Floral and Nursery Stock

Revised 2024

Storage Conditions for Floral and Nursery Stock

	Storage Temperature		Approximate Storage Life	Highest Freezing Point	
	°F	°C		°F	°C
Major Cut Flowers					
Carnation	31 to 33	-0.6 to 0.6	2-4 weeks	30.8	-0.6
Chrysanthemum	31 to 33	-0.6 to 0.6	2-4 weeks	30.5	-0.8
Gardenia	32 to 34	0 to 1.1	2 weeks	31.0	-0.6
Gladiolus (as buds)	40 to 42	4 to 6	5-8 days	31.4	-0.3
Iris, bulbous	31 to 33	-0.6 to 0.6	1-2 weeks	30.6	-0.7
Orchids	45 to 50	7 to 10	1-2 weeks	31.4	-0.3
Rose (dry pack)	32	0	1-2 weeks	31.2	-0.4
Rose (in water)	33 to 35	0.6 to 2	4-5 days	31.2	-0.4
Snapdragon	33 to 35	0.6 to 2	1-2 weeks	30.4	-0.8
Other Cut Flowers					
Anthurium	56	13	2-4 weeks	----	----
Aster, China	32 to 40	0 to 4	1-3 weeks	30.3	-0.9
Bouvardia	32 to 35	0 to 2	1 week	----	----
Calla	40	4	1 week	----	----
Daisy, Shasta	40	4	1 week	30.0	-1.1
Eucharis	45 to 50	7 to 10	7-10 days	----	----
Freesia	32 to 33	0 to 0.6	10-14 days	----	----
Gerbera	34 to 40	1 to 4	1-2 weeks	----	----
Gloriosa Lily	40 to 45	4 to 7	1 week	----	----
Hyacinth	32 to 33	0 to 0.6	2 weeks	31.4	-0.3
Lily, Easter	32 to 35	0 to 2	2-3 weeks	31.1	-0.5
Lily-of-the-Valley	31 to 33	-0.6 to 0.6	2-3 weeks	----	----
Marigolds	40	4	1-2 weeks	----	----

Narcissus (Daffodils)		32 to 33	0 to 0.6	10-21 days	31.8	-0.1
Peony (as buds)		32 to 35	0 to 2	4-6 weeks	30.1	-1.0
Squill		32 to 33	0 to 0.6	2 weeks	----	----
Statice		35	2	2-3 weeks	26.3	-3.2
Stephanotis		40	4	1 week	----	----
Strawflower, fresh		35	2	3-4 weeks	----	----
Sweetpea		31 to 33	-0.6 to 0.6	2 weeks	30.4	-0.8
Tulips		31 to 33	-0.6 to 0.6	2-3 weeks	----	----
Zinnia		40	4	1 week	----	----
Violet		34 to 41	1 to 5	3-7 days	28.8	-1.8
Greens[1]						
Asparagus, Plumosa		35 to 40	2 to 4	2-3 weeks	26.0	-3.3
Boxwood		35 to 40	2 to 4	1-2 months	----	----
Camellia		40	4	----	----	----
Cedar		32	0	1 month	----	----
Croton		35 to 40	2 to 4	----	----	----
Dieffenbachia		55	13	----	----	----
Dracaena		35 to 40	2 to 4	----	29.1	-1.6
Eucalyptus		35 to 40	2 to 4	1-3 weeks	28.8	-1.7
Ferns	Adiantum (Maidenhair)	32 to 40	0 to 4	----	----	----
	Brake	32	0	----	----	----
	Dagger and Wood Ferns	32	0	2-3 months	28.9	-1.7
	Leatherleaf	34 to 40	1 to 4	1-2 months	----	----
	Staghorn	55	13	----	----	----
	Woodwardia	32 to 40	0 to 4	----	----	----
Galax		32	0	----	----	----
Groundpine		32	0	----	----	----
Holly		32 to 40	0 to 4	3-5 weeks	27.0	-2.8
Huckleberry		32	0	1-4 weeks	26.7	-2.9
Ivy, English		32	0	----	29.9	-1.1
Juniper		32	0	1-2 months	----	----
Laurel, Mountain		32	0	2-4 weeks	27.6	-2.4
Leucothoe, drooping		35 to 40	2 to 4	----	----	----

