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A Primer on Hydroponic Cut Tulips

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The tulip is a good example of a flower bulb crop that can be adapted to hydroponic culture. In Holland, approximately 30-35% of the cut tulip crop is forced hydroponically, and we have been evaluating this production method at Cornell over the past two seasons. While our experiences have been very positive, there are several important details to be understood and acted upon before a high quality crop can be produced. In this article, I'll present the basics of this production technology, relate some of our research results, and speculate on the future of this technology.

Basics

The basic procedure with hydroponic tulip forcing is to give approximately 75-80% of the cold requirement to dry, unplanted bulbs (Figure 1). Depending on the cultivar and time of year, this might be 12-14 weeks). Then, bulbs are "planted" into the system and a dilute calcium nitrate solution is added for rooting (about 1.0-1.2 mmhos/cm^2). Rooting proceeds at 40F for 3-4 weeks (early crops) or 2-3 weeks (later crops). The entire cold requirement thus given, the bulbs are moved into the greenhouse for forcing. In the greenhouse, plants are fed with calcium nitrate, with the goal of maintaining an EC of 1.2-1.5 mmhos/cm^2 (see Figures 2-5).

Roots

It is important to realize that the longer the rooting period (above ca. 2-4 weeks) the lower the eventual quality of the flower. This is because longer roots cause more rapid oxygen depletion of the solution, and become more susceptible to disease. Also, the longer and more entangled the roots are, the more difficult harvest is (harvesting one stem pulls up many more with entangled roots). A key realization of the success of hydroponic forcing is the relatively small root system that is needed to produce a good quality plant, probably much less than is necessary for cut tulips in soil or peat-based forcing (Figure 6).

Advantages of hydro forcing

Compared to traditional "soil" culture in "boxes" (where bulbs are planted in crates, cooled, then forced), hydroponic forcing has the following *advantages*: 1) it is 3-5 days faster than soil culture, 2) much less cooler volume is required for chilling bulbs. (This is because most of the cold period is given to densely-packed, unplanted tulips in their shipping crates), 3) harvesting is easier and cleaner (Figure 7), 4) there is no waste soil at the end, greatly reducing materials handling problems.

Why do hydroponic plants force faster than plants grown in traditional soil culture? It is not due to any inherent superiority of hydroponics, it is simply due to the prevailing temperature (ca. 40F) of the plants during the 2-4 week rooting period. This is 6-8 degrees warmer than is typical during the last few weeks of cooling, where, normally, temperatures of 32-33F might prevail to reduce stem growth in the cooler. These few degrees over a 2-4 week period can easily account to the reduced crop time in the greenhouse. Plus, in traditional cut flower forcing in boxes, the mass of the bulbs and soil are substantial, and probably take 1-2 days to warm to prevailing greenhouse temperatures.

Disadvantages of hydro forcing

The *disadvantages* of hydroponic forcing are 1) when grown at the same temperature, the ultimate quality of the stem is not quite as good as when the same cultivar is grown in soil (hydro stems tend to be 1-2" shorter and 6-8% lighter compared to substrate-grown stems), 2) not all cultivars are suited to this system, 3) very high quality and disease-free bulbs are required, especially for later plantings (Careful attention must be placed on proper bulb storage, including temperature, humidity, and ventilation), 4) especially for individual trays, a level bench or tray support system is critical to maintain a level nutrient solution (old, uneven benches won't cut it), and 5) the need for exceptional cleanliness. The trays and components are sometimes difficult to wash and sanitize (although, on a large scale, a machine could be used for this).

The weight and length issues of hydroponic tulips are solvable problems, and ongoing work in Holland is indicating that adjustments in rooting period and aeration (see below) can compensate for most of the weight and length reduction.

Available systems

After considering the biological merits of hydroponic forcing, thought must be given to the hydro system itself. As this is being written, a tray (60 cm x 40 cm, ca. 10 cm tall, designed to fit inside a black plastic bulb crate) designed by the Bulbfust Company is still the major one used in Holland. It is characterized by a grid of plastic "pins" that the bulb is pressed onto for upright support (Figure 5). The tray has two drainage holes to maintain the proper solution depth when the tray is level. A number of other systems are available from manufacturers in Holland that are very similar in appearance to large plug trays (Figures 8 and 9). These come in a variety of sizes to match the size of bulb being forced (10-11 cm, 12 cm, etc). As expected, each system has its own plusses and minuses. The Bulbfust "pin tray" has proven to be popular because it is very durable and the pins, while causing some injury to the bulbs, are usable for nearly all sizes of bulbs, and provide an infinite number of spacing and arrangement options. The plug-like trays are designed for specific bulb sizes, and multiple trays are needed if a company forces different sizes of bulbs. In either case, there are two components to handle: the crate and the water tray itself (although, this is being solved by new, larger scale systems designed to utilize larger ebb and flow greenhouse benches.

