasibility of using low temperature storage as a scheduling aid in nursery stock production), reducing the need for subsequent growth control and enabling the development of scheduled production programmes.

No published work appears to have been done to determine more precisely the temperature requirements of HNS species when stored in this way; whilst 3-4°C is likely to be a good starting point and widely used for bedding plants, research is needed to develop a more specific understanding of HNS requirements, which would enable firmer guidelines to be developed for growers to exploit cold storage for scheduling purposes.