Factsheet 09/05

Bedding plants

PC 196 and 196a

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Low temperature storage of bedding plant plugs

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This factsheet collates information from HDC projects PC 196, 196a and other related work. Recommendations are provided on optimal environmental conditions and storage periods for the low temperature storage of a number of summer and autumn bedding plant species. Information on appropriate cold storage facilities and plug plant management techniques is also provided.

Introduction

Various techniques to delay plug development and growth are used in the bedding plant industry including: manipulation of growing temperatures, reduced watering regimes, nutrient restriction, physical means (such as pinching and cutting back) and the use of chemical plant growth regulators. Most of these techniques however rely on the availability of suitable production space. If space is limited, holding back plugs can be difficult without loss of quality. Low temperature storage, in the short term, allows bedding plant plugs to be held without tying up valuable production space and with no significant loss in plant quality.

Holding plug material and scheduling plant production

Low temperature storage can simply be used to hold plug plant material back for a few days to help deal with logistical issues or production peaks. Plug plants can be placed into store on Danish trolleys whilst they await despatch or transplanting.

However, low temperature storage also permits the longer term storage of plugs over several days or weeks (or at the extreme even months). This opens up the possibility of scheduling plant production to meet specific marketing targets which would otherwise be difficult to achieve either because of lack of plant material at a suitable growth stage or as a result of restrictions on available production space.

Fig 1 Finished Primrose 'Quantum Blue' plants grown from plugs stored (clockwise from top left) for 4, 8, 12 and 16 weeks at 4ºC demonstrating the long-term capability of cold stores

The economics of low temperature storage

The precise financial benefits of using cold stores to hold bedding plant plugs are generally determined by individual nursery circumstances. However, a positive financial benefit from using cold stores has been shown in the following areas.

Scheduling crops and reducing wastage
Depending upon the size of the store and the number of plug trays contained in it, cold stores can show a positive financial benefit if they reduce plug wastage by as little as 2.5%.

Holding crops prior to transplanting
When hold ups occur during production it can be more cost effective to hold plugs in certain cold stores for a short while (2-3 days) prior to transplanting than it is to unload them onto the floor or benching and then reload them back onto Danish trolleys.

Substitution for glasshouse space
Cold stores can be cost effectively used as a substitute for glasshouse space, depending upon the plug tray stack height on the trolley in the cold store.

Use of the cold store for seed germination and dormant plant storage
Increases in the germination level of primrose by only 7% can recoup the cost of using a cold store for this purpose in seed cost alone.

A literature review was undertaken as part of HDC project PC 196. This contains detailed calculations on each of the points discussed above.

Facilities required

There are two kinds of cold storage facility suitable for the storage of bedding plant plugs. The first is a refurbished/modified refrigerated lorry body (which can be purchased or leased), the second is some kind of purpose built facility.

The advantage of the first is that it is relatively inexpensive to buy or lease, but the cooling system used in it can produce a vigorous airflow that can have a severe drying effect on plant material in store. Purpose built stores on the other hand are expensive to construct, but cooling systems can be installed in them that produce environments more suited to the storage of living plant material.

Any store used must be equipped with accurate temperature control to permit temperatures around 4ºC to be held without the risk of freezing.

Examples of companies supplying refrigerated lorry bodies – Grenco Articstore, Oliver Road, West Thurrock, Essex (www.grenco-articstore.com) and Seven Asset Management, Cardinal Court, 35-37 St Peters Street, Ipswich, Suffolk (www.sevenasset.co.uk).

