The bulk of this article was published in *Greenhouse Product News* , 11(8):28-29, 2001. Additional images of bulb digging and handling have been added to this electronic article.

Flower Bulb Transportation and Handling

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The transoceanic journey of flowerbulbs from Holland to your greenhouse is now a routine matter. Each day, horticulture is becoming more and more globalized and flowerbulbs epitomize international trade. The Dutch imported their first bulbs into Holland from Turkey and the Old World (their native habitat) more than 400 years ago, and within a relatively few years, were exporting bulbs back to Turkey. Not long ago, however, bulbs were shipped under what we would now consider barbaric conditions. In this article, the technologies and procedures for shipping ulbs from Holland to North America will be presented. Also, practical steps growers can take to maintain high quality bulbs for forcing will be given.

The Old Days

As a child growing up in my family's business, I was all too familiar with 50 lb. crates of Easter lilies. That was tough enough….but imagine the 200+ lb. wooden crates used by Dutch bulb exporters through the mid-1900's. These were loaded by crane into the stuffy holds of steam ships until the mid-1950's. 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 these products do have. Similarly, the toll exacted on the Dutch men (and they were all men) and their families back home were high. Sales trips extended to months on end, with a multi-week ocean voyage on each end of the trip. It must have been exhausting, but was indeed the genesis of an industry.

Major Infrastructure Advances

By the 1960's the steamship industry was rapidly converting to unitized "containers" as the basic shipping unit. These stackable and easily handled 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 US, then placed on a dolley for final delivery to the customer on the east coast. For west coast or mid-west delivery, transport on a fast, container-based freight train might also be involved. These containers were mechanically ventilated to allow fresh air to be provided to the bulbs during the trip. Furthermore, portable refrigeration units were developed by the late 1960's to allow climate modification in each individual container. This made it possible to provide tighter control of temperature and fresh air within the container and to allow shipment of bulbs at a range of temperatures. Another major advantage of container-based shiping is more rapid turn-around in each port, with containers typically leaving the port less than 24 hours after arrival of the boat.

Bulb Biology Related to International Trade

Considering the spring flowering rooting room bulbs (tulips, hyacinths, daffodils, crocus, etc.), we can see that they 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 cut flower or pot plant. In other words, their forcing behavior is directly related to the environmental conditions (especially temperature) to which they are exposed after digging.

Given that equipment can malfunction during transport, and that bulbs constantly sense their environment, flowerbulbs are susceptible to numerous problems during the journey from Holland. The major difficulties encountered for North American forcers are often related to problems encountered during shipping. High or low temperatures, inadequate airflow (leading to ethylene build-up) or moisture condensing on bulbs as warm, humid ocean air is pulled through the container can all lead to problems expressed as physiological abnormalities (flower development) or biotic injury (diseases, insects, mites).

Even so, the advent of temperature-controlled shipping containers has revolutionized transport of all perishable commodities, from bulbs to shrimp to tuna. We can now see that a tulip may be received in America from very early August (for dry sales in retail stores) through January or February (precooled bulbs, for cut flower forcing), in good condition and ready to perform. This covers as much as 7 months, a time span unequalled by any other ornamental crop.

What are the critical factors for shipping bulbs?

Time. Ocean transit time from Rotterdam to Newark, NJ is approximately 9 days. Additional time is necessary to load the container at the exporter's facility, transportation to Rotterdam, placement and securing on the vessel, as well as unloading and customs clearance at the port of entry, and transportation to the receiver's facility (1 to 6+ days depending on location and method). Thus, the minimum time bulbs are enclosed in a container is just under 2 weeks and may be 4+ weeks, in the case of a west-coast shipment via the Panama Canal.

