Did your bedding plant plugs come on too fast last spring? You might want to try to . . .

Store Plugs at Low Temperatures

by NATHAN LANGE, ROYAL HEINS, and WILL CARLSON

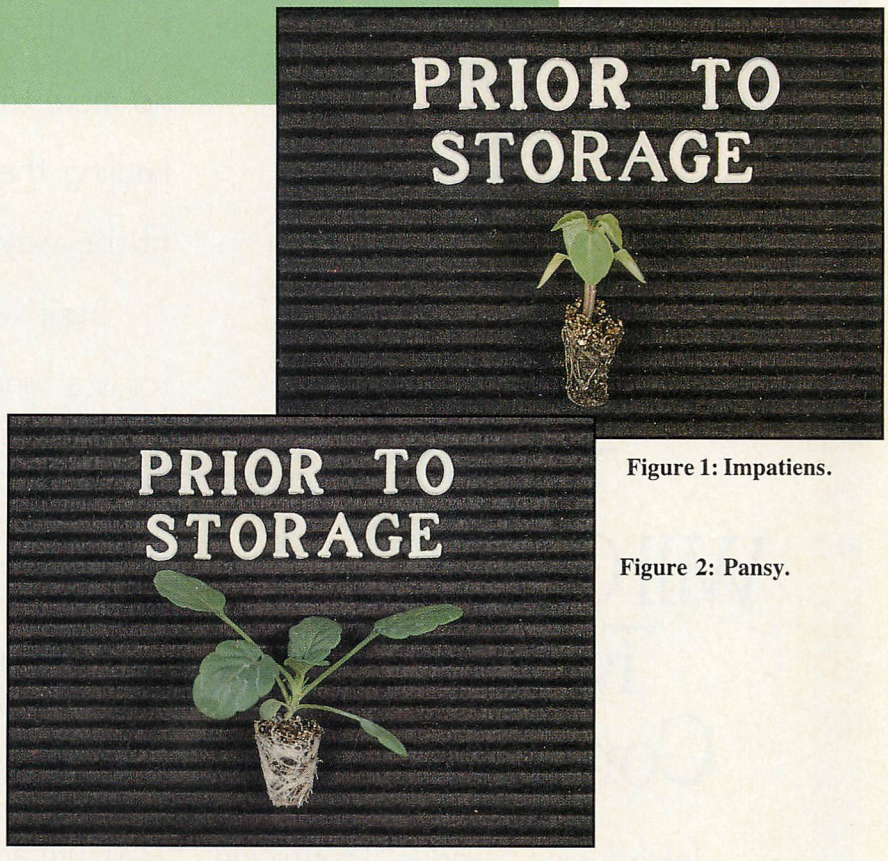


Figure 1: Impatiens.

Figure 2: Pansy.

MOST bedding plant seedlings are now produced as plugs. Under ideal conditions, seeds are germinated and plants are transplanted when they reach the correct size.

Unfortunately, plugs are often ready for transplanting before growers are ready to transplant them. When this occurs, growers must slow or delay growth of the seedlings until they can be transplanted.

There are some traditional methods of slowing plug growth, including water and nutrient stress and growth regulator applications. These methods stress the plugs, however, and have the potential to slow and delay plant growth after transplanting. If the plugs are held in a greenhouse, valuable bench space is often taken for extended periods of time — and any extra time a plug sheet spends in the greenhouse decreases overall production and total profits.

One alternative to the use of stress to hold plugs is the use of low temperature. Low temperatures can be used in the plug production area but the low temperature slows development of all plants, whether they need it or not. Moving the plugs to another location at low temperature solves the problem of slowing all plants.

Alternative areas include another greenhouse, walkways, the headhouse, and a cooler. These areas will likely have very different light and temperature conditions; therefore, it is important to understand how holding plugs under different light and temperature conditions will affect growth of the seedlings after transplanting.