Cornell Experience and Dutch Research

Our research at Cornell has indicated that static nutrient solution (as is characteristic in individual trays) is often difficult to maintain at optimal EC, aeration and pH levels. The volume of solution in each tray is only about 10 liters; this is not a lot of solution for 60-80 tulips. We adapted our irrigation and fertilization practices such that new calcium nitrate solution (at an EC of 1.2) was used during the week, and only clear water applied on weekends. In this way, we were able to maintain the EC at an acceptable level and grew excellent quality tulips (Figure 10).

And, even though the solution in hydroponic trays is only about 1.5-2" deep, it is possible for the dissolved oxygen level in the solution to drop sufficiently low that root growth is reduced. Research in The Netherlands at the Zwaagdijk experiment station confirms this, and has demonstrated the expected advantages of larger nutrient reservoirs with solution that flows constantly over the roots. In this way, there is a greater buffering of nutrients, a slower rate of change of pH and EC, and better aeration of the solution. Thus, it should be easy to adapt existing ebb and flow benches to hydroponic tulip production. An indication of the plant and root response to simple aeration of the solution is shown in Figures 11 and 12. Interestingly, the dissolved oxygen level of our non-aerated treatment was still above the minimum needed for good growth of hydroponic lettuce crops; perhaps this indicates tulip has an especially high dissolved oxygen requirement for growth. Currently, the answer to this question is unknown.

The Future for Hydroponic Tulips?

It is easy to see hydroponic tulip production continuing to increase worldwide. In the United States and Canada, one can envision its use for large-scale production, with all the advantages above. It is also easy to see it as an interesting component for smaller retail greenhouse operations, where a few trays could be forced weekly to provide very high quality locally produced products. Because a smaller cooler volume is needed, capital costs are lower, making it easier to get into cut tulip production. Eliminating the direct cost of the substrate and the associated handling costs probably allow payment of the hydroponic trays in 2 years (although, of course, costs and savings would vary tremendously between companies). Our own experience with hydroponic tulips at Cornell has been very positive, and in most cases the advantages more than compensate for the negative aspects of this way of forcing. One thing is clear: an ultra-fresh cut flower tulip is a beautiful thing, and is rarely seen by most consumers in North America. There would seem to be many opportunities to incorporate hydroponics into the product mix of many smaller growers.

Contacts

Below are contact numbers for three of the major suppliers of hydroponic forcing systems in The Netherlands. In addition, your bulb supplier may be consulted for additional sources and information. These numbers are provided for convenience only, and are not intended to be an endorsement. Similarly, omission of information on other manufacturers is not to be taken as criticism of their products.

BulbFust: 31-227-603582, e-mail: info@bulbfust.nl
Ons-Belang; 31-252-343536, e-mail: onsbelang@flowerbulb.nl
Potveer: 31-229-542324, email: info@potveer.nl

Flower Bulb Research Program

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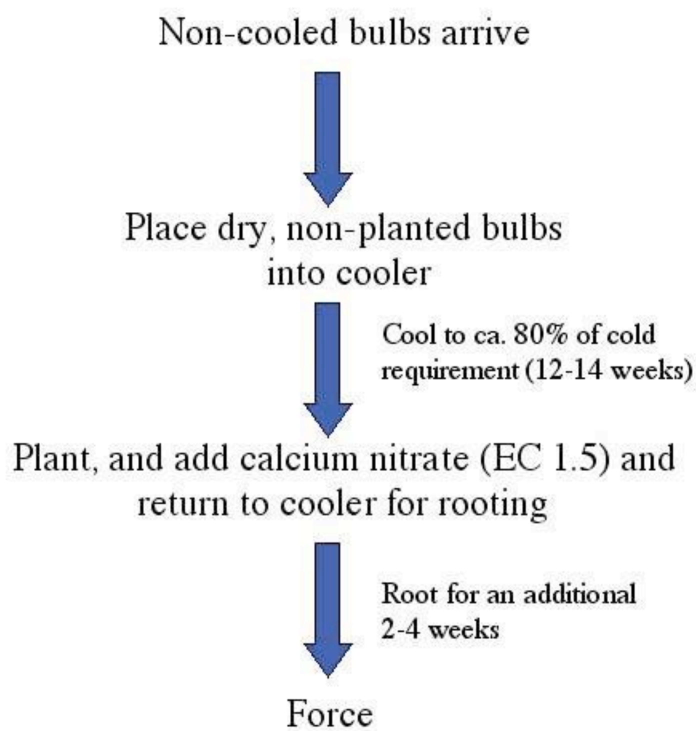

Figure 1. Basic scheme for forcing hydroponic cut tulips.

