

Project title: Management tools for optimising nursery space use and production forecasting

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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.

Professor John Colvin

Professor

Natural Resources Institute, University of Greenwich.

Signature Date21st October 2013.....

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GROWER SUMMARY

Headline

Reduce the risks inherent in your HONS business and increase its profitability by investing in systems that cost production accurately and manage space efficiently.

Background

A previous HDC-funded project (HNS 136) found that liner nurseries involved with the project lacked an accurate way of costing their production process, thereby making it hard to identify easily where losses were occurring or how the profitability of individual varieties was affected by crop non-uniformity and yield.

To help address this problem, a decision-support modelling package called “ProGro 2009” was built, which was designed using knowledge and feedback from nursery managers at key stages of the program’s development. HNS 136’s activities were focused on the beginning of the plant-production process, because this was considered to be the most cost-effective way to tackle the non-uniformity problem. ProGro 2009, therefore, now provides liner producers with a method of costing production, identifying losses at the different stages and optimising profits in relation to variability in the crop. It was built in the familiar Excel spreadsheet format and so can be customised easily to suit individual nurseries’ needs.

With the ability to cost and optimise production for individual liner varieties, the related issue of the efficient use of nursery space immediately arises. ProGro 2009 shows consistently that when production is optimised, significant areas of nursery space become freed up and therefore potentially available for the production of additional profitable product lines.

Some finished-plant producers already have bespoke plant-variety costing systems and so important information on the relative profitability of different plant varieties is available to them. These systems, however, apparently lack a production-time component to costing, which is incorporated into ProGro 2009. The adaptation of existing finished-plant nurseries’ costing tools to include a production time component, therefore, would be one of the first steps required for creating a widely applicable space-management tool.

The efficient management of space, which is particularly important when it involves expensive heated glasshouses or propagation facilities, is a complex problem that all

nursery growers face, which is suited to modeling. The complexity of the problem is compounded by the seasonal and biological constraints that determine the availability of new plant material or liners, as well as the requirement for plants to be moved between the different types of plant-growth areas.

Such complex problems do require the power provided by computers to help find practical solutions quickly. In 2004, a survey on the use of computers in the retail and amenities sectors was carried out by KPMG. It showed that information technology (IT) was widely used in sales, finance, inventory, dispatch and communications and most nurseries used bespoke IT systems. Microsoft Excel was mentioned by many respondents and a few used Wintree, Growmaster, IFS and Plantpro.

Apart from IFS and Excel, however, these software packages lack an operations modeling capacity. The IFS Business Modeler is difficult to apply to HNS nursery operations, due to the biological constraints inherent in plant production (John Woods Nurseries, pers. comm.), and so there is a need for a software package to be developed that is capable of assisting managers to plan and optimise the use of their different space resources. Excel, when used in combination with Visual Basic programming, provides a powerful platform able to achieve this. The activities and milestones described below, therefore, were formulated both before and after the initiation and commissioning of this project, with the active participation of HONS nursery production managers.

The project was commissioned with a particular set of objectives and associated milestones for the first year. In the light of information collected after initial visits to growers' nurseries, the Year 1 activities and milestones were re-assessed at a meeting with the project's Industry Representatives at Farplants Sales Ltd., West Sussex, on 10th August 2010. Discussions from the previous meeting were presented and it was decided that an industry-wide, 'base-line' survey was required in order to collect information on current approaches and methods used to calculate the cost of production of HNS product lines. It was also decided to build a basic costing tool, with the provisional name "ProGro Bronze". This costing program was subsequently re-named "ProCost". In order to achieve this, the project (HNS 136a) was put 'on-hold' for four months to allow Professor Colvin and Mr Will George to submit a concept note and full proposal for a survey to the HNS panel. This funding application was successful and the survey was subsequently conducted. It generated substantial interest and 72 (approximately 20% of HONS businesses) returned forms were received from a broad spectrum of nurseries of all sizes operating in the various HONS market sectors.

