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RESEARCH NEWSLETTER

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Flower Bulb Research Program
CORNELL

Dept. of Horticulture Cornell University
134 Plant Science Building
Ithaca, NY 14853, USA
Phone: + 1 0016072272780
Fax: + 1 0016072559998
wbm8@cornell.edu

Anthos
Royal Dutch Trade Association for Flowerbulbs and Nursery Stock

Weeresteinstraat 10
P.O Box 170
2180 AD Hillegom
Phone: +31 252 53 50 80
Fax: +31 252 53 50 88
secretariaat@anthos.org
www.anthos.org

Research Newsletter No. 35
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Bill Miller

In this newsletter: 1) Reducing tulip root growth in the cooler and 2) Effects of soil temperature at planting

There are two major topics in this newsletter. The first concerns tulip root growth in the rooting room and how root growth can be controlled and managed. The second topic looks at the effects of soil temperature at planting and how this affects tulip growth and quality. This topic is especially important for southern forcers, but everyone should make note of the important results we will discuss.

Controlling and Managing Tulip Root Growth in the Rooting Room

Why are we interested in tulip root growth in the rooting room? The answer is that many forcers in recent years have seen an uptick in problems that seem to be associated with very highly rooted plants, especially of *Botrytis tulipae, Trichoderma* and related diseases.

These diseases probably have many causes with (undoubtedly) many interactions among them. The cultivar, source (grower, field and bulb lot), environmental conditions during bulb growing, bulb harvest time and handling procedures, bulb storage regime (temperature and other factors?) and, finally, planting and cold storage conditions (substrate, moisture, cold temperature and duration) can all have an impact.

Our basic supposition is that excessive rooting in tulip plants (Fig. 1) is undesirable. The mass of circling and matted roots surely exposes the roots to more rapidly fluctuating conditions than roots that are surrounded by soil. Water, temperature and salinity conditions change much more quickly for roots in the bottom mass than for other roots in the pot.

Figure 1. A heavily rooted 6" tulip. Image 2185.

Hydroponic cut tulip production also tells us that tulips grow very well with a root system that is much less extensive than the commonly-seen root masses in pot tulips (Fig. 2).

Fig. 2 Hydroponic cut tulips. Note the small root systems, ideal for hydroponic forcing. Image 8134.

So, how do we minimize tulip root growth? There are several ways to do this, that will be described in this newsletter, most of which based on current research at Cornell by the Flower Bulb Research Program.

The main factors affecting root growth in potted (or cut) tulips are:

- Temperature in the cooler (warmer = more roots)
- Length of time for rooting in the cooler (longer = more roots)
- Whether or not the bulbs have already received cold before planting (prior cold = faster rooting)
- Moisture level in the substrate at planting (wetter soils = more roots)
- Cultivar (cultivars vary in rooting intensity)

Let us examine each of these in turn.

Temperature in the cooler.
The objective here was to document the effect of cooler temperature in rooting of tulip roots. We planted single- bulbs into 4" pots and then put them at different temperatures in controlled growth chambers. After 8 weeks, we removed soil from the roots, washed them, and took photos of the bulbs and roots.

The results were clear: tulips, like most bulbs, produce roots much faster at 10C (50F) than at lower temperatures, and produce roots only very slowly at 1-2C (33-34F). See Fig. 3 for examples, where it is clear that even after 8 weeks, bulbs rooted at 1C (33F) had barely any root growth at all.

Figure 3.

Fig 3. Root growth after 8 weeks in the in rooting room at different temperatures. Oscar (page 2) and Leen vd Mark (above). Bulbs were planted and held for 8 weeks at 1, 4, 7 or 10C in each picture. Images 7620, 7621.

This is probably why the original research on rooting room management recommended starting cooling at 9C (48F), with reductions down to 40F (4C) and 33F (1C) as rooting proceeded and shoots began growing. Tulips roots do not grow (much) at 1-2C, but grow very readily at 9C (48F). Given that the objective of the initial phase in the rooting room is to get roots on the plants quickly, a warm (9C or 48F) temperature is appropriate. However, keeping the temperature at 9C longer than needed will allow roots to continue growing rapidly. Thus, rapid reduction of rooting room temperature after roots are established is a good way to reduce excessive root growth. However, a certain caution should be exercised on the correct moment to drop temperature. It should be after all bulbs in the pot are adequately rooted. Dropping temperature when only 2 or 3 bulbs in the pot are rooted is too early, as the remaining bulbs will not develop roots as well at the colder temperature, and this will lead to uneven pots during forcing.