Magnolia	35 to 40	2 to 4	2-4 weeks	27.0	-2.8
Mistletoe	32	0	3-4 weeks	25.0	-3.9
Palm	45	7	----	----	----
Peperomia	35 to 40	2 to 4	----	----	----
Philodendron	35 to 40	2 to 4	----	----	----
Podocarpus	45	7	----	27.9	-2.2
Pothos	35 to 40	2 to 4	----	----	----
Rhododendron	32	0	2-4 weeks	27.6	-2.4
Salal (lemon leaf)	32	0	2-4 weeks	26.8	-2.8
Scotch-broom	40	4	2-3 weeks	----	----
Smilax (southern)	40	4	----	----	----
Ti (palm lily)	40	4	----	----	----
Bulbs, Corms, Rhizomes, Tubers, and Roots[2]					
Amaryllis	38 to 45	3 to 7	5 months	30.8	-0.6
Begonia, tuberous	35 to 45	2 to 7	3-5 months	31.1	-0.5
Bletilla orchid	35 to 40	2 to 4	----	----	----
Caladium, fancy leaf	70	21	2-4 months	29.7	-1.3
Calla	36 to 40	2 to 4	----	27.5	-2.5
Canna	40 to 50	4 to 10	----	----	----
Crocus	63	17	2-3 months	----	----
Dahlia	40 to 48	4 to 9	5 months	28.7	-1.8
Freesia	86	30	3-4 months	----	----
Gladiolus	45 to 50	7 to 10	5-8 months	28.2	-2.1
Gloxinia	41 to 50	5 to 10	5-7 months	30.5	-0.8
Hemerocallis	50	10	1 month	----	----
Hyacinth	63 to 68	17 to 20	2-5 months	29.3	-1.5
Iris, Dutch	68 to 77	20 to 25	4-12 months	----	----
Lily — Gloriosa	50 to 63	10 to 17	3-4 months	----	----
Lily — Longiflorum (Easter)	35 to 45	2 to 7	6 weeks	28.9	-1.7
Lily — Candidum and Regal	31 to 33	-0.6 to 0.6	1-6 months	----	----
Lily — Speciosum (Japanese)	31 to 33	-0.6 to 0.6	1-6 months	----	----
Lily-of-the-Valley	25 to 28	-3 to -2	1 year	----	----

Muscari	63	17	2-4 months	----	----
Narcissus	55 to 63	13 to 17	2-4 months	29.6	-1.3
Peony	33 to 35	0.6 to 2	5 months	----	----
Snowdrop	55 to 60	13 to 15	----	----	----
Squill	55 to 60	13 to 15	----	----	----
Taro	45	7	----	----	----
Trillium	33 to 35	0.6 to 2	----	----	----
Tuberose	40 to 45	4 to 7	4 months	----	----
Tulip	63	17	2-6 months	27.6	-2.4
Cuttings					
Azalea, un-rooted	31 to 40	-0.6 to 4	4-10 weeks	----	----
Carnation	31 to 33	-0.6 to 0.6	5-6 months	----	----
Chrysanthemums, unrooted	31 to 33	-0.6 to 0.6	5-6 weeks	----	----
Chrysanthemums, rooted	31 to 35	-0.6 to 2.0	3-6 weeks	----	----
Nursery Stock: (Miscellaneous)					
Asparagus rhizomes	30 to 32	-1 to 0	3-4 months	----	----
Christmas Trees	22 to 32	-5 to 0	6-7 weeks	----	----
Conifer seedlings	32 to 35	0 to 2	3-6 months	----	----
Foliage plants	55 to 60	13 to 15	----	-----	----
Herbaceous perennials	27 to 28	-2.7 to -2.2	4-8 months	----	----
Herbaceous perennials	31 to 35	-0.6 to 2	3-7 months	----	----
Rose bushes	29 to 40	-1.6 to 4	4-5 months	----	----
Strawberry plants	30 to 32	-1 to 0	8-10 months	----	----
Tomato plants	50 to 55	10 to 13	4-10 days	----	----
Trees and Shrubs	32 to 35	0 to 2	4-5 months	----	----

[1] A high relative humidity of 90-95% is recommended in refrigerated storage rooms for cut flowers and florist greens. Most of the cut flowers and greens are stored in a dry pack without water, but with protective packaging to prevent moisture loss. Orchids and anthuriums are exceptions and should be stored with their stems in vials of water. For carnations, snapdragons, and orchids, ethylene absorbent compounds are recommended.