Figure 2. Cornell Research. Tulip bulbs planted in the Bulbfust "pin-tray". At this point, bulbs have received about 80% of their cold requirement (ca. 12-14 weeks). They have been pressed onto the pins, and calcium nitrate at an EC of 1.0 has been added. The tray will be placed back into the cooler at 40F for an additional 2-3 weeks of rooting prior to greenhouse forcing. Image 5344.

Figure 3. Cornell Research. Hydroponic tulip crop upon moving to the greenhouse. At this point, bulbs have received their full cooling, and will be flowering in ca. 21 days. 0112

Figure 4. Cornell Research. Several cultivars of hydroponic tulips about a week after moving to the greenhouse. Image 0113.

Figure 5. Dutch hydroponic tulip crop nearing harvest. Also, empty Bulbfust trays and irrigation tubes are visible. Image 0871.

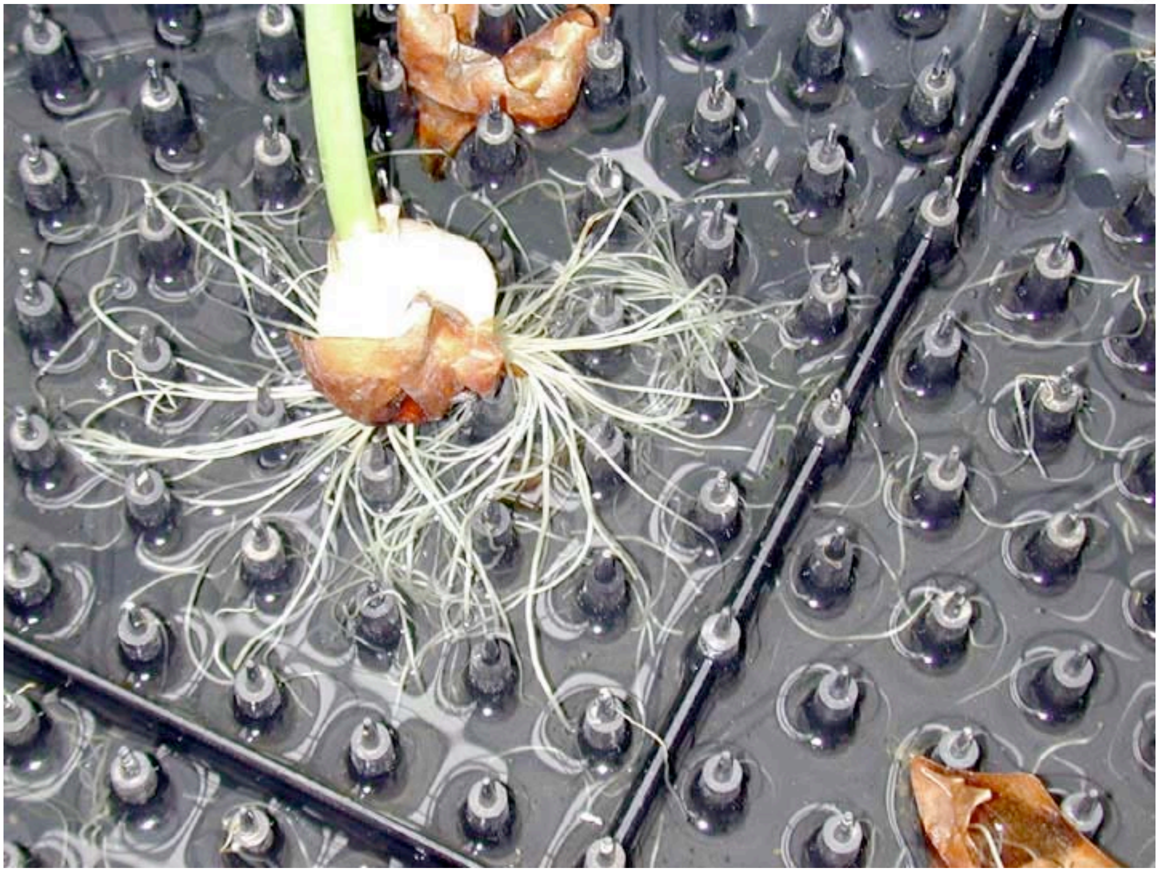

Figure 6. Example of root mass that is typical on hydroponic tulips. Also visible is the grid of "pins" that are characteristic of the Bulbfust hydroponic system. Image 0814.

