Ethephon Dip Concentration and Heat Cure
ning Duration Influence Forcing Performance of Dutch Iris

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Abstract. When compared to non-eTHEPHON treated bulbs, time to flowering of U.S.-grown Dutch iris (Iris hollandica Hoog) "Ideal" and 'Blue Ribbon' was shortened by 14 and 27 days, respectively, by dipping bulbs for 1 hr in a solution of eTHEPHON at a concentration of 0.25 g-liter\(^{-1}\) and then heat curing at 32°C for 3 days. This treatment also decreased leaf number and maximum leaf length. Thus, the plants were commercially more acceptable than those not treated with eTHEPHON. With 'Blue Ribbon', treatment with eTHEPHON at 5.0 g-liter\(^{-1}\) reduced flowering percentage relative to that obtained with several lower concentrations because of prevention of flower initiation. Chemical name used: (2-chloroethyl)phosphonic acid (eTHEPHON).

Ethephon treatments have been used to promote earlier and more reliable flowering of bulbous iris (5, 9-11, 16). In the Netherlands, spraying iris plants in the field with eTHEPHON several weeks before the shoots senesced reduced the number of plants that failed to initiate or abort flowers (5, 9). This treatment, however, causes undesirable flowering of planting stock and has not received wide-spread commercial use. Other studies in The Netherlands (16) conducted with 'Ideal' showed that bulbs placed in a solution containing eTHEPHON at 0.2 g-liter\(^{-1}\) for 24 hr before dry storage flowered earlier and more uniformly than those not treated. Similarly, French researchers (10, 11) found that when bulbs of 'Ideal' or 'Blue Ribbon' were dipped for 15 min in a solution containing eTHEPHON at 0.5 g-liter\(^{-1}\), plants showed increased flowering percentage, earlier flowering, and required less high-temperature storage than plants grown from untreated bulbs.

The United States is a major producer of bulbous iris (2). Bulbs are grown in the Pacific Northwest and shipped to forcers throughout the country. Because iris bulbs from different growing regions and climates require different forcing conditions (4), we investigated the effects of heat curing duration and eTHEPHON concentration on the early forcing performance of 'Ideal' and 'Blue Ribbon' iris, the two most important cultivars grown in this country. Preliminary results (1) showed that certain eTHEPHON treatments could enhance early forcing performance of iris grown in the Pacific Northwest, and also provided background information on the effect of heat curing durations with eTHEPHON-treated bulbs.

'Ideal' (10 to 11 cm in circumference) and 'Blue Ribbon' (12 to 13 cm in circumference) bulbs were harvested in Aug. 1986 from commercial fields in western Washington. These bulbs were dipped for 1 hr at 20°C into solutions of eTHEPHON at 0.25, 0.5, 2.5 or 5.0 g-liter\(^{-1}\) and then were air dried before being heat cured at 32°C for either 0, 3, or 6 days. After these treatments, bulbs were held for 2 weeks at 18°C and then for 6 weeks at 10°C. Bulbs were planted in a synthetic potting medium (Redi-Earth) using (16 × 16 × 14 cm deep) plastic pots and grown in the greenhouse arranged in a randomized complete block design with five blocks and three bulbs per pot. Greenhouse temperature was maintained between 16° and 21°. Additional illumination was provided from 0600 to 2200 hr each day by three 400-W high-pressure sodium lamps suspended 1 m above each 1 × 4 m bench (photon flux density of supplemental lighting = 115 μmol·s\(^{-1}·m^{-2}\)). Leaf number, maximum leaf length (soil surface to uppermost leaf tip), and flower stem height (soil surface to tip of flower) were measured on the harvest date of each plant. Flowers were harvested in the bud stage when about one-half of the corolla was visible.

Treatment with eTHEPHON and heat curing decreased the number of days from planting until flowering (Fig. 1). The shortest greenhouse phase for 'Ideal' was obtained with eTHEPHON at either 0.25 or 0.5 g-liter\(^{-1}\) and 3 days of heat curing. These combinations reduced the needed greenhouse phase by about 20% relative to the control (Table 1). Heat curing the bulbs for 3 days in combination with eTHEPHON at 0.25 g-liter\(^{-1}\) was the most effective treatment in shortening the period from planting to flowering with this cultivar. With 'Blue Ribbon', this period was reduced by about 30% in comparison to an untreated check by treatment with eTHEPHON at 0.25, 0.5 or 2.5 g-liter\(^{-1}\) followed by 3 days of heat curing (Fig. 1).