Due to the lack of an easy-to-use production costing tool, the overwhelming majority (81.4%) of respondents to the questionnaire said that they wanted to receive an HDC-funded costing tool to calculate plant production costs. In addition, when the responses were analysed by nursery turnover, even nurseries in the smallest turnover group expressed a strong demand for a production-costing tool.

The survey data also showed that for nurseries in all turnover categories, space management (“fitting production into the available space”) could be a highly important issue and that when turnover exceeds £2.0 million, the importance attached to space management increases substantially. Almost all nurseries (92.8%) also rated forecasting demand either a score of six or higher (out of 10). Demand forecasting, therefore, is clearly also an issue of great interest to almost all HONS nurseries and, in general, ranks above space management in importance. When asked if their nursery (production or marketing managers) would be interested in using space management and demand forecasting tools, if they were developed and distributed free by the HDC, 72% and 73% said “yes”, respectively. These percentages are only slightly lower than the percentage requesting a production-costing tool.

The survey data were analysed to determine the percentages of respondents that requested none (15.3%), one (19.4%), two (9.7%) or all three (55.6%) of the proposed tools. 84.7% of the nurseries, therefore, said they would like to receive one or more of the tools.

The nurseries stipulated that the key characteristics of the tool(s) must be “ease and simplicity of use and data capture”, as well as the ability to simulate situations and to optimise (maximise) profits.

Reference

KPMG (2004) HDC survey analysis, 10th June 2004, Final Report.

Summary

The mini-survey of six nurseries at the start of the project provided an indication that there was no widely-used production costing tool available to HONS nursery managers. This presented a problem for the proposed space-management tool development planned for the project’s first year. At the first project review meeting, therefore, it was agreed to carry out an industry-wide survey to collect the data to confirm or reject this preliminary conclusion.

The outcome of this much larger survey confirmed the findings of the mini-survey and so the project's milestones were revised with the aim of developing a 'simple-to-use' production costing tool. The tool was initially called "ProGro 2012 *Bronze* version" and subsequent to its release renamed "ProCost" to differentiate it from previous work. It was designed and built following an iterative process that involved Professor Colvin interacting with HONS production managers to obtain clear feedback after each stage of the tool development had been completed. ProCost has now been released and is readily available on the HDC website for all growers to download and use. This is now in use and workshops have been held to promote the tool amongst growers.

Many years of experience and frustration experienced by HONS production managers have highlighted the requirement of a tool that could take account of different environment types specific to individual nurseries and cope with the different categories of space that are found within nurseries such as heated and unheated glasshouses, poly tunnels and outdoor areas to name a few. The tool also needed to be capable of fine tuning space requirements as the year progresses and had to be powerful enough to cope with the production of more than 2000 species. At the project review meeting at the end of year 1, it was agreed that ProSpace development should go ahead. ProSpace was designed and built following a similarly iterative process to ProCost. Professor Colvin attended several project meetings with HONS production managers and HNS managers to obtain clear feedback and address specific requirements/requests of the HONS production managers. The tool was built and is ready for release on the HDC website in two different versions of Excel that account for the different operating systems used in nurseries across the country.

Financial Benefits

There has been insufficient time to assess the financial benefits from this project, because the production costing tool has only recently been released to industry. However, at the grower workshops organized for ProCost, several of the participants said that they were already using ProCost to make business decisions.

The longer-term goal of HNS 136a is to help to improve the profitability of HONS nurseries by building computer-based tools that help management make financially beneficial decisions. The survey data collected by HNS 136b provided base-line data which provides an accurate measure for future benefits of the project.

The space management tool, "ProSpace", has been built and is ready for release to industry; it is anticipated that this tool will deliver significant financial benefits to nurseries

that utilize it and it is now available on the HDC website for all growers to download and use.