[2] Desirable relative humidity for most bulbs and corms in storage is 70-75%.

Flowers and Florist Greens

Short storage customary: Present methods of marketing cut flowers in quantity involve several short storage periods. Immediately after cutting, the blooms are usually placed in water in the grower's storage room for several hours before shipping to the wholesale florist. The wholesaler stores them for a day or so and sells locally or ships to a retailer who also refrigerates the flowers during the short sales period. These merchants try to expedite the movement of fresh flowers to the consumer, and store them for as short a time as possible, customarily in water. It should be noted that the longer the storage period, the less the vase life in the consumer's home. Therefore, the use of appropriate floral preservatives at all stages of the marketing chain is highly desirable.

The temperature and storage life given in the table allow for a reasonable vase life after removal from storage. Much additional research is needed to determine storage requirements for flowers, greens, and foliage plants. While data for major cut flowers have been carefully determined through experimentation, other recommendations are based on meager evidence and will need revision in the future.

Most flowers must be handled as highly perishable products. They should be refrigerated promptly to prevent moisture loss, to remove field heat, and to delay deterioration. In the major production areas flowers are now often pre-cooled after harvest. This may be done after packing by using forced-air cooling of ventilated containers. The main causes of deterioration of flowers and greens include:

1. Senescence-related wilting of petals or yellowing of foliage. Precooling and refrigerated storage and transport are strikingly effective in reducing the rate of deterioration.
2. Flowers are very susceptible to postharvest diseases, which reduce salability. The most important postharvest disease in flowers is *Botrytis cinerea*, commonly called gray mold. The primary means of reducing losses from diseases is adequate disease control in the greenhouse and field, particularly removal of dead or dying plant parts (prunings, elimination of fallen leaves), which are the primary source of spores of the fungus. Although proper temperature management will reduce its impact, *Botrytis* grows at low temperatures. Proper temperature management can, however, greatly reduce its effects, because the spores require free moisture to germinate. Prompt pre-cooling and maintenance of steady cool temperatures reduce the probability of condensation on petals and leaves, and so reduce the danger of *Botrytis* infection.
3. Normal development and aging may limit storage and shelf life. Stage of maturity at harvest thus becomes critical. Some flowers must be picked as opening buds to have an adequate market life. Fully opened roses, gladioli, or snapdragons are often not salable because of their advanced development. Mature flowers such as larkspur may shatter.
4. Wilting through excessive loss of moisture may limit storage or vase life. Maintenance of high relative humidity in holding rooms or use of moisture-retardant packaging can minimize such losses. Flowers placed in water may still wilt because the stem is blocked by air bubbles in the

water-conducting tubes or by bacteria growing in the water. Re-cutting the stems, preferably under water, will remove the portion of the stem containing air, and the use of preservatives containing effective biocides will prevent growth of bacteria in the water.

5. Bruising and crushing will shorten storage life and reduce marketability, so blooms must be handled carefully. Flowers and leaves that are bruised or otherwise damaged by careless handling will respire faster and not last as long as those that are properly handled. Damaged tissue is also more prone to attack by disease organisms and can generate wound ethylene.
6. Color changes, such as fading of carnations and blueing of rose petals, are symptoms of deterioration. Again, refrigeration is desirable for preventing color changes and maintaining fresh color. Flower preservatives containing sugar are effective in preventing blueing of rose petals.
7. Accumulation of ethylene in storage may accelerate the rate of development and aging of some flowers or cause the abscission of florets as sometimes occurs with snapdragons and larkspur. Some flowers produce ethylene gas as they wilt. Curiously, roses, which normally produce little ethylene, may produce considerable quantities after a period of cold storage. Many fruits and vegetables also produce ethylene, so mixed storage may be very harmful to flowers. Pretreatment with silver thiosulfate (STS) or 1-methylcyclopropene ("EthylBloc") is used to prevent the deleterious effects of ethylene.
8. Chilling, or holding at temperatures lower than optimum, may cause deterioration in some flowers. Some gladiolus varieties, if stored for even a week at 40°F (4.4°C) or below, may fail to open properly on removal from storage. Spotting has also been alleged on some gerbera cultivars stored at 35°F (2°C). With these exceptions, the chilling sensitive flowers all derive from the tropics and subtropics. Vanda and Cattleya orchids, anthuriums, Birds of Paradise, ginger flowers, and heliconias all require storage, depending on species, cultivar, and growing conditions, in the 45 to 55°F (7 to 13°C) range.