Temperature. As mentioned above, a tulip may be transported any time during an approximate 6-7-month window. Depending on the use of the product, shipping temperatures may range from ca. 63F (17C) down to 40F (5C). Considering the operating environment, the equipment used on a modern ocean vessel is very robust and reliable and allows accurate and consistent temperatures within the container. All shipments, however, should have two portable temperature recorders to monitor temperature of the air flowing around the bulbs. These are invaluable should a malfunction occur with the containers' environmental control equipment. Most of the time, of course, all equipment functions perfectly, even in poor conditions. Considering that vessels have arrived in North America with two feet of ice covering the ship, you can get a feel for the brutality of the winter trip across 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 (Figs. 1 and 2) 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. There are also large cultivar effects. For example, 'Prominence' and its sports are extremely sensitive to the disease.

Fusarium becomes a transportation issue when we realize the *Fusarium* fungus produces large quantities of ethylene. A key reason for ventilating containers on board, 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 both Holland and Cornell, there are several research studies underway to investigate additional effects of ethylene during transportation and possible ways to reduce its negative effects.

Ethylene injury in tulip is expressed as uneven, stunted growth, flower bud withering, or complete flower bud necrosis before the bud emerges from the bulb. For example, the disorder called "kernrot" 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 1-3 leaves, but of course no stem elongation of flowering. The bud is merely a blackened stump (see Fig. 3).

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 must be notified.

Humidity. The relative humidity inside a shipping container is another critical factor for problem-free bulb shipment. Relative humidity is a measure of the quantity of water (held as vapor or gas) in the air relative to the quantity of water the air could hold at the same temperature. A related measure is the dew point, or temperature at which moisture condenses from the air onto surfaces. The more humid the air, the greater (warmer) the dew point.

Especially with precooled shipments at 48F (9C), 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 the moment of arrival at the warehouse. Failure to do so can increase disease problems.

In summary, successful forcing of bulbs is a series of detailed steps in a highly complex, international industry. In this article, we have examined some of the steps involved in this international 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, their proper and reliable execution is. Similarly, bulb forcers must handle the product correctly to finish the process.

The following tips are offered to help ensure the maximum quality of forced plants or cut flowers with the upcoming bulb crop.

- 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% of the shipment is infected with Fusarium, the supplier should be contacted immediately.
- Place bulbs at the proper temperature (see Table 1). The proper temperature depends upon 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%. If a superficial layer of blue mold (*Pennicillium*) develops on the surface of the bulbs, it is an indication that the air flow 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 onto 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, be given another 1-5 weeks of 63F 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), or poorly vented heaters.

Acknowledgements

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 providing me with firsthand experience with the steamship industry, and to the numerous companies and people who continue to share their knowledge of the flowerbulb industry.

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

Bulb type	Forcing program	Ventilation?	Temperature F	Temperature C
Tulip	1. Bulbs not yet in “G” stage	Yes	63	17
	2. Precooled bulbs (early)	Yes	44.5	7
	Precooled bulbs (mid)	Yes	48	9
	3. Nonprecooled for cut flowers	Yes	55	13
	Nonprecooled for pot plants	Yes	63	17
Hyacinths	1. Prepared bulbs	Yes	48-55	9-13
	2. Regular bulbs	Yes	63	17
Daffodil	1. Precooled bulbs	Yes	48	9
	2. Nonprecooled for cut flowers	Yes	55	13
	Nonprecooled for pot plants	Yes	63	17
Crocus, dwarf Iris, Scilla tubergeniana (S. mischtschenkoana)	1. Precooled bulbs	Yes	48	9
	2. Nonprecooled bulbs	Yes	63	17
Allium karataviense Leucojum aestivum	1. Nonprecooled 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.

Figure 1. Severe *Fusarium* infection of 'Winterberg', a sport of the tulip cultivar 'Prominence'. The internal tissues are very dry, and the bud is dead. The Fusarium fungus living on bulbs such as these produce large quantities of ethylene, and their presence in shipments can affect adjacent bulbs through the evolved ethylene.

Figure 2. Close up and internal view of Fusarium-infected tulip bulbs.

Figure 3. An example of tulip “kernrot”. This disorder begins when tulip bulbs are exposed to ethylene (often coming from nearby Fusarium-infected bulbs). Following ethylene-stimulated elongation of the immature shoot, the bulb tip opens, and mites enter and feed on the very small, immature bud. What you see is the result upon forcing: a necrotic, dead bud on a suppressed and malformed stem.