Additionally, if feasible, holding or storing plug sheets in a cooler or reefer offers many opportunities for

better plug scheduling management. While a grower may wish to just "hold" some plugs for a few days until transplanting, actual storage of plugs for several weeks may also be desired. We use the word "storage" to refer to both short- and long-term holding of plugs at low temperature.

Many questions about temperature, light requirements, and growth after different storage periods need to be answered before considering plug storage. You might be tempted to ask: "What is the best combination of temperature and light for storing plugs at low temperatures?"

There is an ideal combination — but equally important are the consequences of storing plugs under non-optimal conditions. Growers may wish to store different species with different storage requirements in the same cooling facility. In that case, a compromise will have to be made.

In addition, a warmer temperature than the optimum may be more cost effective if only short-term storage is necessary.

These and other management decisions require an understanding of how different species perform under a wide range of storage conditions.

The objective of our research was to determine how long plugs could be stored satisfactorily under different temperature and light combinations without affecting adversely growth and forcing time after transplanting.

This article discusses research results on impatiens and pansies. Next month, we will describe results on geraniums and petunias.

How We Did It

Twenty-five plug sheets (406 size) of 'Accent Orange' impatiens were obtained from a commercial grower when plugs were at a transplantable stage (see Figure 1). These plants were held in a glass greenhouse at 68°F for 1 week prior to the start of the storage treatments to remove any possible side effects from shipping.

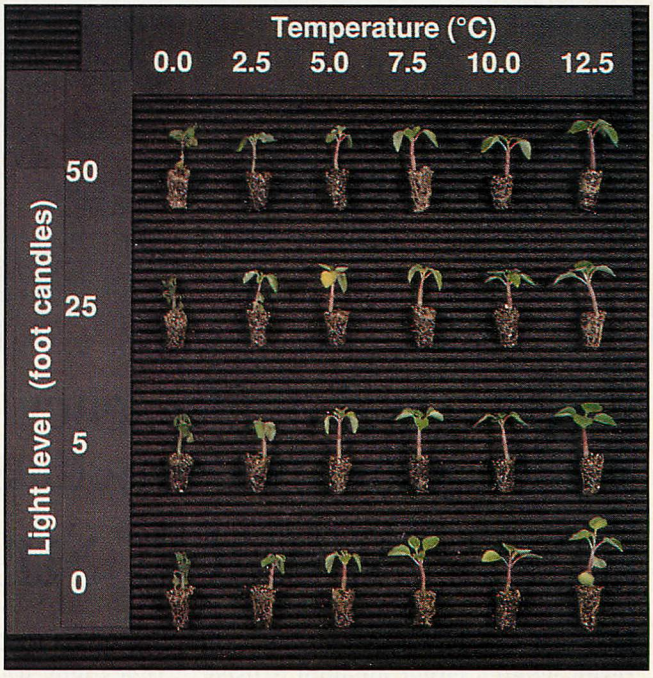
On February 28, 1990, one plug sheet was placed at each of 24 different temperature and light level combinations. Temperatures were 32°, 36.5°, 41°, 45.5°, 50°, and 54.5° F. Light levels were 0, 5, 25, and 50 footcandles. Light levels were provided by cool white fluorescent bulbs with a photoperiod of 24 hours per day. Darkness (0 footcandles) was provided by placing a plug sheet in a closed cardboard plug shipping box.