Action Points

- Spend as much time as possible using the tools and getting to know the software and what the tools can do. Invest time to understand what the tools can do for you and you will reap huge dividends for your business.
- Collect up-to-date financial information on production costs, which will enable you to derive benefits immediately from the production costing tool. Necessary data include the costs of: the plant starting material, compost, containers, agrochemicals, sundry items, crop density, type of plant-growth area, staff labour, distribution and marketing, overheads, a category of all other costs not included under the other headings and the total annual costs for the nursery.
- Ensure records are kept of the initial number of plants present in each 'batch', the numbers that reach a 'saleable' standard, as well as the total numbers sold.
- Ensure that you are not inadvertently under-pricing products. To avoid this, make sure that production cost calculations are accurate and that they include all production costs as well as overheads.
- Increase computer skills on the nursery. Send key personnel on a course(s) to update their computer skills, particularly in Excel.
- Obtain the production costing tool from the HDC website.
- Obtain the production space management tool from the HDC website.
- Put into practice what has been learnt at the knowledge transfer workshops. Follow advice provided and guidance given and pass this on to your staff who may use the tools.
- Read and use the ProCost and ProSpace user manuals, it will help you understand what the tools can do and how best to enter data and obtain outputs from the tools.

- Ensure the details being entered into the various datasheets are accurate and complete. It is important to make sure data is entered correctly and fully to avoid error messages.

- Discuss issues you may find with the ProSpace model with your colleagues and other growers.

SCIENCE SECTION

Introduction

HONS nurseries tended to be highly profitable prior to the 1990s, with the consequence that production-based costing systems for individual product lines were probably unnecessary. In the last 20 years, however, external financial pressures and overproduction have created a much harsher business environment. This has meant that nurseries without a good understanding of their changing production costs have become vulnerable to making losses.

An initial small survey was carried out at the start of HNS 136a (“Management tools for optimising space use and production forecasting”) that found that only a very few nurseries had accurate systems for costing production. In the August 2010 HNS 136a project meeting, this finding was discussed and it was agreed that in order to manage space rationally, a good understanding of the profit, after the allocation of gross margin associated with each product line, was required. As a first step in this process, it was decided that the objectives of the first year should be changed and a robust costing tool should be built in the first year of HNS 136a. This is now freely available to HONS growers (ProCost).

In order to be able to build the most useful tools for the largest number of levy payers, it was decided that it would be extremely useful to carry out an HONS industry-wide survey on the approaches currently used to cost production, space management and demand forecasting. The intention was to complete and release the costing tool after the survey, because the survey data, contacts with interested nurseries, and the conclusions drawn would be essential to inform the building of these tools, thus ensuring the widest possible uptake and subsequent impact.

In order to be able to measure accurately the future benefits that a widely adopted costing tool and other decision support tools could have on the profitability of HONS businesses, it was essential to collect an industry-wide, pre-release data set, which could then be used to assess and monitor improvements following uptake of the tool(s). The collection of a ‘baseline’ data-set, therefore, was the second important reason for carrying out this much larger survey. A proposal for this activity was therefore submitted to the HNS panel and subsequently approved.

Materials and methods

An important first objective was to identify through the HNS panel production managers in charge of small, medium and large nurseries who were willing to participate actively in the project. Previous research and experience has shown that due to the complexity of the production planning process and the general level of familiarity of growers with computers, a high degree of interaction and co-operation between researchers and growers would be necessary throughout the project's lifetime. The main method utilised by the project, therefore, involved the iterative and time intensive process of Professor Colvin interacting with HONS growers and developing the tools with his expertise in mathematical modelling and computer programming.

The original methodology planned for the project was to:

Year 1

- Identify through the HNS panel, managers in charge of nurseries who are willing to participate actively in the project (March 2010).
- Carry out visits to the participating small, medium and large-scale nurseries to discuss the space allocation problem with their production control managers (June 2010).
- Contact a Dutch researcher that had worked previously on nursery space management to investigate how far they have progressed since their last papers on this topic published in 1998 (June 2010).
- Build an initial space-management model to help solve the complex space-planning problems (January 2011).
- Attend a one-year project review meeting to assess progress and make any required changes to facilitate project work in years two and three (January 2011).