It is very interesting the narrow temperature band we are talking about…from 1-2C to 9C. Those few degrees of temperature are critical and therefore cooler management and *knowing what is actually happening in the cooler* is very important. Are your thermometers accurate? Are your controls working properly? This very simple experiment points out that for root growth, you can easily be too cold with bad consequences for forcing.

Substrate moisture level at planting. In this experiment, we prepared planting mix (Lambert LM-111) to different levels of moisture, relative to the water content of the mix at container capacity (which we designated at 100%). Knowing how much water was contained in the pot at container capacity (essentially, once the pot has stopped dripping after thorough watering, which was 100% water holding capacity), we prepared mixes with 15, 30, 45 and 60% of the moisture present at container capacity. We planted bulbs into these mixes (6" pots), then, (importantly!) did not water them in. The controls were watered in, and served as the 100% moisture controls. For this experiment, the crates containing the planted bulbs were wrapped in plastic film to maintain soil moisture in the pots.

The results were striking. Drier soils led to less shoot growth in the cooler (Fig. 4) and also much less root growth in the root ball (Fig. 5). We find most people to be surprised by this result. Most people believe that the drier root environment would increase root growth as the roots should grow to "seek out" water.

In fact his is not true, and the additional water is the actual driver of longer roots. As long as there is water, the cells in the roots will continue to divide and elongate (from turgor pressure)…within reason. Drier soils in the pot leads at some point to a dry enough condition where the roots no longer elongate.

Fig. 4. 1st picture: Carola. 2nd picture: Leen vd Mark. Left to right in each panel: 100%, 15, 30, 45 and 60% moisture level. Images 8919, 2173.