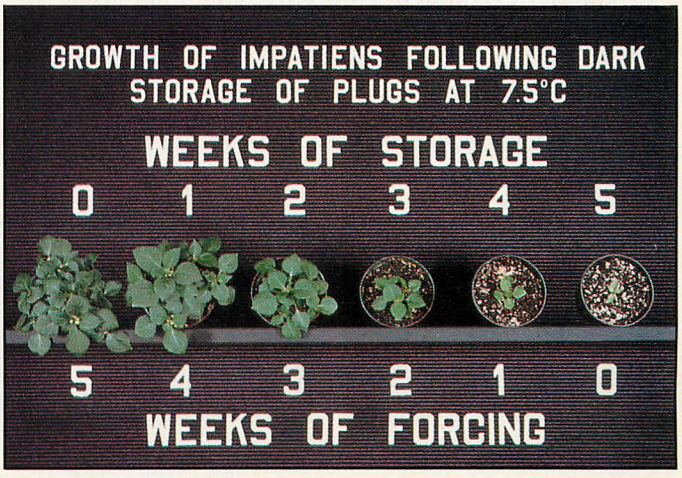
Ten representative plants were removed from each plug sheet of each temperature/irradiance treatment after 1, 2, 3, 4, 5, and 6 weeks. A representative plant from each treat-

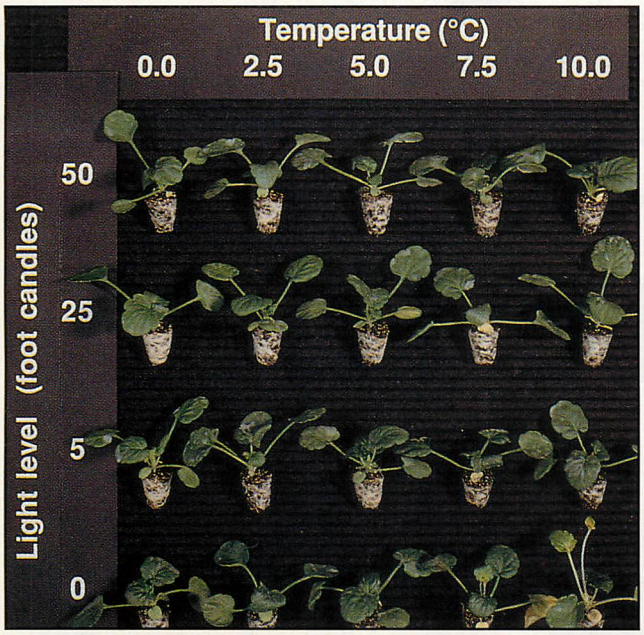
Figure 3 (right): Appearance of impatiens plugs immediately after storage for 3 weeks.

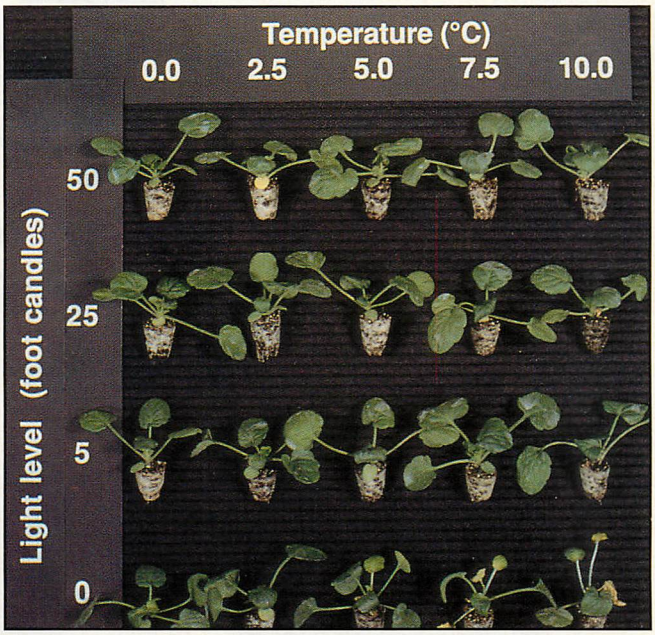
Figure 4 (below, left): Impatiens plugs after storage for 6 weeks.

Figure 5 (below, right): Growth of impatiens plugs after storage of 0-5 weeks at 45.5°F in the dark and 5-0 weeks of greenhouse forcing, respectively.









ment was used for a photograph and all plants were then potted in 4-inch pots using a commercial soilless mix. The plants were forced into flower in a glass greenhouse with a minimum temperature of 68°F.

