A North American view of forcing potted spring bulbs

Pot flower bulb culture in North America has increased in recent years with still many opportunities seen to improve quality and extend the sales window.

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North America is the single largest export market for Dutch-grown flower bulbs. In sheer dollars, US bulb flower production is dominated by cut lilies (US$78 million in 2004). Cut lilies totalled $36 million and iris, $22 million. Bulb cut-flower production is dominated by large producers, mainly in the states of California, Florida and Washington. Collectively, pot spring bulbs accounted for $53 million in 2004, up from ca. $37 million in 2000. This industry is much more dispersed in the US, with large production volumes in the midwest, northeast, pacific coast and Ontario, Canada, with significant production able to be found in nearly every other state in America.

Pot tulip showing typical symptoms of Trichoderma. The root infection proceeds through the cooling and greenhouse period, with symptoms (leaf tip or edge "burn") showing in the very latest states of the crop. Note also uneven growth resulting from the infection.

As with any floriculture crop, successful production of bulb crops involves detail and manipulation of the product before and during forcing. A major advantage of spring bulbs such as tulip, daffodil, crocus, hyacinth, *etc.* is the short to very short greenhouse time and close greenhouse spacing, usually pot-to-pot. This potentially allows many turns of the greenhouse space and consequently high returns per square foot.

Rooting room bulbs

One of the most critical steps for successful forcing spring bulbs is providing the proper length of cold treatment. Depending on the cultivar, product type, and the forcing period, the length of cold treatment may range from 10 weeks in the case of prepared hyacinths for early forcing to more than 20 weeks for late forced daffodil or tulip crops.

Tulip bulbs showing basal rot (Fusarium) infection. Bulbs such as these should be removed from tour shipment as soon as possible. These bulbs can produce large concentrations of ethylene that can cause aborted flowers, poor rooting and uneven growth in nearby, non-infected tulip bulbs.

With many bulbs, it is possible to give some of the cold to unplanted bulbs; pre-cooling is done for early forcing, a service provided by the bulb exporter. Upon receipt of pre-cooled bulbs, it is critical that they are inspected for quality attributes (e.g. presence of disease, or mechanical injury from shipment), maintained at the correct temperature, and planted as soon as possible. Typically after planting, pots are placed into a rooting room at an initial temperature of 9°C. Since the bulbs are already partly cooled, root growth tends to occur quickly, and pots will be well rooted within 3 or 4 weeks. Then temperatures must be reduced to retard shoot growth and avoid excessive root growth.

Bulbs for later forcing are not pre-cooled so often the forcer gives the entire cold period to the bulbs after they are planted. Thus, non pre-cooled bulbs are inspected upon arrival, planted, and placed into the rooting room.

General planting and cooling guidelines for spring bulbs are as follows:

- Water in bulbs after planting: Keep high humidity in the rooting room. Usually, keeping the floor wet is sufficient to maintain moisture in the pots after an initial watering.
- Initially maintain 9°C for rooting: As pots become well-rooted (roots coming out of the holes in the pot), lower temperature to 4°C. Cultivars vary in rooting speed, so approximations are necessary. Watch temperatures closely. Maintain 4°C until shoots are 2.5 cm long, and then reduce temperature to 0-2°C to minimize shoot elongation. Again, species

Early Trichoderma symptoms in a 15-cm tulip crop. Note uneven growth on the bench. Plants will begin to show leaf-tip injury within a few days, as plants come into flower.

Nice job on hyacinths in larger pots (20 cm); six bulbs of Pink, Blue and White Pearl per pot. When blooming, the display is excellent.

and cultivars vary, so approximations are necessary. There is a trend in North America to dramatically reduce the rooting room temperature as soon as plants are rooted. The reason is to limit root growth. Excessive root growth is linked to *Trichoderma*, a potentially very serious tulip disease.

- Give the proper number of cold weeks for each cultivar: Temperatures from 9°C to 0°C are "cooling" temperatures. Total length of cold is all the time spent in the rooting room plus any precooling time, if any, given by your supplier. A general rule for tulips is the lower the cooling temperature, the longer the stem, but smaller the flower. Be certain to keep shoots short, typically less than 8-10 cm. Once well rooted, it's better to reduce temperature early to minimize shoot and root growth.
- When needed, use the proper growth regulator at the right time for height control. This is usually within just a few days after moving to the greenhouse.

Growth regulators

Depending on the growing situation, tulips, daffodils and hyacinths can all benefit from growth regulator application. Growth regulator use on spring bulb crops is somewhat complicated by variety of chemicals, application methods and rates involved. The basic techniques are given below. Much more detailed information can be found in the *Holland Bulb Forcer's Guide*.

In the past, tulips were commonly treated with ancymidol (A-Rest), but increasingly paclobutrazole (Bonzi or Piccolo) drenches are being used due to better effectiveness and lower cost. Since the paclobutrazol must be applied before the plant is more than 10-12 cm tall, drenching is done within a few days of bringing pots into the greenhouse. Paclobutrazol drenches are typically in the 0.5-2 mg/pot range (this is 4.1 to 16.6 ppm paclobutrazol, assuming 120 ml are used on a 15 cm pot). Research at Cornell University has shown over the past two years that fluprimidol available in Europe, is also very effective on pot tulips. Cultivar and length of cooling (time of season) have large effects on the proper dosage required.

Daffodils (including paperwhites) and hyacinths benefit from ethephon (Florel) sprays for height control. Rates are typically 500-2,000 ppm, depending on the cultivar and forcing period. Multiple applications may be needed. Again, early treatment is necessary, optimally before plants are 10 cm tall. Hyacinths must be treated before florets are open and substantially coloured, otherwise flower blasting and reduced post-harvest life may result.