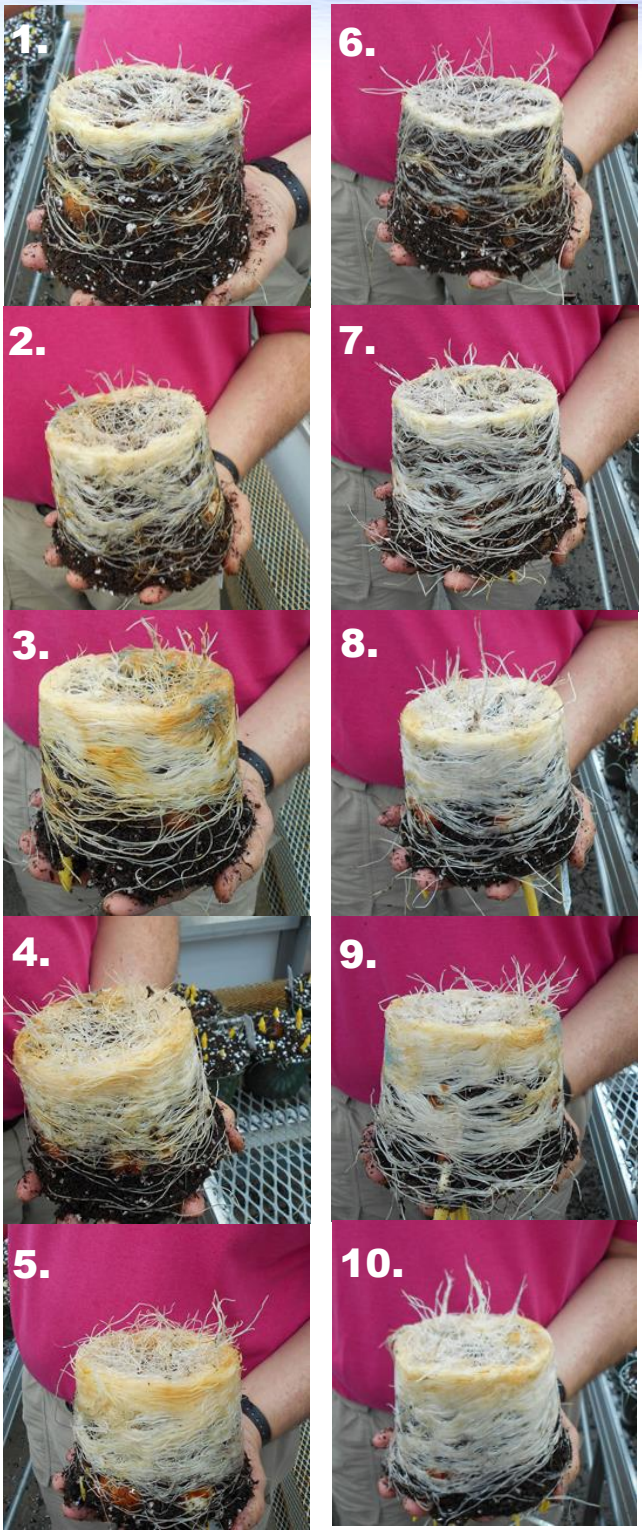

Fig. 5. Appearance of rootballs of Carola (figure 1 till 5) and Leen vd Mark (figure 6 till 10) upon removal from the cooler. Top to bottom: 15, 30, 45, 60, 100% soil moisture at the time of planting. Images 8552, 8553, 8557, 8562, 8545 (Carola) and 8569, 8573, 8578, 8584, 8568 (Leen vd Mark).

At flowering, plants rooted in the driest mixes (15 and 30% moisture) were a little shorter, and in some cases, delayed in flowering compared to plants that were watered-in (100% soil moisture) or even the wettest treatment that was not watered in (60% moisture) (Fig. 6).

Fig. 6. 1st picture: Carola. 2nd picture: Oscar. Appearance of plants at flowering, as a result of different initial soil moisture levels in the pot at planting. Left to right: 100, 15, 30, 45, 60% soil moisture. Images 2148, 2376.

What happens if you water dry pots in the cooler? Some growers do this, thinking it important to keep the moist dry throughout cooling. By accident, we conducted such an experiment, when some pots dried out, we watered some of them, and others were left dry. Plants that were watered in the cooler resumed root growth as seen in the graph (Fig. 7). This clearly shows that soil moisture level can significantly control root growth during cooling, for tulips, hyacinths and daffodils.

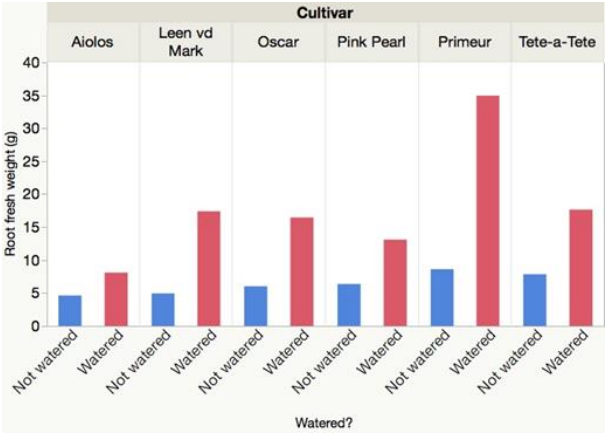

Fig. 7. Effect of watering pots during cooling in tulips, hyacinth and daffodil. Bulbs were planted and cooling started on 15 October. By 30 Dec., pots were very dry, and half were watered. In early February (5 weeks later), plants were harvested, and the graph shows final root weight as a result of the additional water. Blue bars are pots that remained dry, red bars are those given water on 30 Dec.

Dry Cooling Before Planting.

Another way to reduce root growth is to simply give them less time to grow. We learned this from hydroponic tulips, where bulbs are first cooled dry, and planted after a relatively long period of dry cold (12-14 weeks perhaps). One of the real challenges in developing hydroponic forcing was to reduce root mass in the trays. It took a number of years to fully realize that cut tulips need a relatively small root system when they are grown hydroponically, and the same is probably true for pot tulips, although the root mass needed in a pot is likely to be somewhat larger than in the hydroponic situation. The caveat being, uniformity of all 6 bulbs in a pot is important.

For this experiment, we cooled bulbs for 7, 9, 11 or 12 weeks as dry bulbs. After each duration, bulbs were planted into 6” pots then

further cooled at 4C (40F) for 9, 7, 5 or 3 weeks, such that all bulbs received 16 weeks of cold. The only difference was that they had different length of rooting times before forcing began.

When plants came into the greenhouse, those that had longer rooting time in the cooler were taller and more developed (Fig. 8). This is logical, as rapid growth and shoot elongation can really only begin after roots are present to provide water to drive cell expansion and shoot growth. Thus, shortening the rooting time after planting (precooling) inhibits total growth in the cooler. But what about roots? The results were striking. Limiting the length of rooting after planting leads to much less total root mass at the start of forcing (Fig. 9) This is probably simply due to the less time available for roots to grow, and not to the speed or intensity of rooting. Plants did not look greatly different at flowering (Fig. 10).

