Herbaceous Perennials

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Introduction

Herbaceous (nonwoody) perennials are a diverse group of plants grown primarily for their ornamental value in gardens throughout the world. Storage of herbaceous perennial plant material may be required at several steps during the production and marketing of the final product, which is often a containerized flowering plant for retail sales. Some herbaceous perennials such as strawberry, rhubarb, potato, and asparagus are grown as food crops, but the storage of their underground organs is discussed separately in this handbook. Many herbaceous perennials have succulent stems and leaves that, in cold or dry climates, die back in fall to an overwintering crown or root structure, while others cease growth but do not go dormant in response to inclement weather.

Herbaceous perennials include species in just about every plant family and vary greatly in adaptability, growth patterns, and tolerance to heat and cold. In fact, it is the great diversity that presents the most problems, including that of postharvest storage. Some nurseries carry hundreds if not thousands of species, and methods of production vary greatly.

Storage of Bare-Root Crowns

Seedlings, rooted cuttings, or divisions can be field-planted, grown, and harvested as bare-root (crowns and roots with soil removed) plants in fall. Storage of the bare-root plants is convenient, since they can be trimmed, processed, and packaged during winter when harvest may not be practical because of snow, ice, or rain. Throughout winter and spring, bare-root plants are removed from storage and shipped to wholesale and retail nurseries.

Grower experience and research results have established that many hardy herbaceous perennials will retain excellent regrowth quality after several months of storage when properly packed to control moisture loss and stored at -2 °C (28 °F) (Walters 1983). Mahlstede and Fletcher (1960) published an excellent and comprehensive summary of the requirements for storage of nursery stock (unfortunately out of print).

Field Conditions and Harvesting of Bare-Root Crowns

Rain and excess moisture in the field can cause serious problems during storage, particularly if any free water from the harvested plants is not removed before storage. Crowns and roots can be difficult to dry and can quickly develop surface molds and rots. Many growers prefer to grow plants on sandy soils so that harvesting is interrupted as little as possible during wet periods (Walters 1983).

Field-grown herbaceous perennials should be harvested after the crowns are fully mature for optimum storage success. Peony, iris, mertensia, and poppy can be harvested even before the first freeze, since they tend to mature early in the fall. However, many other hardy herbaceous perennials enter dormancy later in the season or not at all and should be harvested as late in fall as possible for best storage success (Mahlstede and Fletcher 1960, Hanchek and Cameron 1995). For most hardy herbaceous perennials, sugars and nutrients accumulate in the roots, crowns, and other underground organs, while leaves and above-ground tissues senesce in response to short days, low temperatures, or both in a process similar to that in potato, sugar beet, and certain other edible herbaceous perennials.

If harvested before complete maturation, bare-root plants will have a much shorter storage life because of various factors such as incomplete carbohydrate accumulation, insufficient suberization of the roots and crowns, lack of overwintering buds, and ultimately the development of molds and rots (Hanchek and Cameron 1995). In practice, however, growers often harvest prematurely in fall, especially in northern regions, since snow can quickly end the harvest season. Growers must accept the extra risk of reduced storage life imposed by the earlier harvest.

When possible, plants should be harvested after tops have at least begun to die back, often after the first hard freeze. Some species never really go dormant and do not completely die back to the ground except in the coldest of winters. In some instances, the tops can be cut with a rotary mower to remove excess leaves and stems before harvest to reduce postharvest cleaning and grading and potentially increase storage success. However, most species that do not attain full dormancy are difficult to store for long periods, since many have wounded green tops with a high respiration rate, fibrous roots, and insufficient carbohydrate storage reserves. Also, the more green tissue removed, the more likely that the crowns are not fully mature.

Classification of Perennials by Root Characteristics

Mahlstede and Fletcher (1960) suggested several categories of perennials based primarily on structural or physical characteristics of the overwintering underground structures. Considering the diversity of herbaceous perennials, the overwintering root structure can provide one additional piece of information that can be used to develop storage recommendations.

Greentops are one group of herbaceous perennials that overwinter with at least some above-ground leaf and stem tissue remaining. Green tissue increases the storage difficulty for a great percentage of the plants in this category. Difficult-to-store greentops include ajuga, arabis, alyssum, creeping phlox, coreopsis, dianthus, and gaillardia.

Numerous difficult-to-store herbaceous perennials have fibrous roots. During the natural cycle of growth, it is not uncommon for plants to recycle fibrous roots, meaning that most small roots die during winter and are replaced the following spring as growth commences. The dead and dying roots do not usually create problems outdoors but can feed numerous surface molds while in storage. The molds are unsightly and can lead to loss of product (Hanchek et al. 1990). Fungicides are seldom used to control molds, in part because of the great diversity of plant types and sensitivity.