After the visits were carried out, however, it became apparent that probably only a very few HONS nurseries had, or operated, accurate systems for costing production. In the August 2010 HNS 136a project meeting, therefore, this finding was discussed and it was agreed that in order to manage space rationally, a good understanding of the profit, after the allocation of gross margin associated with each product line, was required. As a first step in this process, it was decided that the objectives of the first year should be changed and a robust costing tool should be built in the first year of HNS 136a. These changes did not

affect the methods employed by the project, but did involve agreeing a revised set of milestones. The revised and additional milestones agreed for Year 1 were:

- A prototype version of a production costing tool will be produced incorporating critical parameters determined, in part, through feedback from the industry-wide survey (HNS 136b) (25th July 2011).
- An updated workplan for the remainder of the project circulated to the Industry Representatives (July 2011).
- A Year 1 project review meeting at which progress will be assessed and a decision made on whether or not to fund the proposed work of Years 2 and 3 (25th July 2011).
- Circulate the production costing tool with User Guide and annual report to the Industry Representatives for comment (30th September 2011).
- After four weeks, incorporate feedback from Industry Representatives and send agreed outputs to the HDC for distribution to levy payers (30th November 2011).

These milestones were delivered and the prototype ProCost tool was made available to HONS nurseries through HDC. The new milestones for Year 2 were also agreed as listed below.

Year 2

- Agree the inputs required for ProSpace and the model structure to take account of the different environment types within nurseries.
- For this tool, the time-frame units should be week-number per year.
- Able to cope with the different categories of space, e.g. heated/unheated glass-houses, winter protection tunnels (French Tunnels), cold poly, heated poly with capillary irrigation and overhead irrigation, outdoors (both wet and dry beds) and shaded, 'mother-plant' areas, cold store, 'holding area' prior to dispatch.
- Able to fine-tune the space requirements during the year, based on how advanced the crops are (usually determined by the weather each year). The range of adjustments would be 1-3 additional weeks.
- Capable of dealing with crops that are on the ground for longer than a year, which means there can be two crops of the same species on the ground at the same time.
- Facility for increasing the space given to crops to improve their 'bushiness/quality'
- Able to cope with the production of more than 2000 species or varieties. Batch sizes range from 1-5000 plants.

- Have a data entry form (through creation of a data entry sheet).
- Build a data-import system with a search facility, so that ProCost data can be loaded into ProSpace. Make the search result area as large as possible.
- Build an improved data-base search facility for ProSpace.
- Write a program to convert dates (used for ProCost) to the new Week Number system.
- Write software and build 'sheets' to be able to move large numbers of batches of plants (as many as possible) between locations at the same time.
- Write software and build 'sheets' to be able to change the densities and spacing of large numbers of batches of plants between locations at the same time.
- Report creation – Summary tables to be developed, if time permits within the contract there is also a need to create a report summarising multiple batches (from different stages) at the point that the location area is exceeded in capacity so a decision can be made about which batches to include or exclude. Must be able to show individual houses or areas.
- Write a User Guide to go with the Space Management tool (subcontract to Will George, ADAS, to provide technical expertise, attend meetings with the Industry Representatives, help write a User Guide, and involvement in the testing of the model).
- Attend regular meetings with the Industry Representatives to discuss progress and provide an iterative feed-back loop to assist building the software.

Results

Year 1

Participation of HONS nursery production managers

Six HONS Industry Representatives, with a keen interest in this subject area, kindly agreed to participate in the project and to contribute their expertise to it. In addition, Mr Will George (ADAS), who has previously built a spread-sheet based costing model agreed to become involved in the survey project (HNS 136b) and to contribute towards building the production costing tool in his capacity as an ADAS contractor.

Visits the participating small, medium and large-scale nurseries to discuss the space allocation problem with their production control managers

Visits were made to the following nurseries: Hook Mill Nursery (30/3/2010), Hillier Nurseries (22/04/2010), Fleurie Nursery (29/4/2010), John Richards Nursery, Robin Tacchi Plants (13/05/2010), (17/5/2010), John Woods Nursery (19/05/2010). Mr Lyndon Mason (29/04/2010 - Consultant for cut-flower growers) and Mr Harry Kitchener (29/04/2010 - Consultant for container-plant growers) also attended the meeting at Fleurie Nursery and contributed their views to the discussions. All of the nursery managers and staff who facilitated these meetings were extremely generous with their time and expertise, which was appreciated greatly. The following is a summary of the main points raised at these meetings.

