



While 'Tête-a-Tête' narcissus is a miniature plant, it shows robust growth in postharvest. Left: Plant in a 4-inch pot at first flower opening. Right: Similar plant after being in an interior room at 70° F for seven days. (Photos courtesy of Bill Miller)

Using PGRs on Spring Bulbs

Proper cultivar selection, length of cooling and forcing temperature can all affect plant height.

By Bill Miller

Flower bulbs comprise a significant proportion of spring production in many North American greenhouses. Their quick greenhouse time, close spacing and "green" reputation (little fertilization required, limited pest problems) are all attractive to growers. In North America,



Effect of length of cold period on height of tulip cultivar 'Pinocchio'. Plants were given 17 weeks (top) or 22 weeks (bottom) of cold. Within each panel, the treatments were (left to right): control, 1 mg Bonzi drench, 2 mg Bonzi drench. (Plants in the bottom panel had been in a cooler for a day before the photo was taken).

many of the crops and cultivars are too tall when grown in 4- or 6-inch pots, and this is one of the issues we are addressing at Cornell University.

In many cases, the real issue for growth regulation of spring bulbs does not come during production but during postharvest. This is clearly seen above with the miniature 'Tête-à-Tête' daffodil as it appears during marketing and after seven days in a typical interior (consumer) environment at 70° F. Similar exuberant growth is seen in many hyacinth cultivars. Thus, spring bulb growth regulation is often a case of PGR application in the greenhouse for growth control in the low light and warm interior environment.

FACTORS AFFECTING HEIGHT

Cultivar. Effective height management in bulb crops depends on proper cultivar selection. Most tulips were originally selected for use as cut flowers. Therefore, for effective use as potted plants, PGRs are generally needed. There is a constant (and increasing) stream of new tulip cultivars being introduced, with increasing emphasis on cultivars adapted to pot culture without the need for PGRs. Across the range of bulb genera, there are numerous other examples of smaller cultivars available for pot forcing: Dwarf lilies, dahlias, daffodils and amaryllis are but a few.

Length of cold. Tulips, daffodils and hyacinths all share a common characteristic: The longer the length of cooling (and



The 2002 spring season represents the second major forcing year of the Flower Bulb Research Program at Cornell University. Established in 1998, the first two growing seasons were devoted to facilities upgrades (including new greenhouses), installation of about 700 sq. ft. of state-of-the-art rooting rooms and capacity building of students and technical support. Cornell's flowerbulb work is conducted in close cooperation with a research advisory group from The Netherlands, with input from many growers and industry stakeholders in the United States. Major areas of emphasis include the development of new forcing information (for example, the use of Fascination on lilies); evaluation of bulb cultivars for landscape use in differing climates (including upstate New York, Long Island and the Southeast in cooperation with Jim Faust at Clemson University); packaging and handling of bulbs, especially for spring retail sales; and the analysis of factors affecting deer and vole predation of bulbs.

rooting) before forcing, the taller the plant ultimately will be. Therefore, not exposing plants to excessive lengths of cold can achieve a significant degree of height control. The obvious problem here is that growers want to plant their entire bulb crop at one time. While efficient at the start, this method leads to excessive height and possible lost quality for the last crops of the year. Cooling bulbs to the proper length would require bulbs to be delivered at differing times or for proper temperatures to be applied at each grower's facility. Labor scheduling can be an issue as well.

Temperature. Generally speaking, warmer forcing temperatures promote greater overall elongation of bulb crops. A good example can be seen in pot freesia, where George Wulster showed that increasing temperature from 50-68° F doubled plant height.

PLANT GROWTH REGULATORS

With most spring bulbs, the primary PGR application is by media drench. This is especially true for tulips, and to date, the major products used have been ancymidol (A-Rest) and paclobutrazole (Bonzi). Hyacinths and daffodils are an exception, and foliar sprays with ethephon (Florel) are the standard treatments used. While an important product for Easter and hybrid lilies, Sumagic has not emerged as a major PGR on rooting-room bulb crops even though it is an effective product in many cases.

A few words on media drenches are in order. The optimum drench completely saturates the media with solution and allows less than 10 percent of the applied volume to leach. This is especially true for bulb crops where the vast majority of the roots are in the bottom third of the root ball. Typically, drenches are applied in two or four ounces of volume for 4- and 6-inch pots, respectively. Recipes are given in Table 1 on the right. To ensure even solution dispersal, plants should be watered 24 or fewer hours before applying the drench. Drenching into an overly dry media may lead to unevenness from channeling, or at the very least, less PGR effect as the material may not penetrate to the bottom third of the pot where the roots are.