Some herbaceous perennials such as *Dicentra spectabilis* (bleeding hearts) have more specialized crowns and roots. These enlarged roots hold substantial food reserves and can be successfully stored for several months when harvested mature. However, when harvested immature, bleeding hearts are very susceptible to surface molds (Hanchek et al. 1990). In many respects, this process is similar to maturation and storability of potato tubers.

Postharvest Grading and Packaging

Ideally, harvested roots and crowns should be processed, packed, and immediately cooled for long-term storage. In practice, herbaceous perennials are often harvested in fall faster than they can be processed. Crowns, roots, and remaining above-ground tissue are rapidly respiring immediately after harvest because of wounding, and to prevent fermentation it is critical to keep plants cool and to provide adequate ventilation for the tissue. Initial plant temperature depends on soil and air temperatures during harvest. Harvested plants should be quickly cooled to 0 °C (32 °F) to reduce respiration and moisture loss, though precooling seldom occurs in practice. Temperatures of harvested material should be monitored closely with hand-held or automated thermometers. There is a real possibility of fermentation when O_2 movement is restricted in large piles or tightly packed crates of plants, particularly those with green tops or fibrous root systems. If temperatures rise in stacks of plant material, then it is critical to add refrigeration, improve ventilation, or both.

Excess green tissue is usually removed during grading, and plants may be cut into smaller divisions for propagation. The wounds caused during division can be a source of subsequent infection if not properly healed before storage. Even typically easy-to-store plants such as hosta and daylily can be lost during long-term storage because of fungal and bacterial wound infection. Conditions favoring wound healing could be useful for these crops after grading. No studies have been published on wound healing of harvested herbaceous perennials, but wound healing and suberization of potato tubers occurs most rapidly at 15 to18 °C (60 to 65 °F) and <90% RH.

Packaging depends on the intended means of storage. Unsealed polyethylene liners (1.5 to 3 mils thick) are used for -2 °C (28 °F) storage. At below-freezing storage temperatures, these liners permit O_2 movement adequate to supply the needs of respiration and protect against water loss (Cameron 1988). These same liners can lead to fermentation and loss of product at higher temperatures, since they may limit air movement to such an extent that the supply of O_2 can not meet the increased demands of respiration. Many herbaceous perennials are packaged in multiples of 25 with the liners in a cardboard box ready for shipping later in the season. It is important to match box size to crown size since overpacking can also lead to fermentation and loss of product, particularly for plants with green tops, fibrous roots, or both. Wood fibers or other dry fillers (such as shredded paper) should be added inside the polyethylene liner to absorb free moisture (condensation etc.) and improve gas exchange inside the package.

In some cases, bare-root plants are stored in bulk bins (often the same as bins used for storage of apples). Although appropriate for some otherwise difficult-to-store plants, bulk bins can lead to problems if extra care is not taken to ensure that the entire contents are cooled quickly. Temperatures at the center of the bin need to be monitored closely, especially for the first 2 to 3 weeks. Heating, fermentation, and eventually decay will start at the middle of the piles. Boxes, crates, or bins should be placed into cold storage in rows that maximize air movement and cooling rate. They can be restacked closer together after they reach storage temperature.

Optimum Storage Conditions

The optimum storage temperature for most hardy herbaceous perennials is between -2.8 and -2.2 °C (27 to 28 °F) (Mahlstede and Fletcher 1960, Maqbool and Cameron 1994). At these temperatures, tissues are generally not frozen, and respiration and water activity are minimized. However, not all herbaceous perennials can withstand subfreezing temperatures, and the following are best stored at 0 to 2 °C (32 to 34 °F) (Mahlstede and Fletcher 1960, Maqbool and Cameron 1994): aconitum, agapanthus, althaea, anchusa, aentranthus, helleborus, hibiscus, malva, shasta daisy.

Some perennials have very poor regrowth following storage, regardless of pretreatments and storage conditions, and are best overwintered as potted plants. These plants, such as gaillardia and coreopsis, can be stored as small containerized plants packed into polyethylene-lined boxes up to several months. Hibiscus, alcea, sidalcea, and other malvaceous plants are sensitive to low temperature storage, even in minimally heated greenhouses. Short-term storage of these genera should be at warmer temperatures. Herbaceous perennials considered very difficult to store for extended durations (Mahlstede and Fletcher 1960) are alcea rosea, anemone, anthemis, asclepias, clematis, coreopsis, epimedium, gaillardia, helleborus, hibiscus, lavender, lithospermum, malva, primula, sidalcea.

