Project title:	Hardy ornamentals: Survey to determine current industry practice and future needs for the use of low temperature storage as a scheduling aid in nursery stock production.
Project number:	HNS 140
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1 GROWER SUMMARY

1.1 Headline

Low temperature storage of hardy nursery stock offers opportunities to schedule production, manage quality and maximise sales.

1.2 Background and Expected Deliverables

A survey of 23 growers was undertaken to identify the level of interest and relevance to the industry of low temperature storage as a scheduling aid in nursery stock production.

The survey delivered information on the current use of cold storage, current use and awareness of scheduling methods and further research needs for cold storage. The information delivered could be used to prepare a full project proposal for the use of low temperature storage as a scheduling aid in nursery stock production. The survey also demonstrated to growers the cost-benefit of using low temperature storage.

Additional resources will be necessary for future research projects to develop clear guidelines on how UK growers can use low temperature storage to improve crop scheduling.

1.3 Summary of the Project and Main Conclusions

The survey found that low temperature storage is a widely used technology within the hardy nursery stock industry, although its use is mainly limited to storing propagation material. The type of storage used and the level of investment was found to be dependent on the intended use, with field producers making the greatest investment in the technology. For those not using the technology it was felt that a cost-benefit would need to be demonstrated before its use could be considered.

The primary benefits of using cold storage were identified as assisting in production scheduling and maintaining plant quality during storage periods. The secondary benefits were that customer requirements could be met, sales maximised and efficiency improved. Few limitations of using cold storage were noted. Knowledge of species dependency and optimum storage conditions was the main perceived limitation.

The technique was perceived as applicable to over 75% of the participants interviewed and over half thought that there was a need for further research. Research needs identified included providing guidelines to optimise storage, investigating post-storage performance of plants and best use of storage to improve marketing advantage.

1.4 Action Points for Growers

- Assess the potential to use hired space in local storage facilities or purchase second-hand refrigerated bodies.
- Carry out a cost-benefit analysis to assess the potential to use low temperature storage as a scheduling aid.

SCIENCE SECTION

1 INTRODUCTION

Accurate scheduling is becoming increasingly important in the production of nursery stock in the UK. Larger retailers can exert considerable pressure over their supply base. They tend to operate a "24/7 approach" with very short lead times in what is a seasonal market place. The use of low temperature storage can be used effectively by growers to 'store' material for short-medium periods to ensure a continuity of supply and also demand to be met at seasonal peaks. This is reflected in other ornamental industries, and in edible crops. Many nurseries also face the problem of trying to find sufficient space for plants under protection during the winter months. Low temperature storage provides another means of holding plants through the winter period in a 'controlled' environment.

For some species grown as liners (e.g. *Hydrangea*) a cold period is necessary to stimulate and promote flowering. Much of the supply for this type of product is from Europe, who make use of naturally colder climates or controlled cold storage. UK growers of liner material could take advantage of these techniques and compete more effectively with imported plant material.

Growers producing their own liners, as well as specialist liner producers, would benefit from the ability to store liners during the summer. This would reduce the number of trimming and other management operations required and could prepare liners to be at the correct stage of potting. This would enable a more accurate scheduling of potting and also offer greater flexibility.

HNS 113 ('The Feasibility of Using Low Temperature Storage as a Scheduling Aid in Nursery Stock Production') has thoroughly explored all the current uses of low temperature storage, within the industry, and highlights many potential benefits. The aim of this survey is to identify the level of interest and relevance to the industry of low temperature storage as a scheduling aid in nursery stock production.

2 METHOD

A questionnaire was constructed by Anna Kearton (ADAS) and ratified by HDC and members of the hardy nursery stock panel. Twenty three members of the industry were contacted and questioned by Anna Kearton on the telephone. To ensure that all sectors of the industry were represented, it was agreed that growers with a range of business turnovers would be questioned, as well as growers with a variety of customer bases i.e. multiple retailers garden centres, amenity and contractors. It was also agreed to contact specialist propagators as wells as those who produce their own plugs and liners.

3 RESULTS

- In most cases, results are expressed as a percentage of the responses
- In some instances, verbal responses are listed.

1. Participants were asked if they use cold storage in their production systems?

Yes	No
57	43

2. Participants were asked if not, why is cold storage not used?

Reason	% of Participants
Not necessary	60
Unsuitable for crops grown	0
Cost	40
Limited by facilities	0
Lack of knowledge	0
Other	0

Comments noted under this question:

- Previous cold store used proved too expensive due to size.