The rate ranges, products and application methods are given below

Table 1. Selected recipes for the preparation of PGR drench solutions for bulb crops grown in 4- or 6-inch pots.

CHEMICAL AND DOSE (MG PER POT)	PPM OF SOLUTION	FLUID OUNCES/ GALLON OF FINAL SOLUTION	MILLILITERS/ GALLON OF FINAL SOLUTION	MILLILITERS/ LITER OF FINAL SOLUTION
<i>For 4-inch pots, apply 2 fluid ounces (60 ml) per pot</i>				
A-Rest				
0.125	2.1	1.0	30.2	8.0
0.25	4.2	2.1	60.5	16.0
0.50	8.5	4.1	120.9	32.0
1.0	16.9	8.2	241.9	64.0
Bonzi				
0.5	8.5	0.3	8.0	2.1
1.0	16.9	0.5	16.0	4.2
1.5	25.3	0.8	24.0	6.3
2.0	33.8	1.1	32.0	8.4
Sumagic				
0.1	1.7	0.4	12.8	3.4
0.2	3.4	0.9	25.5	6.8
0.3	5.1	1.3	38.3	10.1
0.4	6.8	1.7	51.1	13.5
<i>For 6-inch pots, apply 4 fluid ounces (120ml) per pot</i>				
A-Rest				
0.125	1.1	0.5	15.1	4.0
0.25	2.1	1.0	30.2	8.0
0.50	4.2	2.1	60.5	16.0
1.0	8.5	4.1	120.9	32.0
Bonzi				
0.5	4.2	0.1	4.0	1.1
1.0	8.5	0.3	8.0	2.1
1.5	12.7	0.4	12.0	3.2
2.0	16.9	0.5	16.0	4.2
Sumagic				
0.1	0.8	0.2	6.4	1.7
0.2	1.7	0.4	12.8	3.4
0.3	2.5	0.7	19.2	5.1
0.4	3.4	0.8	25.5	6.8

for the major spring crops. Additionally, the *Holland Bulb Forcer's Guide* is an important reference for forcing bulbs, and the industry owes a

great debt of gratitude to Gus de Hertogh for its conception and refinement over the years. It is an essential reference for anyone producing bulbs commercially and is highly recommended. Specific use rates by cultivar and forcing period can be found there.

HEIGHT CONTROL METHODS

Tulip. A key point is that the longer a tulip is cooled (especially while it is rooted), the taller it will be, all other things being equal. Thus, within the confines of labor, facilities and management limitations, avoiding excessive cooling can provide a good degree of height control. A second key point is that growers should constantly check their crops in the rooting room and promptly reduce temperatures to 32-33° F after all plants are rooted. Reducing temperature reduces shoot elongation in the cooler and may also help to control unneeded root growth that can lead to problems with *Trichoderma* fungus. The difference between 32-33° F and 40-42° F is enormous for bulb stem elongation over a 6-8 week period.

The typical treatment for tulips is to apply a Bonzi or A-Rest drench within 1-2 days of mov-

ing into the greenhouse. Rates vary from 0.125-0.5 mg per pot of A-Rest and approximately 0.5-2 mg per pot Bonzi, depending on cultivar and time of year. Delaying the drench will give significantly less growth control, as much of the PGR effect is concentrated in the bottom internode of the plant. Conversely, Bonzi and Sumagic are both effective in reducing the elongation of the top internode and can provide good height control in the postproduction environment.

Experimentally, pre-plant bulb soaks in Bonzi or Sumagic are effective on tulips. While not recommended as a potted plant, certain dip treatments are practically capable of tailoring 'Apeldoorn' into a usable, 4-inch plant. Another interesting find is that even with severe height reduction, there is essentially no delay in flowering, nor any reduction in flower size. Also, we have achieved effective height control by drench-



Left: 'Apeldoorn' tulips in 4-inch pots. Bulbs were dipped for 10 minutes in PGRs, planted, cooled for 16 weeks and forced at 62.5° F. Treatments (left to right): control, 50, 100, 200, 400 ppm Bonzi, 5, 10, 20, 40 ppm Sumagic. Right: 'Anna Marie' hyacinths precooled at 48° F starting October 5. On November 1, bulbs were dipped in PGR solution for 10 minutes, planted November 2 and placed back into the cooler (with temperature decreasing from 48-35° F) for a total of 13 weeks of cold (left to right): control, 400, 200, 100 ppm Bonzi; 40, 20, 10 ppm Sumagic. Plants were forced to the first open flower stage, then placed in a low light room at 70° F. Photo taken seven days later.

ing with Bonzi or Sumagic immediately after planting and prior to cooling.