We recorded the date of first flower for each plant surviving storage. We also determined the average number of days from the start of forcing until first flower and the percentage of plant survival for each treatment.

Rating the Treatments

We then rated the storage treatments as satisfactory or unsatisfactory. Satisfactory storage treatments had no more than one out of 10 plants die after storage and plants did not exhibit a delay in flowering of more than 5 days compared to control plants, which were potted directly — without any storage.

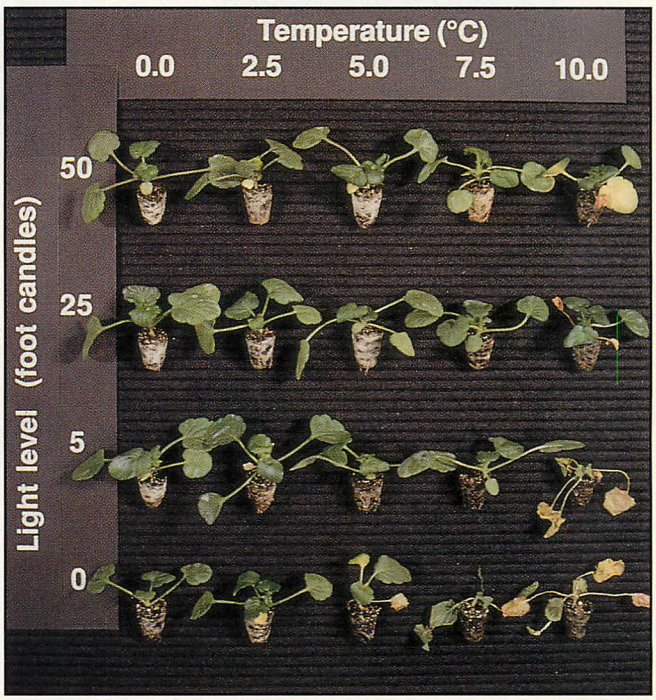
'Majestic Yellow' pansy plugs (see Figure 2) were treated in the same manner as the impatiens plugs, with the following exceptions: Size 406 plug sheets were placed into storage treatments on April 3, 1990 and plants were removed after 2, 4, 6, 8, 10, 12, 14, and 16 weeks of storage. Pansy plugs were not stored at 54.5°F.

All plugs were subirrigated with clear water as needed during storage. We used clear water because the plants' nutritional needs are minimal under lower temperatures.

Figure 6 (above, left): Appearance of pansy plugs immediately after storage for 4 weeks.

Figure 7 (above, right): Pansy plugs after storage for 8 weeks.

Figure 8 (right): Pansy plugs after storage for 16 weeks.



The frequency of irrigations varied from 2 to 10 days, depending on the temperature treatment and relative humidity of each cooler. Contact between the foliage and water was minimized to avoid any possible fungal infection.

The Results

Impatiens and pansy plugs differed in their response to storage temperature. For instance:

- Impatiens plugs were far less tolerant of temperatures below 45.5°F than pansy plugs.
- Storing impatiens plugs at 32°F for even 1 week resulted in 100% plant death.
- Storing impatiens at 36.5°F for more than 2 weeks or 41°F for more than 3 weeks resulted in severe chilling injury and subsequent plant death regardless of irradiance (Table 1).

Chilling injury is defined as damage to plants by low temperatures

Table 1. Impatiens

Foot Candles	TEMPERATURE (°F)					
	0	36.5	41	45.5	50	54.5
0	0	2	3	6	5	4
5	0	2	3	6	6	6
25	0	2	2	6	6	6
50	0	2	2	6	6	6

Table 2. Pansy

Foot Candles	TEMPERATURE (°F)				
	0	36.5	41	45.5	50
0	16	16	14	10	6
5	16	16	16	16	10
25	16	16	16	16	16
50	16	16	16	16	16

Acceptable durations (weeks) of plug storage at different temperature and light combinations in MSU experiments.

above freezing. Interestingly, impatiens satisfactorily tolerated 3 weeks of storage at 36.5°F in the dark and at 5 footcandles, but not at the higher irradiances of 25 and 50 footcandles.