3. Participants were asked if yes, which of the following are the cold storage facilities used for?

Reason	% of Participants
Store propagation material - Seed - Cuttings - Rootstocks / transplants *Total*	 13 37 50 *92*
Over-winter stock	38
Stimulate flowering	8
Growth regulation	0
Scheduling	15
Hold finished plants	46
Other	31

Reasons given under other included:

- Induce frost hardiness
- Hold plants for flower shows (Chelsea, Hampton Court)

4. Participants were asked when do they use the cold storage facilities?

Season	% of Participants

Spring	92
Summer	77
Autumn	46
Winter	62

5. Participants were asked which months of the year are the cold storage facilities used for?

Month	% of Participants
January	69
February	77
March	85
April	92
May	77
June	38
July	38
August	31
September	46
October	54
November	69
December	62

6. Participants were asked which type of storage facility they used?

Type of Storage	% of Participants

Purpose built – jacketed	31
Purpose built – direct cooled	23
Refrigerated unit / lorry-back	54
Rented space	8
Other	0

7. Participants were asked what is the target environment for the store (temperature and humidity) how is this achieved (ambient temperature / fogging)?

Temperature	Number of Participants
-3 to –4°C	1
0 to 1°C	3
1 to 2°C	6
2 to 3°C	1
3 to 5°C	1
5 to 7°C	2
8 to 10°C	1

The temperatures used for low temperature storage are explored in more detail in the discussion. However, as a generalisation the uses were:

- -4 to 2°C used for bare material storage
- 0 to 2°C used for finished plant storage
- 1 to 5°C used for cutting material storage

8. Participants were asked what were the costs involved in:

a) Purchasing and installing cold storage facilities?

Cost	Number of Participants
£1,700	1
£4,000	2
£40,000	1
£120,000	1
£125,000	1
Not known / given	8

b) Annual running / maintenance costs?

Cost	Number of Participants
25-30p per day	1
Not known / given	12

9. Participants were asked what were the perceived benefits of using cold storage in their business?

Benefits	% of Participants
Schedule planting	46
Schedule potting	31
Meet customer demands	15
Maximise sales	8
Maintain quality	69
Efficiency	15
Release growing space	8

Participants also used cold storage for:

- Manipulate growth of stock plants for propagation
- Remove heat from cuttings prior to propagation
- Used for seed storage
- Increased efficiency in collecting cutting material as material can be stored in cold storage during trimming operations until labour is available to propagate material.

- Manipulate crop growth including advancing or delaying flowering, holding plant growth or inducing flushing.

10. Participants were asked what were the perceived limitations of using cold storage in their business?

Limitations	% of Participants
None	31
Disease	8
Desiccation	8
Die back	15
Temperature control	8
Cost	8
Knowledge	15
Species dependent	15
Space	15
Other	8

Reasons given under other included:

- The root health of fine-rooted genera deteriorates during storage
- In hot weather have to limit the time in store due to the extreme changes in temperature

11. Participants were asked which of the following methods they were currently using for crop scheduling?

Method	% of Participants
Propagation date	100
Temperature regime	13
Photoperiod	9
Trimming	17
Chemical growth regulation	22
Other	9

Methods given under other included:

- Sales
- Soil conditions

12. Participants were asked if they were aware that cold storage could be used as a scheduling aid?

Yes	No
96	4

13. Participants were asked if they would consider using cold storage as a scheduling aid?

Yes	No
76	24

14. Participants were asked what level of investment would they be prepared to make if they were to use the technique?

Level of Investment	Number of Participants
£0-10,000	2
£10,000-20,000	0
£20,000-30,000	0
£30,000-£40,000	0
£40,000-£50,000	0
£50,0000+	1
Cost-benefit required	12

15. Participants were asked if they think there is a need for further research into the use of cold storage as a scheduling aid?

Yes	No
57	43

16. Participants were asked which aspects of cold storage of HNS crops they would like to see research focused on?

Aspect	% of Participants
Bring forward flowering	20

Schedule potting	13
Long term storage (1-2yrs)	13
Out of season sales	13
Marketing advantage	53
Crop protection	27
Optimum conditions	53

4 DISCUSSION

4.1 Current Use of Cold Storage

Over half of the participants interviewed currently use cold storage in their production systems. The primary uses for the cold storage facilities were:

- Store propagation material (seeds, cuttings, rootstocks and transplants)
- Over-winter stock
- Hold finished plants
- Induce frost hardiness
- Hold plants for flower shows

There were two primary reasons given for not using the technique for those not currently using cold storage in their production systems, which were cost (see 6.2) and seen to be not necessary. Reasons covered under 'not necessary' were that for the species grown the technique is not suitable and delaying of plant growth is not advantageous for the markets supplied and the growing techniques used. One grower noted that to maximise cutting collection they require as much vegetative growth of the container plant as possible prior to sale, and cold storage would interfere with this process.