Key attributes of the space-management tool

Suggestions and 'wish-list' for outputs generated by the tool

- Optimises profits in terms of space use, e.g. answer questions such as, what percentages of the different types of nursery space are being used by the most profitable/least profitable product lines? It may also suggest additional ways in which the most expensive areas can be used more efficiently or profitably to produce increased financial returns.
- A facility to suggest the best option, given the level of order 'back-up'. This might be based on the relative values, profitability, or sensitivity of crops competing for the same space and would take account of fixed-week delivery orders.
- Highly visual, which would be of benefit to the user, and able to produce a view of space required by environment type and by date range, with 'drill-down' to individual areas or beds.
- Able to be used as a simulation tool to enable "what if" planning.
- Aims to free-up big blocks of space at a time and keep stock movement to a minimum, due to the labour costs involved.

Characteristics

- Built-in flexibility, due to the unpredictability of when stock leaves the nursery and when space is vacated. Include a 'ready' date, which could be altered depending on crop development.
- Linked to sales data, which includes targets, what has been sold, as well as when it should be, or has been, dispatched.
- Operate in 'real-time' to provide a snap shot of what is free 'now'.

- A simple and easy-to-use front end, so that the nursery is not dependent on a single person to operate and understand it, and so that data can be entered by more junior staff.
- Protected/secure data and front end, so that things are not changed inadvertently.
- Generate reports to help assess the need for new capital equipment requirements.

Framework for the space-management tool

- The time-frame units should be week-number per year.
- Able to deal with the different categories of space, e.g. heated/unheated glass-houses, winter protection tunnels (French Tunnels), cold poly, heated poly with capillary irrigation and overhead irrigation, outdoors (both wet and dry beds) and shaded, 'mother-plant' areas, cold store, 'holding area' prior to dispatch.
- Able to fine-tune the space requirements during the year, based on how advanced the crops are (usually determined by the weather each year). The range of adjustments would be 1-3 additional weeks.
- Match plant requirements and growth habit (characteristics), e.g. tall plants are unsuitable for the sloping sides of a semi-circular polytunnel.
- Needs to take account of space requirements of (i) plants for sales and (ii) for potting on.
- Capable of dealing with crops that are on the ground for longer than a year, which means there can be two crops of the same species on the ground at the same time.
- Facility for increasing the space given to crops to improve their 'bushiness/quality'
- Able to cope with the production of more than 2000 species or varieties and batch sizes in the range of 1-5000 plants.
- Ability for 'drilling down' to find out what happened to different batches of plants.
- Meet production orders grown for supermarkets, who give a pre-agreed delivery schedule.
- Management expertise would need to be incorporated somehow into the tool to create an 'expert system'.
- Group plants by "order or project" as well as by species / variety (crop).
- **Warning 'flags'**
- Generated by historical data including timings of sales to serve as a helpful reminder of forthcoming space availability or requirements. Also show that a crop needed to be moved e.g. to speed it up.

- Overlay data for the cultural control practices for pests and diseases. A flagging system could also be used to remind managers about pest and disease spraying requirements.
- The same alert system could be used to notify the nursery office that orders haven't been collected or dispatched and so the office could chase these up with the purchaser.

Demand forecasting

- Usually carried out by the sales team. Matching sales targets with stock targets is where space management comes in.
- Computer-based facility to assist with looking for long-term trends in the sales.
- A demand forecasting tool could consider speculative production versus contract growing. This could involve using the tool in a "what if" manner.

Predicting/forecasting space requirements

- Planning tool at the beginning of the year.
- The immediate to 'short-term' future (2-3 weeks ahead).

Data compatibility

- It needs to have a data-upload function from the software used by other nurseries, e.g. Growmaster (linking to their export data facility). This would potentially remove much of the data-entry requirements and ensure the integrity of the data.