In general, the eTHEPHON treatments tested did not affect the percentage of bulbs that flowered. However, with 'Blue Ribbon' a dip in eTHEPHON at 5.0 g-liter\(^{-1}\) markedly reduced the number of flowering bulbs by preventing floral initiation (Table 1).

Ethephon treatment decreased leaf number and maximum leaf length in both cultivars (Table 1). The effect of 0.25 and 0.5 g-liter\(^{-1}\) on leaf length was similar. 'Blue Ribbon' plants forced from bulbs dipped in eTHEPHON at 2.5 g-liter\(^{-1}\) had an average leaf length 16 cm shorter than that of bulbs treated with 0.5 g-liter\(^{-1}\). 'Blue Ribbon' is noted for excessive leafiness, and bulbs of this cultivar destined for early forcing are usually given an extended precooling treatment, 8 to 10 weeks, to reduce leaf length (6, 7). Results presented here suggest that a reduction in precooling duration may be possible by selection of appropriate eTHEPHON dip concentrations. Flower stem height was very uniform (Table 1) in both cultivars and was reduced only by treatment with eTHEPHON at 5.0 g-liter\(^{-1}\).

This study showed that a postharvest dip in eTHEPHON can be used to promote earlier flowering of 'Ideal' and 'Blue Ribbon' Dutch iris grown in the Pacific Northwest of the United States. This growth regulator did not only reduce the greenhouse forcing time, but also decreased the time required for heat curing (when compared with the standard treatment (usual­ly 10 to 20 days) (2). Another positive effect of eTHEPHON application was a reduction in the number of leaves and in the maximum leaf length. De Munk (3) has suggested that ethylene treatments, which cause these same effects, make possible a planting density greater than that possible without such treatment, an economic consideration for greenhouse forcers.

Although treatment with ethylene gas or smoke generated using grass straw can also enhance early forcing performance of bulbous iris (1, 3, 8, 13-15), an eTHEPHON dip treatment would be preferable for some growers because ethylene gas treatment requires specialized equipment. Facilities for dipping bulbs are available at virtually all bulb-growing establishments in the United States, because hot water dips are often used to control pests (12).

The following eTHEPHON dip treatments appear to serve as a starting point for developing successful forcing schemes: Treat freshly lifted bulbs for 1 hr at 20°C with...
Table 1. Effect of ethephon dip concentration on forcing performance of ‘Ideal’ (ID) and ‘Blue Ribbon’ (BR) Dutch iris.a

<table>
<thead>
<tr>
<th>Ethephon concentration (g-liter⁻¹)</th>
<th>Days to flower</th>
<th>Leaf number</th>
<th>Leaf length (cm)</th>
<th>Flower stem height (cm)</th>
<th>Percent flowering</th>
</tr>
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<tr>
<td></td>
<td>ID BR</td>
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<tr>
<td>0</td>
<td>58 a 97 a</td>
<td>5.8 a 7.4 a</td>
<td>56 a 100 a</td>
<td>55 a 56 a</td>
<td>96 a 98 a</td>
</tr>
<tr>
<td>0.25</td>
<td>46 c 79 b</td>
<td>5.2 b 6.5 b</td>
<td>49 b 81 b</td>
<td>53 a 52 a</td>
<td>98 a 93 a</td>
</tr>
<tr>
<td>0.5</td>
<td>47 c 77 b</td>
<td>5.0 b 6.5 b</td>
<td>50 b 74 b</td>
<td>54 a 52 a</td>
<td>98 a 96 a</td>
</tr>
<tr>
<td>2.5</td>
<td>50 b 81 b</td>
<td>5.2 b 6.4 bc</td>
<td>42 c 58 c</td>
<td>52 a 53 a</td>
<td>98 a 93 a</td>
</tr>
<tr>
<td>5.0</td>
<td>53 b 84 b</td>
<td>5.1 b 5.8 c</td>
<td>37 d 45 d</td>
<td>47 b 49 b</td>
<td>93 a 71 b</td>
</tr>
</tbody>
</table>

aData are treatment effect means including all three heat curing durations for 15 replications (pots), three plants per pot (mean of 45 observations). Means within a column followed by the same letter are not significantly different at the 5% level of probability as determined by Tukey’s studentized range test. For analysis of variance, flowering plants were scored as 1 and nonflowering plants as 0.