Fig 2 Modified refrigerated lorry body suitable for low temperature storage of bedding plant plugs – inexpensive to install but can dry plant material depending upon the speed of air movement in store

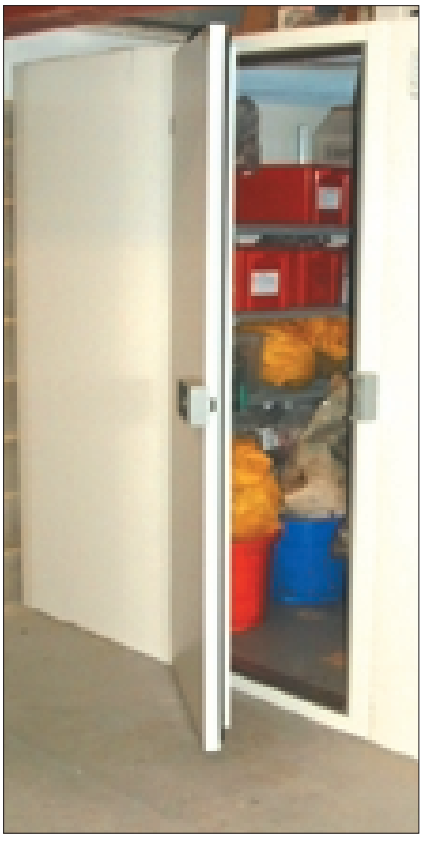


Fig 3 Purpose built cold store – expensive to construct but generally more suited to the storage of plant material

Storage conditions

To maximise the storage period of plug plants and minimise any loss of plant quality during storage, the following parameters need to be carefully considered.

Temperature

A store temperature of 4ºC appears to be the best average option for the storage of a range of mixed summer bedding plant species. Higher temperatures (8ºC and above) are required for the longer term storage of tender plant species that suffer chilling injury (primarily impatiens), whilst slightly lower temperatures around 3ºC appear more suitable for autumn bedding plant species (pansy, viola and primrose). Optimum storage temperatures for a range of bedding plant species were determined from research work carried out in America in the mid 1990's, a summary of this information is presented in Table 1.

If the temperature is set too low during storage chilling injury may result, if the temperature is set too high growth may continue in store with a corresponding reduction in plug quality.

Table 1 Optimal storage temperatures for a range of bedding plant species

Species	Optimum storage temp ºC	Species	Optimum storage temp ºC
Ageratum	7.5	Lobelia	5.0
Alyssum	2.5	Marigold (French)	5.0
Begonia (fibrous)	5.0	N G Impatiens	12.5
Begonia (tuberous)	5.0	Pansy	2.5
Celosia	10.0	Petunia	2.5
Cyclamen	2.5	Portulaca	7.5
Dahlia	5.0	Salvia	5.0
Geranium	2.5	Verbena	7.5
Impatiens	7.5	Vinca	10.0

Airflow and humidity levels

Air movement within the store needs to be sufficient to prevent the development of high humidities that may encourage foliar diseases such as grey mould (*Botrytis cinerea*) to establish on plant material. However, the airflow rate should not be overly vigorous as this can lead to plug plant desiccation and necessitate the frequent watering of plant material in store. Any air movement around the plants will be determined by how full the store is with trolleys and how the trolleys are orientated relative to the airflow.

Fig 4 Avoid botrytis infection of plug plants by ensuring air movement within the store is sufficient to prevent the development of high humidities

Light source

A low level of continuous light (sufficient just to read by) can help maintain plant quality in store and extend the viable storage period for some species. A light source can help to keep plants 'greener' and prevent stretching, especially if plant material is being stored for longer periods of time. A light source from tubular fluorescent bulbs is more suitable than tungsten bulbs.

Level of watering

The level of watering applied to the plug plants during storage will be determined by the environment in the cold store. Plugs should be inspected at least weekly and irrigation may also be required on a weekly basis.

Ensure no other plant material is kept in the cold store along with the plug plants. For example, ripening fruit gives off ethylene gas that can have a serious impact on plant quality even when present in minute amounts. Good store and trolley hygiene are also essential to minimise disease carry over between crops in store.

Low temperature storage periods

Wherever possible the storage period should be kept to a minimum in order to reduce any potential loss of quality (usually increasing levels of leaf paleness and stem and leaf petiole stretching) and avoid possible plant death post-transplanting (for example in the case of nemesia, dahlia and salvia). Species that are susceptible to chilling injury such as impatiens, celosia etc should be stored for the shortest period possible.