How Cold Could They Go?

The coldest temperature that impatiens plugs could tolerate beyond 3 weeks without chilling injury was 45.5°F. Impatiens satisfactorily tolerated 6 weeks storage at 45.5°F at all light levels, including darkness.

The longest satisfactory duration impatiens plugs could be stored in the dark at 50°F and 54.5° F was 5 and 4 weeks (respectively). Storage at 54.5°F for more than 4 weeks in the dark delayed flowering. Impatiens plugs could be stored for up to 6 weeks without delay in flowering if they were exposed to as little as 5 footcandles of light during storage.

Figures 3 and 4 show the appearance of the impatiens plugs at all temperature and light combinations immediately following 3 and 6 weeks of storage (respectively). Figure 5 shows the appearance of impatiens plants grown from plugs stored at 45.5°F in the dark for 0-5 weeks and forced for 5-0 weeks.

Pansies Are More Tolerant

Pansy plugs are more tolerant of temperatures below 45.5°F than impatiens. Unlike impatiens plugs, chilling injury was not observed on any of the pansy plugs.

Pansy plugs satisfactorily tolerated 16 weeks storage at 32° and 36.5°F at all light levels, including darkness (see Table 2).

Satisfactory storage time in the dark decreased to 14, 10, and 6 weeks as the temperatures increased to 41, 45.5, and 50°F (respectively). Pansies were satisfactorily stored 16 weeks without delay with light levels of 5 footcandles at 41° and 45.5°F and 25 footcandles at 50°F.

Figures 6, 7, and 8 show the appearance of the pansy plugs at all temperature and light level combinations immediately following 4, 8, and 16 weeks of storage.

Catch 22: Botrytis and Impatiens

While Botrytis was a major problem in storing impatiens plugs at cool temperatures, it did not affect pansy plugs.

Botrytis can be limited by maintaining a low relative humidity during storage. However, low humidity causes plugs to dry out quickly. Maintaining a high relative humidity in a cooler decreases the frequency of watering, but the humidity simultaneously favors the rapid spread of Botrytis.

Be aware of this "Catch 22" dilemma before you implement a plug storage program in a cooler — especially if irrigation may prove to be difficult.

We currently do not have sufficient experience with different fungicides under storage conditions to know if they will adequately control Botrytis under high humidity conditions during extended storage. Therefore, we are currently recommending that impatiens plugs be stored under low humidity conditions. Even so, make appropriate applications of fungicides before storage to ensure Botrytis growth does not become a problem.

Moving to Warmer Conditions

Moving the plugs from a cool storage environment to a warm, high light greenhouse has not been a problem for us as long as the plugs were moist when they were placed in the warm environment.

In one trial set up to simulate extreme conditions, we placed pansy seedlings that had been stored for 3 weeks at 36.5°F directly into a sunny glass greenhouse set at 100°F. There was some leaf damage on the seedlings at the edge of the plug sheet, which were dry and wilted rapidly. Seedlings in moist plugs did not wilt and showed no damage.

We suggest warming the plugs for a few hours in a low light, moderate temperature (60°-70°F) environment. Irrigate if plugs are to be placed into an especially bright, hot environment.

Use Storage as a Management Tool

The results from these experiments suggest there is great potential in storing bedding plant plugs in coolers instead of holding them in the greenhouse. Plug storage could be used as a management tool to help your operation be more successful. **GG**

About the author: Nathan Lange is a master's degree candidate and Drs. Royal Heins and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824. This research was funded in part by the Western Michigan Bedding Plant Association, the Fred C. Gloeckner Foundation, and the American Floral Endowment. Impatiens plugs were supplied by De Winter Greenhouses, Hudsonville, MI, and pansy plugs by Glass Corner Greenhouses, Grand Rapids, MI.