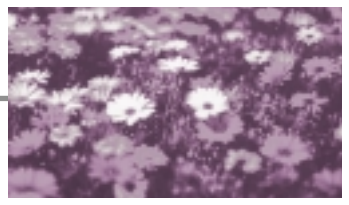


Flower Bulb *Transportation* and *Handling*

Above left: Most all spring-flowering bulbs spend their summers out of the ground, in trays such as these. The wire-mesh bottom allows maximal airflow around the bulbs. Middle: The start of tulip processing in a packing shed. After digging, bulbs are washed free of soil and "peeled" to remove the small side bulbs for propagation. In the last few years, "peeling machines" have been developed to automate this process. Right: Planting a healthy crop is what it's all about. Here, a crop of crocus. (All photos courtesy of William Miller.)

You may not give much thought to the journey your bulb shipment takes from the fields in Holland to your greenhouse. Being aware of the steps in the process can help you identify and prevent potential problems before beginning your forcing program.

By William B. Miller

The outlook for the Dutch tulip crop for the 2002 forcing season is very good. Temperatures in the growing regions throughout the late spring were cool and favorable for a strong crop. Bulbs are now out of the ground, washed free of soil, peeled , sized and packaged. Depending on their use, many are already on their way to U.S. and Canadian customers, with others waiting for shipment during the fall.

The transoceanic journey of flower bulbs from Holland to your greenhouse is now a routine matter. Each day, horticulture is becoming more and more globalized and flower bulbs epitomize international trade. Not long ago, however, bulbs were shipped under what we would now consider barbaric conditions. In this article, I will present the technologies and procedures for shipping bulbs from Holland to North America. I will also offer practical steps growers can take to maintain high-quality bulbs for forcing.

THE OLD DAYS

As a child growing up in my family's business, I was all too familiar with heavy, 50-lb. crates of Easter lilies. That was tough enough…but imagine the 200 plus-lb. wooden crates used by Dutch bulb exporters through the mid-1900s. Until the mid-1950s, these crates were loaded by crane into the stuffy holds of steam ships for the ocean journey. A bit of reflection allows one to realize that it was nearly a miracle any of these bulbs survived and grew at all. Lack of ventilation, poor temperature control and rodents probably all took their toll on the product. Successful flowering, however, does point out the remarkable tolerance bulbs have.

MAJOR INFRASTRUCTURE ADVANCES

By the 1960s, the steamship industry was rapidly converting to unitized "containers" as the basic shipping unit. These stackable and easily handled

The following tips can help ensure the maximum quality of forced plants or cut flowers.

- Ventilate bulbs immediately upon arrival. This means opening cardboard boxes and removing any shrink-wrap that might be used to stabilize pallet-loads of stacked plastic crates. If necessary, use fans to maximize airflow around the bulbs. Store them out of direct sunlight and under cover.
- Inspect bulbs for evidence of serious disease, insects or mechanical injury. If more than 10 percent of the shipment is infected with Fusarium, the supplier should be contacted immediately.
- Place bulbs at the proper temperature (see Table 1, pg. 30). The proper temperature depends on the type of bulb and cultivar, its ultimate use (cut or pot) and any pretreatment received (for example, precooling or preparation for early forcing with hyacinth).
- Maintain the proper relative humidity, generally 85-90 percent. If a superficial layer of blue mold (Pennicillium) develops on the surface of the bulbs, it is an indication that the airflow is too low and/or the relative humidity too high. A minor "dusting" of blue mold is not a problem. Also watch out for extremes in temperature fluctuation to avoid condensation of moisture on the bulbs.
- If necessary, determine the stage of floral development by dissecting bulbs. The flower bud must reach the "G" stage and, depending on the cultivar, must be given another one to five weeks of 63º F storage prior to the start of cooling. This is an issue primarily for the very earliest crops, and your supplier should be in close contact with you regarding the status of such early bulbs.
- Avoid ethylene sources in bulb holding areas: ripening fruits or vegetables, rotting plant matter, internal combustion engines (trucks, forklifts, etc.) or poorly vented heaters.

units allowed the development of a modular and seamless international shipping network for all kinds of products. In the case of bulbs, a container could be loaded in Holland, shipped by boat to the United States, then placed on a dolly for delivery to the customer on the East Coast or freight train for delivery to the West Coast or Midwest.