Discussion points – the need for a production-costing tool

- Four out of six nurseries have no computer/data based costing-system for plant production.
- There is a need for a costing system for finished-plant production.
- A production-time component has to be incorporated into the costing system, along with area (units of week x m²). This would enable the costs of the different types of space to be taken into account. A space x time model would also make allocation of overheads more logical and straightforward.
- An effective costing tool is particularly important, because costs of inputs (labour, fertiliser, pesticides, water etc.) are increasing. A good costing tool would therefore be useful to cost production of the different species. Could make it to output the breakeven price and work backwards from a sale price to work out the profit.
- Able to make calculations of the relative profitability of the > 2000 product lines.

- *Discounting* - The timing of crop readiness is very important and this is especially true for those that are sold when in flower. If this is missed, there are important consequences in that the crop will be sold at a reduced price in order to clear the space. This reduces the overall profitability of particular product lines and so would need to be included in the space management DST.

Cut-flowers

Cut-flowers - costing model for production, i.e. an economic model rather than one for space allocation.

Contact a Dutch researcher that had worked previously on nursery space management to investigate how far they have progressed since their last papers on this topic published in 1998 (June 2010).

Contact was made with the Dutch researcher Dr E. Annevelink and it turned out that his publications arose from his PhD work. A copy of his thesis was obtained and, although fascinating, was found to be of limited value to this project. The main reason for this is that he was modelling Dutch automated systems where plants are moved slowly along conveyor belts. This confirms the conclusion of the survey (HNS 136b) that there does not appear to be any 'off-the-shelf' space management or production costing tools available, that are applicable to UK HONS nurseries.

New activity arising out of the project meeting on 10th August 2010

A prototype version of a production costing tool will be produced incorporating critical parameters determined, in part, through feedback from the industry-wide survey (HNS 136b) (25th July 2011).

The prototype production costing tool was built (Annex 1) and was been sent to the participating Industry Representatives to assess and test. After feedback from the Industry Representatives, it was re-assembled to include features such as the ability to generate unique codes.

An updated workplan for the remainder of the project circulated to the Industry Representatives (July 2011).

The revised milestones for the remainder of the project were circulated and agreed.

A Year 1 project review meeting at which progress will be assessed and a decision made on whether or not to fund the proposed work of Years 2 and 3 (25th July 2011).

The project review meeting took place at John Richards Nursery where the results of the survey (HNS 136b) were presented by Professor Colvin and Mr George, as well as a working version of the production costing tool. The significance of the survey results was discussed in detail and changes suggested to the costing tool by the Industry Representatives. The emphasis of the proposed Year 2 work was discussed and it was decided that, in plain English, the space management tool should assist with “fitting stuff in to the space available”. It was also agreed that, as well as the same criteria that applied to the production costing tool (simplicity of use, etc.), the space management tool should be highly ‘visual’, i.e. have output that includes graphs and ‘images’ of space use over time.

An additional point that was discussed at the meeting was the need for a promotional and extension effort to support the release of the costing tool. A timetable for the release of the costing tool and associated publications was agreed with support from Mr George.

Incorporate feedback from Industry Representatives and send agreed outputs to the HDC for distribution to levy payers (30th November 2011).

After sending out the costing tool to Industry Representatives, some very helpful and informative feedback was received. Work was undertaken to incorporate suggested changes and improvements into the tool. A meeting was held on the 18th November 2011 at Hillier Nurseries, where the production costing tool was demonstrated and work began on the space management tool.

Year 2

Year two focussed on the development of the ProSpace tool. The requirements of this tool were obtained from the previous discussions with nurseries and the Industry Representatives at the various meetings held and discussions had throughout the project. The development of a new piece of software is an extremely time consuming process with small changes or requests for an additional function often requiring a great deal of extra programming or reprogramming of previously completed parts of a model. Many HONS nurseries will have completely opposing views on what a model should include and what is

good for one may not be good for all but the iterative process continued and as many functions and requests were incorporated into the model as were possible within the time constraints of the project contract. The following is a list of the main requirements agreed at meetings and following discussions with HNS managers.

1. *Agree the inputs required for ProSpace and the model structure to take account of the different environment types within nurseries.*

These were discussed and 'evolved' at several meetings with the Industry Representatives due to the creative process of building ProSpace. The final version was delivered to HDC in August 2013.