Common disease problems

The last few years have seen an increase in *Fusarium* infection in tulip bulbs. There are many speculated causes for this, and probably no one knows the full story. Different production locations, systems, machinery, cultivars, weather, and size of farm all seem to be contributing to the problem. *Fusarium*-infected bulbs have light tan and brown blotches, usually on the base of the bulb. Aside from rendering the infected bulb useless, the *Fusarium* fungus can produce large quantities of ethylene, and this ethylene can cause problems in other, non-diseased tulip bulbs, e.g. poor rooting, uneven growth, flower blasting. This is a problem mainly before cooling starts, although it is also known that infected bulbs continue producing ethylene when plants are moved into the greenhouse after cooling. This ethylene can diffuse through the media, and cause growth problems in other plants in the pot. And, unlike cut flowers, one bad plant ruins the whole pot. As far as forcers are concerned, the main control is to carefully inspect each bulb, and throw out infected bulbs prior to planting. Also, buy from high-quality, reputable suppliers. *Fusarium* has been a major problem for the industry, and in general, the Dutch industry has done a good job trying to get this problem under control.

Another significant disease of the past few years is *Trichoderma*. This disease probably infects most all tulip cultivars, but only certain ones show visual symptoms, which are greyish leaf tips developing in the last few days in the

Hyacinths in 15 cm pots for late January marketing. The pot colour corresponds to the flower colour, and is part of the overall marketing scheme for the crop.

greenhouse. The fungus probably originates in the planting mix, as *Trichoderma* is a ubiquitous organism. The fungus is only a weak pathogen on tulips, so a weakened plant is key for infection and symptom development. The usual case is when tulips become heavily rooted in the cooler, with the heavily-matted and circling roots subsequently becoming stressed, e.g. by drying out, salt stress, or by growing with heat from heated floors or heat pipes under the benches. The pathogen can then invade, and cause the injury. Prevention is mainly by sanitation, avoiding all plant stress and by handling pots or crates so that roots coming out of the bottom are "air-pruned", so that roots do not grow below the pot.

Muscari, dwarf iris, crocus, scilla

These rooting room bulbs require cold periods ranging from 14-17 plus weeks. Crocus, dwarf iris, and squills are best sold directly from the rooting room as sprouts. They green up quickly, but also flower quickly, so a greenhouse period is really not necessary. In all cases with this group, prompt marketing is important, as the overall shelf life of these crops can be low. Warm temperature is the main accelerator of quality loss in the retail chain and consumer environment.

Grape hyacinths are a slightly different story as a high light greenhouse period of 3-4 weeks at 12-16°C NT is required. A problem with grape hyacinths can be excessive leaf growth leading to an unkempt-looking plant. This is due to normal rooting after planting and placing in the rooting room. The roots absorb water, thereby driving leaf growth. There are two simple solutions to this:

- Reduce temperature in the rooting room to 0-1°C as soon as plants are rooted;
- Or, pre-cool the bulbs dry for about 3/4 of the required cooling time, then plant and immediately return to a 4-9°C cooler for the last 3 or 4 weeks of cold where they will root quickly. Later planting, but with the same total cold weeks, simply delays rooting and the excessive leaf growth associated with it.

Marketing and post-harvest

A recurring opportunity seen in North America is low quality at the retail outlet. This problem can be found throughout all retail, it does not exist solely in high volume stores. While the fault may indeed lie with the store for failing to remove bad products from the shelves, growers must also pay careful attention to shipping bulb crops at the appropriate time, and thus maximizing the opportunity to increase product value to the retailer. Spring bulbs inherently have rather limited post-harvest life; the flower is on display during the cool springtime, and our warm houses and offices are not optimum for flower life. From a purely business view, the optimum stage to ship a product is when and how the customer wants it! From the plant's viewpoint, it must be developed sufficiently to tolerate the harsh conditions of the retail/consumer environment but not so far along that longevity for the consumer is lost in the greenhouse itself. Thus, the optimum shipping time for tulips, hyacinths and daffodils is well before flowers open. Optimum shipping stages are as follows: tulips-green bud stage; hyacinths-before florets open; daffodils-when buds are green pencils. Crocus and dwarf iris are shipped as sprouts, essentially just out of the cooler. In Europe, hyacinths are sold as rooted bulbs so the consumer can watch leaf and flower development, and get several weeks of enjoyment from the product. This concept is almost nonexistent in North America, but perhaps we might be able to exploit it.

Other opportunities

In North America, growers try to differentiate themselves by growing unusual sizes or grades, one example being larger pot sizes, perhaps 18-20 tulips in a 12" pot. These are non-commodity items that allow growers to command a premium price for premium products. And although we have focused on greenhouse forcing, there are many other ways to use flower bulbs to extend sales windows, both in the spring and into the summer and fall. It is possible to grow and market many kinds of spring bulbs as perennials, the idea being to sell them green in the early spring. In this case, bulbs are planted and over wintered under natural conditions, or in coolers, if needed. When marketed green, consumers gain the opportunity to purchase plants that will bloom soon after planting, and, with proper variety selection, will establish and perennialize in the garden.

A related idea is the bulbs as bedding plants approach, where tulips, narcissus, hyacinths or grape hyacinths are planted in cell packs, cooled, and sold as sprouted plants for immediate spring planting in the garden, again for those customers who can't seem to get it together to plant bulbs in the fall.