Digging tulip bulbs in the Netherlands. When dug, a tulip bulb is vegetative, that is, the flower bus has not yet formed. Temperatures after digging are critical for proper and rapid bud formation, leading to successful forcing.

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The start of summer tulip processing. After digging, bulbs are washed free of soil, and then "peeled" to remove the small side bulbs for propagation. In the last few years, "peeling machines" have been developed to allow this process to be automated.

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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. Airflow is essential to maintain bulb health and vigor and to minimize localized ethylene accumulation.

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Pallets of bulbs ready for loading into a reefer container. The perforated sides of the plastic shipping crates allow air movement through the mass of bulbs on the pallet.

A reefer container being loaded at an export facility in Holland.

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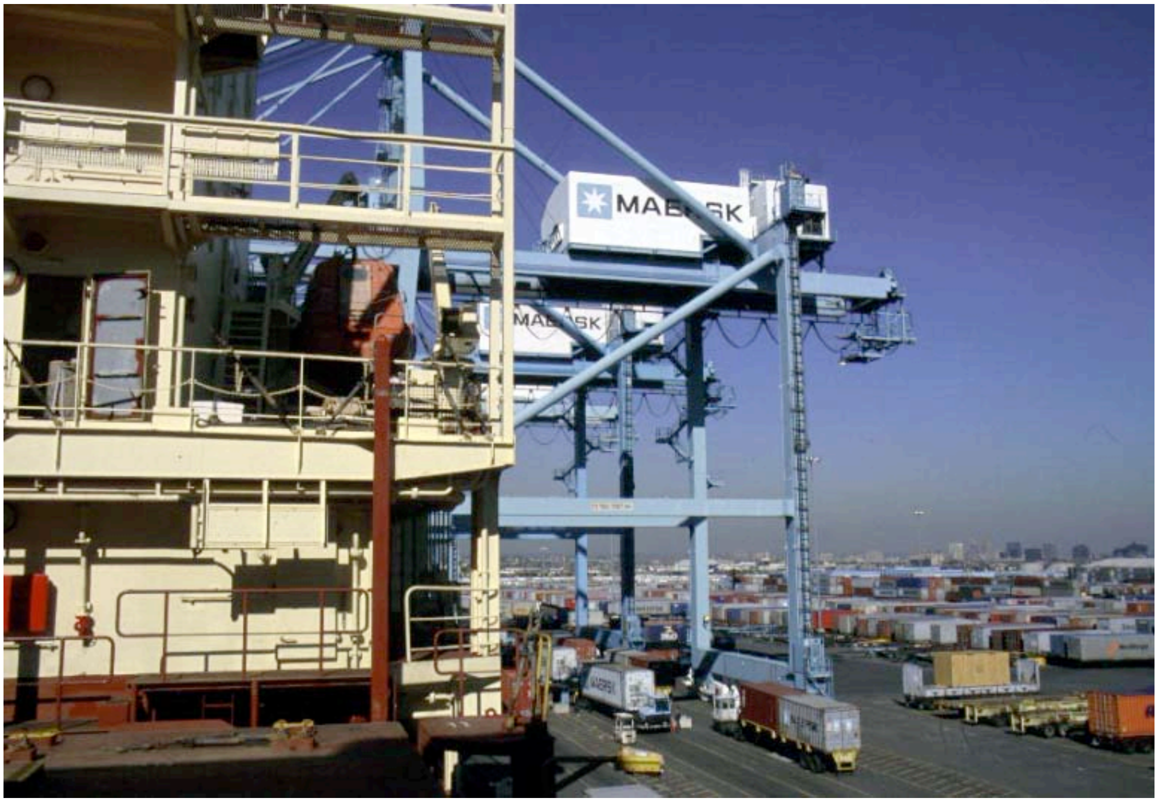
The “reefer bay” on a major container vessel. The reefer bay holds the electric supply for the individual reefers onboard.



View from aboard a container vessel during unloading in port. As each container is removed from the ship, it is placed on a dolley for transport within the arrival area.

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What it's all about: planting a healthy crop.