Fig. 8. Leen vd Mark. Left to right: Bulbs precooled 6, 8, 10, 12 weeks before planting so that bulbs has 9, 7, 5, 3 weeks of cold after planting at 4C. Image 8780.

Fig. 9. Leen vd Mark (figure 1 till 4), van Eijk (figure 4 till 8). Rootballs after a few days in the greenhouse of plants with different lengths of rooting time after planting. Top to bottom: 9, 7, 5, 3 weeks of rooting (at 4C) after planting. Images 8870, 8873, 8876, 8878 (Leen vd Mark) and 8819, 8822, 8825, 8827 (van Eijk)

Fig. 10. Canasta. 9, 7, 5, 3 weeks of rooting at 4C after planting. Image 2151.

Soil temperature for planting tulip.

This experiment was initiated from discussions with exporters and southern greenhouse companies where issues with uneven growth was seen in pot crops, especially with earlier plantings. Ultimately, this comes back around to paying attention to the fundamentals and acting on knowledge that we already probably know.

We planted Carola, Saigon, van Eijk and Yellow Flight tulips into 6" pots (Lambert LM-111) and watered them in. Then, pots were held at 9, 15, 20, 25 or 30C for 3 weeks. This was to simulate planting bulbs into warm soils as could exist in southern nurseries, whether from stockpiles in warm buildings or from piles of mix that could still be heating from sun and decomposition activity. We maintained the warm temperatures for 3 weeks based on the estimation that a rooting room filled with pots of warm soil would probably take 3 weeks for the most central pots to cool to the set point.

As with many experiments herein, the results were striking. The warm temperature treatments were devastating to plant growth. The two warmest temperatures, 25 and 30C were devastating to early shoot growth and final plant quality. For example, Carola held at 25C for 3 weeks only had 4.5 healthy plants per pot (out of 6 bulbs) and when this increased to 30C, the loss was fully half of the plants (Fig. 11). Saigon was even more devastated by the 30C treatment, but was much less affected by the next cooler treatment of 25C. 'Yellow Flight' was, overall, affected *less* than 'Carola' and 'Saigon' but still suffered 33% shoot failure at 25 or 30C. Van Eijk was the least affected of the 4 cultivars, but still lost nearly 1 out of 6 bulbs at 30C. Examples of the plants are given in Fig. 12.

Very early in forcing, above-ground symptoms were uneven growth of the shoots in the pot and failed emergence of one or more shoots per pot. Bulbs of failed or slow growing shoots were rotten and smelled of *Fusarium*.

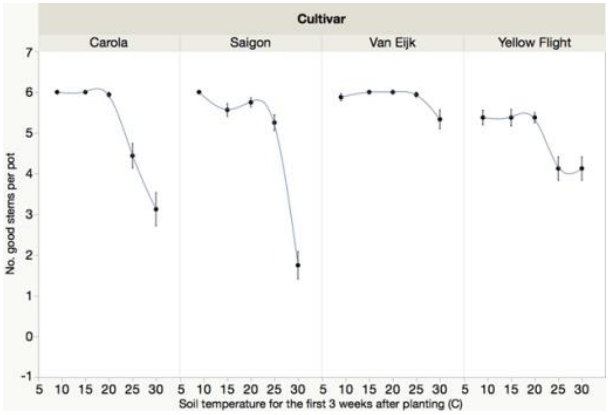

Fig. 11. Effect of varying soil temperatures for the first 3 weeks after planting on the final number of good plants (out of 6 bulbs per pot).

Do tulip roots continue to grow in the greenhouse?

While we have learned a lot about root growth in the cooler, we know just as little about root growth in the greenhouse. In hydroponics, we can observe that tulip roots do growth during actual forcing.