2. *For this tool, the time-frame units should be week-number per year.*

ProSpace has a system for converting dates to week numbers. This includes a year 'identifier' to avoid confusion.

3. *It needs to be able to cope with the different categories of space, e.g. heated/unheated glass-houses, winter protection tunnels (French Tunnels), cold poly, heated poly with capillary irrigation and overhead irrigation, outdoors (both wet and dry beds) and shaded, 'mother-plant' areas, cold store, 'holding area' prior to dispatch.*

The structure of ProSpace has been built to accommodate two 'levels' of space.

4. *Able to fine-tune the space requirements during the year, based on how advanced the crops are (usually determined by the weather each year). The range of adjustments would be 1-3 additional weeks.*

Due to the complexity of the programme required for this function, it was agreed with the technical managers and Industry Representatives in February 2013 to discontinue this function within the software.

5. *Capable of dealing with crops that are on the ground for longer than a year, which means there can be two crops of the same species on the ground at the same time.*

ProSpace has been developed to view a single batch on the same sheet is three years.

6. *Facility for increasing the space given to crops to improve their 'bushiness/quality'.*

This action can be carried out by loading data to the input form (see number 8 also). A separate sheet was built to change the densities of many batches at the same time.

7. *Able to cope with the production of more than 2000 species or varieties. Batch sizes range from 1-5000 plants.*

It is possible to have 65,000 batches with unique codes.

8. *Have a data entry form - Create a data entry sheet.*

A data entry sheet has been built.

9. *Build a data-import system with a search facility, so that ProCost data can be loaded into ProSpace. Make the search result area as large as possible.*

The programming for the ProSpace search has been completed. The sheet then was modified to take an increased number of items.

10. *Build an improved data-base search facility for ProSpace.*

A search facility that allows six criteria to be specified at the same time was built.

11. *Write a program to convert dates (used for ProCost) to the new Week Number system.*

A program has been written for this. An additional logical problem was encountered and so another program has been written to ensure that there is no double batch counting.

12. *Write software and build 'sheets' to be able to move large numbers of batches of plants (as many as possible) between locations at the same time.*

A sheet was built, but it didn't meet the needs of the Industry Representatives. This was discussed at some length, due to the conceptual difficulty of dealing with different stages of the same batch. The Move sheet has now been rebuilt to be able to move batches at the same time and to show the different stages present in the location.

13. *Write software and build 'sheets' to be able to change the densities and spacing of large numbers of batches of plants between locations at the same time.*

This was completed.

14. *Build a 'global' time change facility.*

This facility was dropped following discussions with technical managers and the Industry Representatives in February 2013.

15. *Report creation – Summary tables and graphical output still to be developed, if time permits within the contract there is also a need to create a report summarising multiple batches (from different stages) at the point that the location area is exceeded in capacity so a decision can be made about which batches to include or exclude. Must be able to show individual houses or areas.*

A Summary table was built.

16. *Write a User Guide to go with the Space Management tool.*

This was written and sent to Will George to convert into grower language. Following consultation with the Industry Representatives, the User Guide was finalised and was incorporated in the ProSpace tool.

17. *Attend regular meetings with the Industry Representatives to discuss progress and provide an iterative feed-back loop to assist building the software.*

Regular meetings were attended and feedback used to create ProSpace.

Discussion

The industry-wide survey carried out during year 1 found that 84.7% of the respondents said they would like to receive one or more of the proposed tools and more than half of the nurseries asked for all three tools. Although there was some stratification in the responses, e.g. space management was more important to the larger nurseries than to the small ones, all of the data collected was consistent in that they provide unequivocal evidence of a strong demand for these products.

The mini-survey data collected at the initiation of Year 1 was much more detailed than the industry-wide survey, but several clear messages were apparent from both data sets. These are that the tools: 1) must be simple to use; 2) data capture should be made as easy as possible (including the ability to accept data from other software programs) with built-in error checking; 3) the costing tool eventually needs to be able to have different methods of allocating overheads; 4) the tool(s) need to be able to simulate situations and to help optimise (maximise) profits; 5) the space management tool should take account of the biological constraints of growing plants.