These containers were mechanically ventilated to provide fresh air to the bulbs during the trip. Furthermore, portable refrigeration units were developed by the late 1960s to allow climate modification in each individual container. This provided tighter control of temperature and fresh air within the container. It also allowed shipment of bulbs at a range of temperatures. Another major advantage of container-based shipping is more rapid turnaround at each port, with containers typically leaving the port less than 24 hours after arrival.

BIOLOGY AND TRADE

Spring-flowering rooting room bulbs — such as tulips, hyacinths, daffodils and crocus — are relatively compact, resist water loss, have low respiration and can tolerate a wide range of temperatures. At first glance, spring-flowering bulbs appear "dormant." In fact, they are not dormant and are constantly and slowly growing and developing. This growth and response to the environment has profound effects on the ultimate forcing performance and quality of the final flower or plant. In other words, forcing behavior is directly related to the environmental conditions (especially temperature) to which bulbs are exposed after digging.

Given that equipment can malfunction during transport and that bulbs constantly sense their environment, flower bulbs are susceptible to numerous problems during the journey from Holland. The major difficulties that North American forcers encounter are often related to problems during shipping. High or low temperatures, inadequate airflow (leading to ethylene build-up) and moisture condensation on bulbs can all lead to problems expressed as physiological abnormalities (problems with flower development) or biotic injury (diseases and insects).

The advent of temperature-controlled shipping containers has revolutionized transport of all perishable commodities, from bulbs to shrimp to tuna. A tulip may be received in good condition and ready to perform from very early August — for dry sales in retail stores — through January or February — as pre-cooled bulbs for cut flower forcing. This covers as much as seven months, a time span unequalled by any other ornamental crop.

SHIPPING FACTORS

Time. Ocean transit time from Rotterdam to Newark, N.J., is approximately nine days. Additional time is necessary to load the container at the exporter's facility, transport it to Rotterdam, place and secure it on the vessel, as well as reversing the steps at the point of arrival. This takes from one to six-plus days, depending on the location and method used. Thus, the minimum time bulbs are enclosed in a container is just under two weeks and may be four-plus weeks in the case of a West Coast shipment via the Panama Canal.

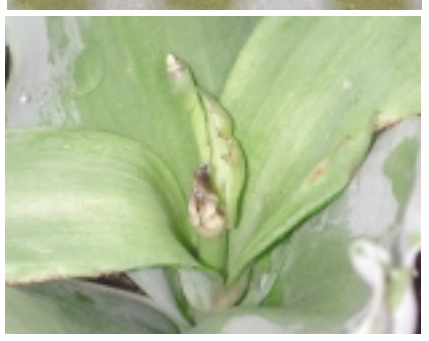
Table 1. Recommended temperatures for storage of selected flower bulbs after receipt by the forcer.

BULB TYPE	FORCING PROGRAM	VENTILATION?	TEMPERATURE °F	TEMPERATURE °C
Tulip	Bulbs not yet in "G" stage	Yes	63	17
	Precooled bulbs (early)	Yes	44.5	7
	Precooled bulbs (mid)	Yes	48	9
	Non-precooled for cut flowers	Yes	55	13
	Non-precooled for pot plants	Yes	63	17
Hyacinths	Prepared bulbs	Yes	48-55	9-13
	Regular bulbs	Yes	63	17
Daffodil	Precooled bulbs	Yes	48	9
	Non-precooled for cut flowers	Yes	55	13
	Non-precooled for pot plants	Yes	63	17
Crocus, dwarf Iris, *Scilla tubergeniana* (*S. mischtschenkoana*)	Precooled bulbs	Yes	48	9
	Non-precooled bulbs	Yes	63	17
Allium karataviense* *Leucojum aestivum	Non-precooled bulbs	Yes	63	17
Amaryllis	Pot plants or cut flowers	Yes	41-60	5-16

Source: A. De Hertogh, Holland Bulb Forcer's Guide, 1996.