Hyacinth. While most hyacinths flower within the “aesthetic ratio,” their very heavy flower stalks often topple over. Cultivar selection can help avoid this problem. Aside from cultivar selection, Florel is commonly used for height control in hyacinths and results in shorter, stockier flower stalks that are more resistant to toppling. The safe window for spraying Florel is short; it should be sprayed

when the plants are 3-4 inches tall, but the flowers must not show full color at spraying. Some cultivars require a second application (2-3 days after the first) to keep the flower stalks sufficiently short; be certain to consider this in relation to the timing of the first spray. If flowers are open, Florel can cause premature senescence. Florel should be sprayed to run off onto well-watered plants. To avoid water on the leaves of flowers at night, a late morning to early afternoon application is rec-

ommended. Guidelines for preparation of Florel solutions are given below.

We have been experimenting with bulb dips and pre- or post-cooling drenches of Bonzi or Sumagic. Bonzi or Sumagic pre-plant dips were effective in controlling height of prepared ‘Anna Marie’ hyacinths. In these experiments, you can see that leaf length was drastically reduced, as was stem length below the flowers. While individual flower size was not affected, the length of the inflorescence was reduced, leading to a tighter appearance. Our trials exploring cultivar effects and alternative application methods continue.

Narcissus. Many potted daffodil cultivars are sprayed with 1,000-2,000 ppm Florel when the leaves and/or flower stems are 3-4 inches long in the greenhouse. With

Table 2. Guidelines for preparation of Florel solutions for use as foliar sprays on hyacinths or daffodils.

Parts per million	fl. oz./gal Final Solution	ml/gal Final Solution	ml/L Final Solution
500	1.62	47.86	12.64
1,000	3.24	95.73	25.29
2,000	6.48	191.46	50.58



Left: 12/14 cm ‘Tête-a-Tête’ plants, cooled 15 weeks, forced to bud color, then held seven days in a low light, 68° F postharvest room when the photo was taken (left to right): control, 50, 100, 200, 400 ppm Bonzi given as 10-minute pre-plant dips. Right: Effect of planting date relative to start of cold on growth of grape hyacinth (*Muscari armeniacum*). All plants received a total of 16 weeks of cold at 45° F (left to right): planted at the start of cold or planted after 4, 8 or 12 weeks of dry cold. All plants were moved to the greenhouse on the same date. Note shorter leaves on plants planted after increasing duration of dry cold.

some cultivars, and especially for late crops where plants have received excessive cold weeks, a second spray 2-3 days later is suggested. Data for many cultivars can be found in the Forcer's Guide.

One cultivar that has no height

control recommendation in the guide is Tête-à-Tête, the most highly used potted daffodil in North America. As mentioned above, this cultivar is susceptible to excessive elongation from the moment the first flowers open. In the postproduction phase, we have seen positive results from Florel sprays (1,000 ppm) applied in the greenhouse at a stage when leaves are substantially unfolded but before buds are readily visible. We have also seen positive results with Bonzi applications, either as pre-plant dips, pre-cooling drenches or as drenches 1-3 days after placement in the greenhouse. All three methods with Bonzi have given positive results over a 2-year period. At present, however, we still consider these to be experimental treatments and look forward to providing more concrete recommendations in the future.

Muscari (grape hyacinth). Grape hyacinth is a highly desirable plant with wonderfully fragrant flowers. Unfortunately, the leaves grow too long and detract from the plant. This is because Muscari leaf growth begins at the end of summer. If you have grape hyacinths perennialized in your

garden, you will see a lush crop of leaves emerge in early fall that persist through the winter.

Typically, growers plant grape hyacinths in the fall, placing them into the rooting room for 14-plus weeks, depending on the marketing date. In the rooting room, leaf growth is retarded by low temperature, especially if the cooler is at or close to 32° F. Upon moving to the greenhouse, leaf growth is very rapid and much more vigorous than flower-stem growth. Consequently, flowers are often buried in the foliage. We have not worked on a growth regulator solution to this problem but do know that "late planting" is an effective method of producing a high-quality plant with shorter leaves.

Late planting is simply planting the bulbs after a substantial part of the cooling phase is complete. Thus, bulbs would be cooled dry (unplanted), using the regular rooting room. Bulbs are planted only after a significant proportion (perhaps 70-75 percent) of the cold weeks have elapsed. Then, bulbs are planted and cooled at 40-45° F for the last 25-30 percent (3-4 weeks) of cold. It is critical to give the proper

total length of cold (before and after planting), as the bulb perceives cold in both stages. Delayed planting has no effect on flowering date or quality but does give shorter, less-rank leaves and markedly improves plant quality. 

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