Storage Temperature. The chief factor influencing storage life of cut flowers and greens is temperature. For maximum storage, "dry" storage at a temperature of 32 to 34°F (0 to 2°C) is recommended for most flowers. Those flower species susceptible to chilling temperatures should be stored at higher temperatures. The freezing point of petals ranges from 28 to 30°F (-2 to -1°C), so storage at 32 to 34°F (0 to 2°C) avoids the danger of freezing. The accompanying table provides information on the optimal storage temperature for a variety of cut flowers. In many cases more research is needed to confirm optimal storage temperatures, and it may be that many of the flowers and greens for which a storage temperature of 40°F (4.4°C) is recommended would keep longer if stored dry at 32 to 34°F (0 to 2°C). If several types of flowers are to be stored and only one storage room is available, it is suggested that the storage temperature be set to 32 to 34°F (0 to 2°C), and that chilling-susceptible flowers be kept at room temperature.

Relative Humidity. A high relative humidity (90-95%) is recommended in refrigerated storage rooms held at 40°F (4.4°C) or below. To maintain these high levels, humidifiers may be necessary within the

coolers. Maintenance of high relative humidity in storage rooms is much less important when moisture-proof packaging or containers are used for dry-pack storage or when flowers are stored in water. To prevent condensation on interior surfaces, flowers should be pre-cooled before packaging in moisture-proof packages.

Air Circulation. Proper air circulation patterns and commodity spacing can be as critical as temperature and relative humidity. Circulation fans should be positioned to "pull" the air throughout the storage versus "pushing" it through. The latter often results in dead spaces where little or no air movement exists. Also, high rates of air movement (i.e., 100+ linear feet/minute [30+ meters/minute]) are only necessary during peak periods when relatively large amounts of heat have to be removed quickly. Otherwise, 50-75 linear ft/min (15-21 m/min) is adequate with higher rates often being detrimental. Finally, the commodities being stored, whether packaged or not, should be so stacked as to have at least one surface exposed to freely circulating air. If this is not done, heat build-up may occur.

Dry-Pack Storage. Most kinds of flowers and greens keep best and longest if packed dry, without water, in containers which prevent moisture loss, and stored at 32 to 34°F (0 to 2°C). Dry-pack storage is used mostly to store flowers for certain peak holiday markets. Flowers stored in water remain turgid and continue developing and maturing even at lower temperatures. On removal from storage, flowers stored in water are more advanced in maturity and may not keep as long as flowers packed dry.

Cut flowers for normal prompt marketing or short holding periods should be held in preservative solutions in refrigerated rooms. Holding temperature is determined by type of cut flower. Flowers that are susceptible to chilling injury should not be put in low temperature refrigerated storage. Examples of flowers susceptible to chilling injury are anthurium, heliconia, torch ginger, and some species of orchids. Hyacinths and tulips should be held in a vertical position when they are dry-stored. Tulips and daffodils can be pulled from the ground with bulb intact and dry-stored. At time of sale, the bulb is cut off and the flower is marketed. If daffodils and tulips are held in water, they should be held in separate containers. Gladiolus, snapdragons, and other spike-type flowers should be stored vertically; tips will curve upward if stems are in a horizontal position.

Conditioning or hardening cut flowers following removal from dry storage at 32 to 34°F (0 to 2°C) is necessary if flowers are flaccid. Conditioning consists of re-cutting stems and placing flowers in vases of preservative at room temperature. Most cut flowers will re-hydrate in this environment. An alternative procedure is to cut stem ends, place in 100 to 110°F (38 to 43°C) water and hold at 40°F (4.4°C). A pH of 3.5 is best for re-hydration. Most flowers will re-hydrate in 4-18 hours under the above conditions. During conditioning, stems should not be crowded in containers. Containers should be spaced to allow good air circulation.