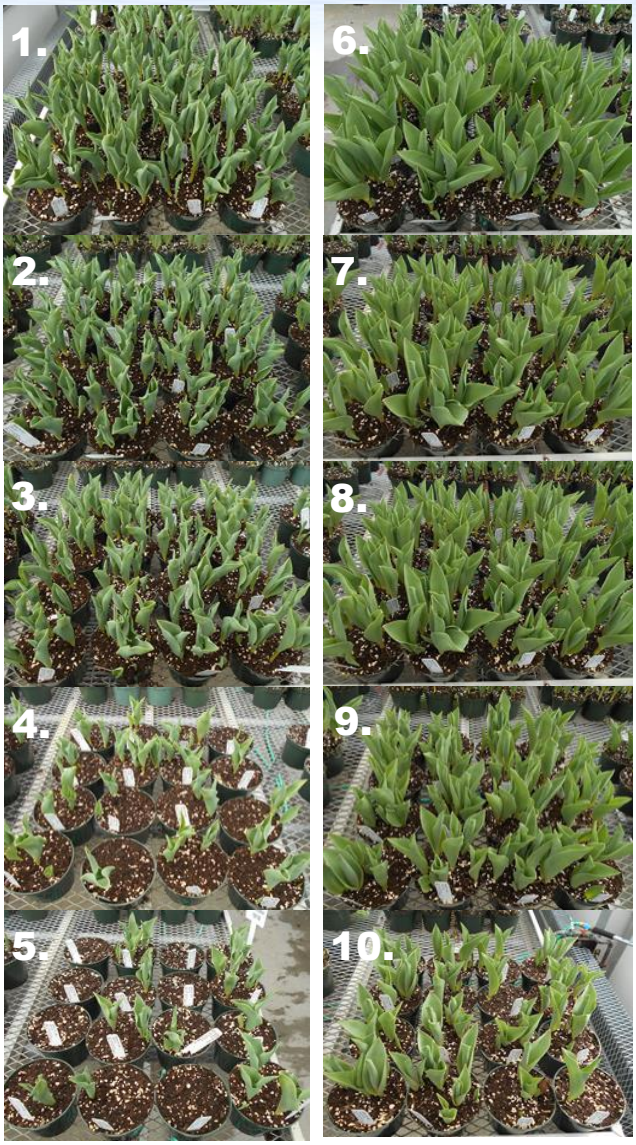

Fig. 12. Appearance of Carola (figure 1 till 5) and van Eijk (figure 6 till 10) plants as a result of 3 weeks of (top to bottom): 9, 15, 20, 25, 30C soil temperatures for 3 weeks after planting. After the temperatures, rooting proceeded as usual at 9C. All plants received 16 weeks of cold. Images 9516, 9518, 9519, 9520, 9521 (Carola) and 9537, 9539, 9540, 95412, 9542 (van Eijk).

But, what happens in pots? We set up two treatments, bulbs planted and cooled on 14 October, and others that started dry cold on 14 October, but were not planted until 11 January. Plants came into the greenhouse on 3 Feb, so each has 16 total cold weeks. We did this two times (two "sets") during the 2016 season.

The results were very interesting, and perhaps not what you would think (Fig. 13) Plants that received all their cold after planting had more roots (measured as total root fresh weight) when they came into the greenhouse (note the difference between the red line, which was planted and received all cold after planting) versus the blue lines, where bulbs only had 4 weeks of rooting before forcing. There were more roots in the bulbs planted in the fall, versus January. But, those same plants, in most cases, steadily lost root weight while in the greenhouse, where as plants that had 12 weeks of dry cooling before planting showed slowly increasing root weight (in most cases). This is similar to what we see in hydroponic tulips. What is surprising is that it seems that fully rooted plants – those who received all their cooling after planting – showed essentially no increase in root mass in the greenhouse.

What is happening to the roots of normally cooled plants? Probably, they are beginning a slow and continuous loss of vitality from the moment they come into the greenhouse. The trick, then, is to maintain these roots in a healthy state, and the fact they are heavily rooted is the crux of the problem. Fewer roots, as in the dry cooled plants, leads to the potential for these roots to continue growing, and thereby may help in maintaining their vitality.

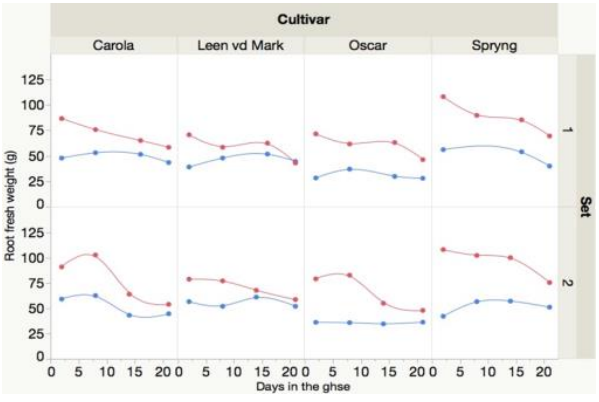

Fig. 13. Tulip root growth in the greenhouse, during forcing. Red: plants cooled for 16 weeks after planting. Blue: plants dry-cooled for 12 weeks, then planted and further cooled 4 weeks before forcing.