HDC trial results

The HDC funded trials PC 196 and PC 196a examined the potential to store a range of summer and autumn bedding plant species in both a purpose built cold store and in a modified refrigerated lorry body. Maximum storage periods were determined for plugs that could be sold on as commercial young plant material (very little quality deterioration) and plugs that could be transplanted on to produce a finished crop (quality deterioration noted, but the plugs were still usable).

Short term storage

Most bedding plant species examined could be stored for up to 7-14 days at 4ºC with minimum loss of quality. Storage periods in excess of 7 days however, generally resulted in paler plugs relative to those stored in the glasshouse. This paleness usually lasted for a number of days post-transplanting but the plants eventually 'coloured up' and made a good quality finished product. Stem and leaf petiole stretching also resulted with longer-term storage periods, especially at higher temperatures, but a low level of light helped to minimise this.

Long term storage

Several plant species including begonia, antirrhinum, lobelia, pansy and viola were stored for 3-4 weeks and were still usable as plug plants.

Extended storage periods were also easily achievable with primrose plugs and in all cases plugs were still usable even after 16 weeks of storage at 4ºC. However, in the case of some plant species (impatiens, nemesia, dahlia, salvia and to an extent marigold) storage periods in excess of 2-3 weeks had a deleterious effect on plant quality post-transplanting, sometimes resulting in plant death.

The results showed that low temperature storage not only halted vegetative growth but also flower development in plugs. However, once the plugs were removed from storage and exposed to natural daylight flower development proceeded as normal.

Table 2 Maximum low temperature storage periods for a range of bedding plant species

Species	Commercial plug quality (days)	Usable plug quality (days)	Storage temperature
Alyssum	7	14	4ºC
Antirrhinum	14	21-28	4ºC
Begonia	14	21-28	4ºC
Dahlia*	7	21	4ºC
Geranium	7-14	28	4ºC
Impatiens*	0-7	0-7	4ºC or 8ºC
Lobelia	14	28	4ºC
Marigold	14	21-28	4ºC
Nemesia*	7	14	4ºC
Pansy	14	28	4ºC
Petunia	7-14	21-28	4ºC
Primrose	28	56	4ºC
Salvia*	7	21	4ºC
Verbena	7-14	21	4ºC
Viola	14	28	4ºC

Notes:

*** Chilling injury and post-transplanting losses were noted with these species. In most instances a light source was not used during storage.**