4.1.1 Cutting material storage

Of those participants using cold storage to store propagation material 37% were storing cutting material prior to propagation. This included specialist liner producers as well as finished container producers. In general refrigerated units were being used for this type of storage. Where the cost of purchasing the store was known it ranged from £1,700 to £4,000. Generally participants were unable to provide details of the cost of running the storage facilities, as the electricity supply to the store was not metered. One participant estimated the cost at between £0.25-0.30 per day. Based on the store running 365 days per year at £0.30 per day this equates to a cost of £1,095 per year.

In line with the main period of propagation for soft and semi-ripe cuttings the stores were mainly being used from March to October, although in some cases the store was running all year round with limited use through the winter months. The target storage environment varied between 1-5^{o}C in spring and autumn and 5-10^{o}C in summer. In most cases humidity control and measurement was not used as the cutting material was stored in polythene bags and damped down prior to storage. Where humidity control was used it consisted of a basic water trough.

Using cold storage facilities allowed growers to maintain the quality of material prior to propagation and maximise efficiency by collecting material whilst trimming, rather than cutting on demand. As a result propagation and the resulting labour requirements could be scheduled to meet production targets. In general there were very few perceived limitations of using cold storage for this purpose. Disease infection was being minimised by limiting the time in storage and maintaining hygienic conditions. One grower commented that in hot weather conditions the time in storage has to be minimised to avoid temperature shock to the material.

4.1.2 Bare-root material storage

Of those participants using cold storage overall 38% were over-wintering stock for sales or potting and of those using cold storage to store propagation material 50% were storing transplant material for planting. This included producers of containerised roses, herbaceous perennials, hardy nursery stock and trees and field grown herbaceous perennials, hardy nursery stock, fruit and ornamental trees.

The majority of participants using cold storage for this reason had invested in purpose built facilities or converted existing structures. One participant was renting jacketed storage space from a local market gardener at low cost. The age of the facilities varied from 5 to 25 years and therefore it was difficult to compare purchase costs, however costs varied from £40,000 to £125,000. In all of the interviews participants were unable to provide the cost of running the storage facilities without further detailed investigation.

The storage facilities were predominantly being used between November and April, in line with field lifting and planting periods. In some cases the storage facilities were being used in the summer months to hold material longer for potting. The target storage environment varied between 1-2^{o}C and humidity was maintained between 80-100% RH. One of the participants interviewed had invested in fogging equipment to maintain humidity, whilst others simply damped down the store periodically with hoses.

The primary perceived benefits of using cold storage to store bare-root material were assisting in the scheduling of planting, in particular season extension, and maintaining the quality of stock whilst in storage. The resulting benefits were that customer demands could be met and sales could be maximised. Overall there were few noted limitations of using cold storage for this purpose. Where deterioration in store occurred (disease infection or dieback) it tended to be seen as species dependent. One grower noted that cold storage had been found to be detrimental to the root health of fine-rooted genera, in particular the *Fagaceae* (forest trees) family. Other participants noted that cold storage had no effect on the dormancy of certain species.

Another limitation noted was that of management skills and knowledge of the technique. One participant noted that the technique could be over-relied upon, and if knowledge was limited as well then poor quality plants could result. Maintaining enough space for storage was also noted as a limiting factor.

4.1.3 Finished Plants

Of those participants using cold storage 46% were holding finished plants to meet sales demands. This included field and container producers of plugs and liners, hardy nursery stock and fruit and ornamental trees. In general purpose built facilities or converted existing structures were being used, although in some cases refrigerated bodies were being used. The cost of purchase and running the facilities has previously been discussed in 1.1.1 and 1.1.2.

In general the storage facilities were being used between November and May, with very limited use during the summer months, in line with the peak sales periods. The target storage environment varied between 0 to 2^{o}C and 80-100% RH. Humidity control was limited to damping down the store, although one participant had invested in fogging equipment to aid control.

The primary benefit of using cold storage to hold finished plants was maintaining plant quality, and in particular holding plant growth and flowering. The resulting benefits were that customer expectation could be met and sales windows could be maximised. The two main limitations of using cold storage for this purpose were that the benefits tended to be species dependent, and there was limited knowledge on how to maximise its use.

4.2 Cost Benefit

The survey found that cost was the reason that nearly half (40%) of the participants were not using low temperature storage. The survey also found that of those who would consider using the method, few growers were prepared to make an investment of £50,000 or more in cold storage technology, and in general the decision to invest would be made following a cost-benefit analysis. HNS 113 and an article in the HDC News ('Cold Comfort in Store for Ornamentals' Feb 2004) looked at the cost-benefit of cold storage use.