Ethylene. The presence of minute quantities of ethylene gas in storage rooms may greatly affect the storage life and quality of flowers and florist greens. Snapdragons, stocks, larkspur, and some roses drop petals or florets, commonly called shattering. Carnations, sweet pea, and baby's breath flowers wilt or

curl inward, commonly called "sleepiness", with exposure to ethylene. Ethylene causes drying and bleaching of the sepals of Cattleya orchids and premature blushing of Cymbidium orchids. Ethylene is produced by ripening fruits and vehicle exhausts and is used to ripen bananas and other fruits and to remove green color from citrus.

Some of these sources of ethylene are beyond the control of the warehouse operator. There are, however, some precautionary measures that should be taken. Fruits that naturally produce considerable amounts of ethylene, such as apples and pears, should never be stored in the same room as flowers. Ripening rooms should be vented to the outside to prevent accumulation of ethylene in warehouses, and only electric forklifts should be used. If ethylene accumulation is a problem, the cheapest solution is ventilation of the storage or warehouse space with fresh air obtained above the warehouse. The response of flowers to ethylene is greatly reduced at low temperatures, and proper storage temperatures are a key to reducing ethylene damage in produce warehouses.

It has been found that silver, complexed as the silver thiosulfate anionic complex (STS), is a potent antidote to ethylene effects in flowers. A number of cut flower crops, including carnations, baby's breath, sweet pea, lily, larkspur, and alstroemeria, are treated with STS as soon as possible after harvest to extend vase life and inhibit the effects of exogenous ethylene. Potted flowering plants, such as calceolaria, Christmas cactus, seed geraniums, hibiscus, pot roses, fuchsia, and impatiens, are commonly sprayed with STS during production to prevent ethylene-stimulated loss of flowers and buds during marketing. 1-Methylcyclopropene (has several commercial names such as EthylBloc), which inhibits ethylene action, is registered for use on ornamentals for the same purposes.

Flowering Plants. Potted flowering plants vary in their optimum storage temperature. Most are marketed shortly after they reach proper maturity. Plants from temperate regions, such as carnations, snapdragons, bulbous plants, and chrysanthemums, may be stored briefly at 40 to 48°F (4 to 8°C). Subtropical and tropical flowering plants, such as African violets, poinsettias, and gesneriads, are chilling sensitive and should be held at 55 to 64°F (13 to 18°C). Research has indicated that potted flowering plants should be refrigerated during long-distance transport.

Temperatures above 80 to 84°F (27 to 29°C) will damage closely-packed flowering plants. Even when foliage is not damaged, many of the flower buds will abort. Condensation that occurs on leaves and flowers results in rapid growth of *Botrytis* and consequent losses, especially at high temperatures.

Avoid storing flowering plants in ethylene-contaminated atmospheres. Sensitive species should be pre-treated with STS or 1-methylcyclopropene (EthylBloc) but may still be damaged by high levels of ethylene.

Green Plants. Most green plants in shipping containers will be marked with a temperature tolerance range, usually between 50 to 85°F (10 to 30°C). The optimum temperature for shipping or holding foliage plants is 60 to 75°F (10 to 24°C). Most plants should not be held in the shipping container more

than 7 days, as they will need light and water. Temperatures below 50°F (10°C) will cause chilling injury (CI). The sensitivity to chilling temperatures varies with the types of plant. For example, the silvernerve plant is damaged by 8 hours exposure to 46°F (8°C), the prayer plant and satin pothos by 2 days at 40°F (4.4°C), the snake plant by 3-4 days at 40°F (4.4°C), the zebra plant and weeping fig by 6 days at 40°F (4.4°C), while the aluminum plant did not show chilling injury after 8 days at 40°F (4.4°C).

Nursery Stock. Fruit trees and shrubs can usually be held satisfactorily in dormant condition in common storage in late fall and winter. Cold storage is required to maintain dormancy and to prevent bud growth in late winter and spring. Many kinds of nursery stock may be stored successfully at temperatures ranging from 31 to 36°F (-0.6 to 2°C). Some kinds of herbaceous perennial may be stored even longer partially frozen at 27 to 28°F (-3 to -2°C).