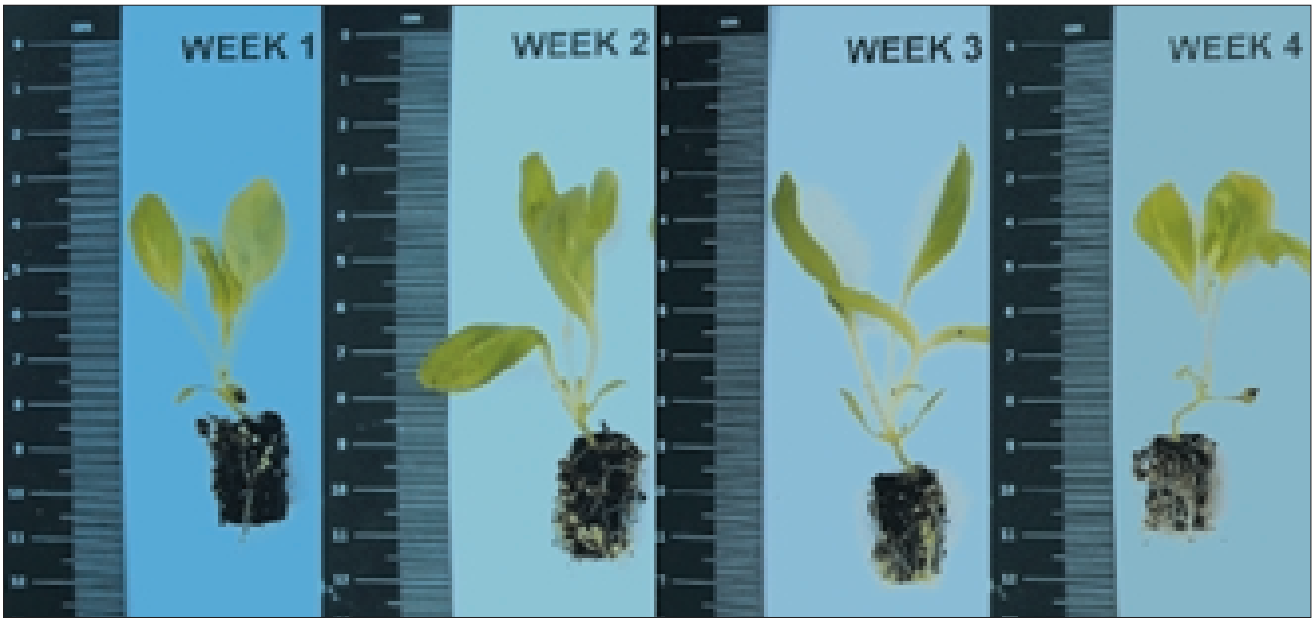
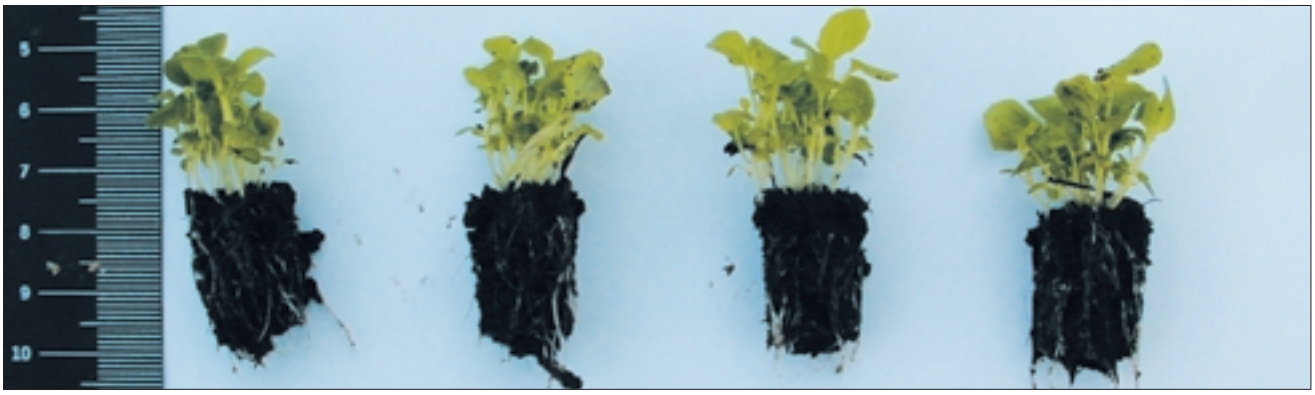


Fig 5 Leaf petiole etiolation in nemesia plugs stored for up to 4 weeks at 4ºC – this may be prevented by use of low level lighting



a

b

c

Fig 6 Lobelia plugs after 2 weeks in storage at 4ºC (a) and then 1 week following transplanting (b) and 3 weeks following transplanting (c) demonstrating normal development was not impeded by cold storage

Plant care before, during and after low temperature storage

Any plug plant material selected for storage must be of high quality. Plugs should be watered before storage, but foliage must be dry before the plugs are placed into store.

The correct store environment and good store hygiene between crops should minimise disease development, if however foliar diseases become an issue during storage then the plugs plants should be treated with a protectant fungicide such as chlorothalonil or azoxystrobin (SOLA 1684/01) prior to storage.

Plants should be regularly inspected for quality and moisture status whilst in store and irrigated as necessary.

For longer-term storage over several weeks consider liquid feeding the plants.

Shading cold stored plugs for a number of days post-transplanting (especially on bright days) reduces plant stress and aids more rapid establishment.