Temperature. A tulip may be transported any time during a six- to seven-month window. Depending on the use of the product, shipping temperatures may range from 63º F (17º C) down to 40º F (5º C). Considering the operating environment, the equipment used on a modern ocean vessel is very robust and reliable, allowing accurate and consistent temperatures within the container. All shipments, however, should have two portable temperature recorders to monitor the temperature of the air flowing around the bulbs. These are invaluable should a malfunction occur with the container's environmental control equipment. Taking into account that vessels have arrived in America with two feet of ice covering the ship, you can get a feel for the brutality of the winter trip across the North Atlantic, the importance of containers to the bulb trade and the robust nature of this equipment.

Ventilation and ethylene. The major disease problem facing North American tulip forcers is Fusarium. This disease infects the basal area of the bulbs and is known to be a greater problem if field temperatures are high in the last 3-4 weeks before digging. Some large cultivars are also more susceptible; for example, 'Prominence' and its sports are extremely sensitive to Fusarium.



Top: Severe Fusarium infection. The internal tissues are very dry, and the bud is dead. Bulbs such as these produce large quantities of ethylene, and their presence in shipments can affect adjacent bulbs. Bottom: An example of tulip "kernrot." This disorder begins when tulip bulbs are exposed to ethylene. Following ethylene-stimulated elongation of the immature shoot, the bulb tip opens and mites are able to enter and feed on the small bud. What you see is the result upon forcing.

Fusarium becomes a transportation issue when we realize the Fusarium fungus produces large quantities of ethylene. A key reason for ventilating containers, and for immediately unpacking and ventilating bulbs upon arrival at your facility, is to remove ethylene from the atmosphere surrounding the bulbs. It is crucial to understand that the ethylene produced by a single "fusarium bulb" can injure numerous surrounding bulbs, both in the shipping case and pot or forcing box. In Holland and at Cornell University, there are several research studies underway to investigate additional effects of ethylene during transportation and possible ways to reduce its negative consequences.

Ethylene injury in tulips is expressed as uneven, stunted growth, flower bud withering or complete flower bud necrosis before the bud emerges from the bulb. For

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example, the disorder called “kern-rot” can be seen in dry bulbs in the early fall. It begins with ethylene-stimulated shoot growth leading to the “opening” of the tip of the tulip bulb. At that point, mites are able to enter the bulb and crawl down to the young, developing bud. Their feeding causes the actual death of the bud. When forced, the resulting plant has one to three leaves, but no stem elongation or flowering. The bud is merely a blackened stump.

In tulips, ethylene exposure leads to another disorder called gummosis. Gummosis is the formation of a hard, clear, brownish-tan substance on the external surface of the bulb. A shipment with a substantial proportion of gummosis tulips is very suspect and your supplier should be notified.

Humidity. The relative humidity inside a shipping container is another critical factor for a problem-free bulb shipment. Especially with pre-cooled shipments at 48º F (9º C), warm, humid air entering the container during ventilation can cause water to condense on the bulbs. In such cases, immediate drying with fans is essential upon arrival at the warehouse. Failure to do so can increase disease problems.

Successful forcing of bulbs depends on a series of detailed steps in a highly complex, international industry. In this article, we have examined some of the steps involved in this global trade. Even now, the technology discussed is allowing increased numbers of bulbs to be transported from other bulb-producing countries, especially in the Southern Hemisphere. While the details of bulb transportation may not be essential for the domestic forcer, knowing what can affect a bulb’s proper and reliable execution during transportation is. GPN

The author is grateful for research support from the Royal Dutch Wholesalers’ Association for Flowerbulbs and Nursery Stock, Hillegom, The Netherlands; to Holly Lohren, Maersk/Sealand for firsthand experience with the steamship industry; and to other companies and people who shared their knowledge of the flower bulb industry.

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