It is desirable, both in common and cold storage, that the roots be covered with moist peat, sawdust, or sphagnum moss. In cold storage rooms, an air humidifier may also be used, but strong air movement over the nursery stock should be avoided. High humidity near 90% is desirable to prevent drying. The chances for moisture loss are much greater for evergreens than for deciduous trees and bushes. Plastic coating or other transpiration suppressants may be of some value in preventing excessive drying. Many kinds of nursery stock are now partly or completely wrapped with polyethylene to retard moisture loss. Traces of ethylene, even 1 ppm, in the storage air can damage dormant nursery stock of apple, pear, and other fruit trees. Young pear trees are particularly susceptible to damage. Apple fruits in the same storage may be the source of the ethylene.

Rose Bushes. Rose bushes are stored anywhere from 29°F to 40°F (-1.6 to 4.4°C) depending on considerations such as length of storage period required and possible cost of storage. Thus, there are several acceptable methods of storing dormant roses; the choice of options depends on facilities available and desired result.

Information supplied by a major rose producer indicates two basic types of storage: 1) above freezing and 2) below freezing. Above freezing could be considered between 33 to 40°F (0.5 to 4.4°C). Most fall-dug bare root rose bushes will begin to "force" (sprout) about April 1, no matter where they are grown. The higher the temperature is above 32°F (0°C), the earlier and faster they will "force." Most rose bush storage is reported to be at 34°F (1°C). This temperature is most likely not a magical number but has been established as a point that can be maintained with confidence without going below freezing. In this type of storage, roses are normally stored shoot to root so as to optimize use of the storage cube. Usually, moist moss is used to cover roots and water is periodically added to replenish evaporation. Some may use periodic misting rather than moist moss. Relative humidity is high, between 90 and 95%. Diseases can be a problem, with *Botrytis* being the most prominent fungal organism. The canes may be dipped in a fungicide to hold down mold. Ethylene contamination is also a problem for stored rose bushes. It has been shown that low concentrations of ethylene reduce sprouting and vigor of plants when they are placed in the garden. For this reason, roses should not be stored with apples or pears.

Where contamination is suspected, ventilation of the storage space with one 1 complete air exchange per hour should prevent any problems.

Below freezing. Below freezing storage would be considered to be between 29 and 32°F (-1.6 and 0°C). The temperature controls and equipment need to be more precise, as dormant rose bushes have a lower limit. At or above 29°F (-1.6°C) would be considered safe for dormant, fall dug rose bushes. The bare root roses are confined in poly bags with a thickness usually less than 0.006 inch (0.15mm). To take advantage of the storage cube, the poly bags are put in corrugated containers and stacked 5-6 high, depending on the strength of the corrugated containers. If greater height is required, stacking frames can be used. A water/fungicide solution can be added at the time of packing with no further addition of water required. Disease is at a minimum since fungal activity is greatly reduced at these temperatures. Also there is little or no bud "forcing" activity, thus fall-dug rose bushes can be held quite dormant at least through June. Any bud activity can usually be traced back to improper handling, generally due to allowing bushes to warm up slightly above the freezing point.

Easter Lilies. Easter lilies (*Lilium longiflorum*), grown as pot plants to hit the Easter market, require special treatment of the bulbs. They are normally not stored. However, a cold moist treatment (vernalization) of the bulbs is essential for rapid shoot emergence and subsequent flowering of the lily by Easter. The standard recommendation is to dig the bulbs and ship to growers, who then cool them for 6 weeks at 35 to 40°F (1.6 to 4.4°C) for the cultivar Ace and 40 to 45°F (4.4 to 7.2°C) for the cultivar Nellie White. If Ace and Nellie White are cooled together, use 40°F (4.4°C). Bulbs are normally cooled in moist peat moss in the shipping case or in flowerpots with moist peat. The relative humidity of the cooler is not critical as long as the peat remains moist. Storage for longer than 6 weeks is detrimental to flower bud number and is not recommended. After the cold treatment, the bulbs are forced in greenhouses for Easter.

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