Problems associated with low temperature storage

Low temperature chilling injury can be a problem on plugs in storage. Chilling injury can be expressed by plugs in store as leaf tip or growing point death or even death of the entire plug. However, chilling injury symptoms may not be expressed immediately in store and symptoms may not become evident until post-transplanting when plugs begin to die.

Fungal diseases can develop on the plugs in store as a result of poor quality plugs being selected for storage or chilling injury occurring in store. Higher storage temperatures (8ºC plus) and the build up of humidities within the store will encourage the development of such diseases. Grey mould (*Botrytis cinerea*) tends to be the most prevalent disease, but other diseases such as *Sclerotinia sclerotiorum* (on alyssum and marigold for example) have also been noted.

If airflows are too vigorous within the store then plug desiccation can result, usually around the edges of smaller cell plug trays (for example 405 plug trays). Each plant species will vary in its susceptibility to desiccation depending upon factors such as plant size, leaf area and shape etc. Once dry, the growing media in the plug tray can be difficult to re-wet.

Fig 7 Chilling injury in impatiens plugs – avoid storing susceptible species below 8ºC

Future potential for plant scheduling using low temperature storage

Evidence suggests there is good potential for the longer-term low temperature storage of bedding plant plugs to meet specific marketing targets. PC 196 examined the storage of a range of summer bedding plant species over a 4 week period, PC 196a however, was designed to test the storage life of pansy, viola and primrose plugs over a 16 week period.

It was envisaged that if plugs could initiate flower buds prior to low temperature storage, then plants could be removed from store sequentially and brought into flower relatively irrespective of the growing conditions post-transplanting.

Although the plugs stored well, an inability of the pansy plugs to make finished flowering plants through December and January and an increasing level of blindness in the finished primrose plants indicated that the plugs had not initiated flowers prior to storage.

Further work is still required to examine the possibility of 'pre-conditioning' plugs to flower prior to storage. If this can be achieved low temperature storage will be an important scheduling tool for both plug and finished bedding plant producers.

Fig 8 Primrose 'Quantum Blue' plugs after 12 weeks of storage at 4ºC – the plugs stored well but blindness was a problem

Summary

General recommendations

- A storage temperature of 4ºC is appropriate for most summer bedding species, 3-4ºC for autumn species. Avoid temperatures near/below 0ºC
- Limit storage of species prone to chilling injury (impatiens, celosia etc) or store at a higher temperature (8ºC plus)
- Ensure plugs are of a high quality before storage. Plugs should be watered but foliage must be dry prior to placing in the store
- Check store temperatures and accuracy of average temperature achieved on a regular basis
- Ensure good air movement to reduce humidity and keep diseases in check, although bear in mind too vigorous an air movement can cause plug desiccation
- Use a low level of fluorescent lighting to prevent plant etiolation especially for longer term storage
- Check plugs in store weekly for quality and signs of disease/ desiccation. Apply fungicide sprays/irrigate where necessary
- Ensure good store hygiene to minimise disease carry over between batches of plants
- Provide shade post transplanting especially on bright days to aid acclimatisation and plant establishment.

Short term storage

Useful to hold back plugs as a result of logistical problems during production

- Up to 1-3 days storage period
- Avoids the need to unload/load trolleys or leave material on trolleys under glasshouse conditions
- Avoids taking up valuable glasshouse production space
- Minimises any loss in plug quality.

Medium term storage

Useful to hold back plug material to meet peak demand weeks or extend the season of availability.

- Up to 7 days for many species, possibly longer with several species (lobelia, primrose, pansy etc)
- Maintains plug quality without stressing plugs or using plant growth regulators
- Avoids using glasshouse production space.

Long term storage

Useful to hold back plugs over many weeks with the potential to schedule production of finished plant material.

- Up to 2-3 weeks with summer bedding (lobelia, antirrhinum, begonia etc)
- Up to 16 weeks with autumn bedding (primrose)
- Potential to target specific marketing periods
- Extends the season for plugs and finished plants.

Additional notes

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Further information
A full copy of the final reports for HDC projects PC 196 and 196a are available from the HDC office (01732 848383)

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