Figure 7. Harvesting of hydroponic tulips in the Netherlands. Notice the lack of soil and very clean roots and stem. Image 0805.

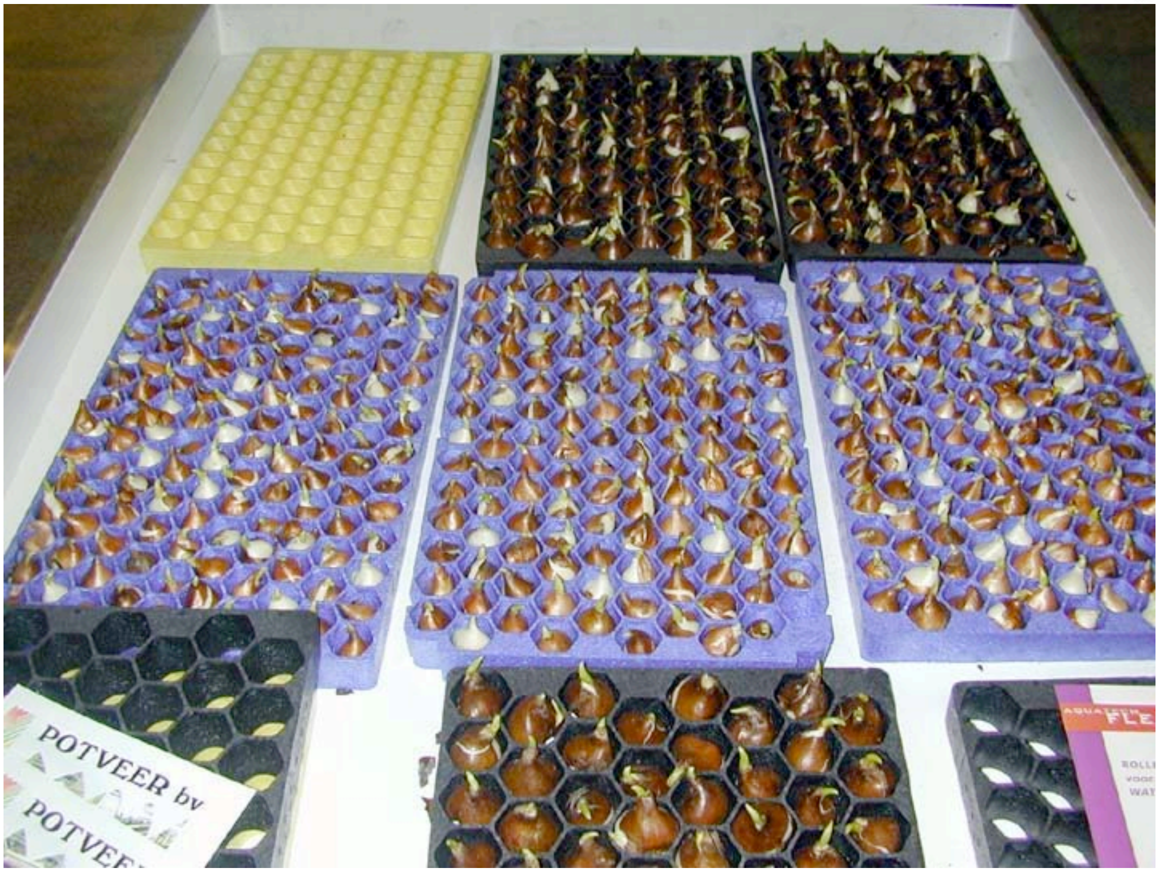

Figure 8. A partial assortment of hydroponic forcing inserts ("plug inserts") for forcing. Note different sizes of holes and bulbs. Image 4352.

Figure 9. A trade-show demonstration of a "plug tray" style hydroponic bulb insert suitable for use on the scale of a "Dutch-tray" flood system. Image 4345.

Figure 10. Cornell Research. 'Monte Carlo' tulips forced in Bulbfust hydroponic trays without supplemental aeration in 2001. Image 4853.

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Figure 11. Cornell Research. ‘Friso’ tulips grown in the Bulbfust hydroponic system. Left: Tray given supplemental aeration from a small aquarium pump and airstone; right: control plant, with no supplemental aeration. Aeration given for ca. 7 days before this photo was taken. Image 9813.

Figure 12. Cornell Research. Close-up of ‘Friso’ roots grown in the Bulbfust hydroponic system. Left: Plant grown in a tray given supplemental aeration; right: control plant, with no supplemental aeration. Image 9814.