It was found that an average annual cost for a cold store, including the average cost (spread over a ten year pay-back period) to build it and running costs, is around £21.35 / m^2 of storage area. This excludes the cost of any building that the store may be situated in. The survey found that several growers (54%) use self-contained stores (e.g. lorry backs), existing barns or they invest in a new steel-framed building, which they insulate to act as a cold store. The economics of using a cold store depend on how well the space is utilised. The greater the number of layers of plants the more worthwhile it becomes.

One advantage of a cold store is to improve 'saleable yield.' The survey found that 53% of participants questioned thought that future research work should focus on using low temperature storage to improve marketing windows. Low temperature storage can be used to delay flowering or growth in order to meet sales windows for crops and reduce wastage. In the survey several growers noted that it would be advantageous to hold certain species, e.g. *Pieris, Lavandula*, at the flower bud stage to maximise sales.

In HNS 113 it was found that if the store was used to hold just one crop of three litre nursery stock long enough to ensure that at least 10% more of it would be sold, (than if it had been kept in a saleable condition), then the benefit exceeds the cost. This is shown in Table 1.

Table 1: Break even yield for one crop per year

Plants or Pot Size	No. of layers on trolley	Cost	Output per m^2	% Break Even Yield
Large plants	2	£21.35	£110.56	19.31
3 litre	4	£21.35	£221.12	9.66
	5	£21.35	£276.40	7.72
9 cm	7	£21.35	£386.96	5.52
Plugs	9	£21.35	£497.52	4.29

4.3 Scheduling Methods

All of the participants interviewed cited that sales targets dictated production planning and was used to devise propagation, planting and potting schedules. This was the case for suppliers to the wholesale, retail and amenity sectors, although the method of implementation varied according to sector. For example suppliers to multiple retailers often had defined target sales weeks, whilst independent garden centre suppliers had less defined targets and batched crops according to predicted sales.

It was found that there was limited use of scheduling aids with the industry. Growth regulators, trimming and temperature regime were being used to varying degrees of success, and the benefits found tended to be species dependent. The use of scheduling aids was limited by the available facilities and knowledge of the techniques.

The majority of participants were aware that cold storage could be used as a scheduling aid and 74% said that they would consider its use. The main reasons noted for not considering the technique were

cost (facilities and plant movement) and that it was not seen as necessary for the crops grown or the market supplied.

4.4 Research Needs for Cold Storage

Of those participants interviewed 61% thought there was a need for further research into the use of low temperature storage as a scheduling aid.

For specialist propagators it was thought that research should focus on providing dormancy to plants in mild winters as global warming increases. It was identified that guidelines were needed on how to hold plugs and liners in storage to allow for scheduling of potting and sales.

Container producers perceived benefits in using cold storage to maximise sales windows and to increase competition with importers. Holding plants in bud, bringing on winter colour in certain species (e.g. *Hebe*) and delaying flushing of certain species (e.g. *Pieris*) were all seen as desirable marketing advantages that could be achieved through cold storage. The need for guidelines to achieve these advantages was identified. A concern noted of using the technique for container plants was the potential effects on shelf life and garden performance post-storage. Conditions to minimise detrimental effects were identified as a research need.

Field producers felt that there was a need to research optimum storage conditions to minimise post-storage deterioration, in particular garden performance and to reduce wastage from difficult storage species. Species dependency was seen as a particular area that required further research to allow cold storage benefits to be maximised. Longer-term storage (one to two years) was noted as a sector specific research need for rose producers.

5 SUMMARY AND CONCLUSIONS

The survey found that low temperature storage is a widely used technology within the hardy nursery stock industry, although its use is mainly limited to storing propagation material. The type of storage used and the level of investment was found to be dependent on the intended use, with field producers making the greatest investment in the technology. For those not using the technology it was felt that a cost-benefit would need to be demonstrated before its use to be considered.

The primary benefits of using cold storage were identified as assisting in production scheduling and maintaining plant quality during storage periods. The secondary benefits were that customer requirements could be met, sales maximised and efficiency improved. Few limitations of using cold storage were noted. Knowledge of species dependency and optimum storage conditions was the main perceived limitation.

The technique was perceived as applicable to over 75% of the participants interviewed and over half thought that there was a need for further research. Research needs identified included providing guidelines to optimise storage, investigating post-storage performance of plants and best use of storage to improve marketing advantage.

Recommended action points resulting from the survey are:

- Devise a cost-benefit analysis guidance sheet for growers, either as an Excel spreadsheet or in a Factsheet format.
- Carry out a review of the storage facilities available including an assessment of energy efficiency, running costs, capacity, insulation properties and opportunities to share facilities with local producers of edible crops.
- Assess a range of species as finished plants under cold store conditions for periods of up to two months in the spring and summer months with an aim of producing guideline for grower to maximise sales and meet customer demands.