With these criteria in mind, a version of the costing tool has been built in Excel 97-2003 and in Excel 2007-10. It does not require the data-base to be filled with all the production data before it can generate an accurate production cost. The tool, therefore, can begin to be used with the collection of a minimal amount of key inputs. This is an extremely important attribute, because data collection and entry often represent significant obstacles to the adoption and widespread use of many decision support tools, such as the ones being developed during this project.

ProSpace has been completed and delivered. The Tool is capable of providing growers with invaluable information that will help optimise profits for the industry and assist with planning how best to use space within the multitude of different nurseries that exist. Several meetings with Industry Representatives were held in Year 2, each one raising issues that required addressing as the Tool took shape. The process required Professor Colvin rebuilding the Tool on several occasions in order to incorporate specific requirements raised by individual members of the representative group.

As with all creative processes, it is only when the programs are being written that the full implications become evident and logical difficulties appear. So far, however, solutions have

been found for all of them and a powerful space management tool for HNS nurseries has been built.

In common with many new technologies, decision support tools themselves require a significant level of support to help them get established and accepted by users. This will be particularly true for the UK HONS industry, given the apparent low level of computer use currently present in nurseries. When dealing with these various issues, it is clear that some knowledge transfer will need to be made in the future to help the industry modernise and take advantage of the huge benefits available from harnessing the power of computing technology. Workshops have been held for HNS nurseries to show the power and benefit of the ProCost model. The workshops were well attended by nursery staff and managers and a general consensus of the importance of the models and how useful they are was fed back to the project team. The models have been received favourably and it is felt they are a highly valuable tool to the industry.

Conclusions

Decision Support Tools for the UK HONS sector, of the type developed by this project have previously been unavailable, although there is an unequivocally strong demand for them. It is also apparent that there is no widely adopted commercial package for costing production of individual varieties, although several different software packages are used for this purpose. Each of these, however, has significant drawbacks, which probably explains why they have not been widely adopted.

The data in the mini-survey and the industry-wide survey were consistent and show that considerable benefits could be derived by the increased use of DSTs by nursery managers.

The main methodology practiced by this project for the development of the DSTs has involved an iterative process of Professor Colvin interacting with HONS growers to obtain clear feedback after each activity and planned stage of development has been completed.

Knowledge and Technology Transfer

Two articles were written on ProCost. Further articles were written for ProSpace. Both models have been presented to Industry Representatives at meetings and to the wider industry at workshop events held at HNS nurseries. In February 2013, Professor Colvin presented the final version of ProSpace to the Industry Representatives and HDC Research and Knowledge Transfer Managers providing a complete “walk through” for entering a batch of data into and the functions of the ProSpace model.

ProSpace and ProCost are both freely available on the HDC website and can be downloaded and used by anybody with a PC and Excel programme. To take account of the differing ages of computers and software held on them, the two models have been written in both Excel 97-2003 and in Excel 2007-10. Both programmes in both versions have user manuals embedded in the model that can be easily accessed by any user whilst data is being entered.

As part of an on-going process of modernisation for HONS nurseries, the training of key staff in the use of the latest Excel package would be highly beneficial.

Glossary

When introducing new concepts and approaches, it is often necessary to use new terms. Wherever possible, however, an attempt has been made to avoid jargon and to use plain English in this Final Report. There are some words in the report, however, that may need some additional explanation. These are:

Decision support tool	A computer-based program that can be used by nursery managers to generate information that aids them to make important decisions (e.g. about setting prices, managing space and estimating future demand).
Costing tool	A computer-based decision support tool designed to be easy to use and to generate production costs for particular products sold by the nursery.
Space Management tool	An easy-to-use computer-based decision support tool designed to help organise space use on the nursery.
Product line	A "product line" is any individual variety in a given cell/liner/pot size, e.g. <i>Choisya ternata</i> 9 cm is one line, <i>Choisya ternata</i> 3L is another.
Product groups	Any grouping of lines that have the same production and costing criteria are "product groups".
Model	The mathematical calculations conducted to generate answers to specific questions.