Problems During Storage of Bare-Root Perennials

Some herbaceous perennials are difficult to store as bare-root plants for extended periods. Even closely related plants can have different overwintering capacities. Much depends on the species, overall plant vigor, and size in the field before harvest. Problems encountered during storage of bare-root plants include development of rots and surface molds, desiccation, and growth of fragile buds after the dormancy requirement has been met. Each of these problems increases with storage duration and temperature. Hourly or daily temperature fluctuations can increase tissue desiccation, condensation on the package, and ultimately surface molds and rots, so it is important to maintain constant temperature into spring.

Molds and bacteria can establish on dead roots or wounded tissue early during storage, especially if plants are not cooled rapidly. Some surface molds do not seriously harm the regrowth capacity of the crowns (Maqbool and Cameron 1994). However, they are unsightly and often cause rejection of a shipment, which can represent a substantial loss of revenue, considering the time and effort spent producing and storing the plants up to the time they are sold. Molds are invariably more severe at elevated temperatures or when there is significant condensation, particularly if packages are poorly ventilated or stacked without sufficient air circulation. Free water must be absorbed or it will increase mold and rot development. Limited trials with fungicides for control of surface molds have been inconclusive (Hanchek et al. 1990).

Bud-break can occur on many perennials such as asters, shasta daisies, geums, lupines, bleeding hearts, and astilbes kept at 1 °C (34 °F) after their dormancy requirement has been satisfied. New growth is usually etiolated and extremely fragile (Maqbool and Cameron 1994). Bud-break can occur during shipping, since lack of temperature control is common. Astilbes and bleeding heart, often shipped from the Netherlands, commonly have new shoot growth in the packages, presumably because of long shipping times at elevated temperatures. Storage temperatures below 0 °C (32 °F) completely prevented bud-break for all herbaceous perennial species tested (Maqbool and Cameron 1994). In some instances, refrigerated storage facilities do not have adequate cooling capacity, so temperatures can rise in spring as the cooling requirement increases. Premature bud-break can be a serious problem in these storage facilities.

Storage of Herbaceous Perennials in Plug Trays

There has been a complete transition in herbaceous perennial production over the past two decades. Most herbaceous perennials are now propagated, from either seeds or cuttings, in plug trays with anywhere from 32 to 516 small plugs (one plug is an individual cell with one plant) per 30×60 cm (12×24 in) tray by using techniques borrowed largely from the bedding plant industry. The shift to plug production has been hastened by improved uniformity of seed-propagated herbaceous perennials and increased demand for large numbers of plants. Typically, plugs are finished within 6 to 12 weeks of seeding or placement of the cutting. Producers often sell their product to finishers—greenhouse growers who pot plugs into larger containers and grow them for retail sale. Traditionally, plugs are purchased and containerized in fall, and finished plants are sold the following spring or summer.

When started from seeds or cuttings, many young herbaceous perennial plants require a period of cold, or vernalization, before they can achieve optimum regrowth potential (Whitman et al. 1996, Runkle et al. 1998). A cold period of 10 to 15 weeks may be needed to fulfill the vernalization requirement for some herbaceous perennials (Whitman et al. 1996), though 6 to 8 weeks is more common (Cameron et al. 2000). The cold requirement is delivered to containerized plants in overwintering greenhouses with supplemental heating to prevent severe cold damage. Bedding plants are sometimes stored as plugs, though most traditional bedding plants do not have a cold requirement. It is becoming increasingly common to store plugs at low temperatures to economize on the amount of controlled temperature space required. Plugs can be stored for convenience (as when the finish date precedes the marketing date) or to provide a physiological requirement for subsequent flowering. Cooled plugs can be sold at a premium price when there is no need for further cooling.

Many species of perennials can be stored as plugs for more than 3 mo at 5 °C (41 °F), but only when provided with sufficiently intense light to perform photosynthesis. Photosynthesis supplements carbohydrate supplies, which can be depleted during storage, particularly in small plugs. Engle (1994) studied storage of plugs at -2.5 °C (28 °F) in a manner analogous to that described for bare-root plants. Plug trays were packed in polyethylene liners and stored in the dark without any additional water. Many perennial species grown as plugs did not survive direct transfer from the greenhouse to subfreezing temperatures. However, 3 to 6 weeks of hardening at 0 or 5 °C (28 or 41°F) improved storage success for many. As for bare-root storage, plugs with significant green tissue were more difficult to store.

Several growers are experimenting with plug storage under controlled conditions, though most storage still takes place in minimally heated greenhouses. If growers rent storage facilities, they should ensure that refrigeration capacity is adequate to reduce storage temperatures to at least 2

°C (35 °F). Insufficient cooling will increase respiration and plant demand for photosynthetic light. Lighting the plugs will improve success.

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