Ethephon at 0.25 to 0.5 g-liter⁻¹ for ‘Ideal’, and 0.25 to 2.50 g-liter⁻¹ for ‘Blue Ribbon’, followed by heat curing (32°C) for 3 days. Then, subject bulbs to standard post heat curing treatments, namely: hold at 18°C for 2 weeks (could occur in transit), precool at 10°C for 6 weeks for ‘Ideal’, and for 6 to 10 weeks for ‘Blue Ribbon’, and force in the greenhouse. Ethephon should be used with caution because, as demonstrated, bulbous iris cultivars differ in their response to ethephon concentrations.

Literature Cited

13. Schipper, J.A. 1982. A smoke treatment in-

Fig. 1. Effect of ethephon dip concentration and heat curing on the number of greenhouse days for 'Ideal' (ID) and 'Blue Ribbon' (BR) Dutch Iris. Each bar represents the average of five replications (pots), three plants per pot (mean of 15 observations). LSD₄,₅,₆ = 3.1 for ‘Ideal’ and 8.6 for ‘Blue Ribbon’.

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Comparison of Paclobutrazol Tablets, Drenches, Gels, Capsules, and Sprays on Chrysanthemum Growth

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Abstract. Paclobutrazol drenches were more effective in retarding chrysanthemum (Chrysanthemum × morifolium ‘Charm’) plant height than paclobutrazol incorporated in plaster-of-Paris tablets, injected hydrogels, and gelatin capsules applied at the same rate (0.5 mg a.i./15-cm pot) in three experiments. Capsules containing paclobutrazol also controlled plant height effectively in all three experiments. Drenches consistently reduced plant area, whereas a 50-ppm paclobutrazol spray did not. Paclobutrazol tablets, gels, and capsules reduced plant area in two of three experiments. Drenches were the only treatment to reduce flower number per plant. Chemical name used: β-[4-chlorophenyl]-α(1,1-dimethylethyl)-1H,1,2,4-triazole-1-ethanol (paclobutrazol).

Paclobutrazol is a growth retardant that has shown promise for controlling the growth of chrysanthemum (Dendranthema grandiflora Tzvelev. (Chrysanthemum × morifolium Ramat.).) Shanks (9) reported that paclobutrazol is effective as a spray or drench on chrysanthemum, whereas McDaniel (5) found sprays ineffective. Paclobutrazol may be absorbed by the leaves and stem, but only that absorbed by the stem is effectively translocated to retard growth (2). Wilfret (11) demonstrated that paclobutrazol was more effective as a drench than as a spray on poinsettia. Various workers have noted that, in general, media drenches use less-active material and lower concentrations, and are more effective, but are more labor- and time-consuming than foliar sprays (3, 6). Working with α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol (anycimidol), Tschabold et al. (10) observed that, while the concentration of a drench is low, 61% of the material is lost in leaching. Of the remaining material, 70% is located in the upper 50 mm of the medium, which may not contain enough roots for adequate absorption. Attempts to solve some of the problems of media-applied retardants have included encapsulated (7) or granular formulations (6, 12), impregnated clay pots (4), and tablets (9). Paclobutrazol is not as soluble in water as some of the other growth retardants (1), so alternate application methods to place the material in the root zone may be a very feasible and efficient method of application. The purpose of the present research was to compare the effectiveness of paclobutrazol tablets, gels, and capsules with drenches and sprays on the growth of chrysanthemum.

Three experiments (Expt. I: 19 Feb.–1 May, Expt. II: 26 Feb.–12 May, Expt. III: 21 Mar.–3 June 1986) were conducted using ‘Charm’ cuttings directly rooted (four per 15-cm pot) under mist with 22°C bottom heat, daily radiation of 972 µmol m–2 s–1 (PAR) and a minimum night temperature of 17°C. The medium was soil: 1 sphagnum peat: 1 perlite (by volume) amended (all in m3) with 2.6 kg dolomite limestone, 1.2 kg superphosphate, 0.9 kg gypsum, and 0.4 kg Micromax (Sierra Chemical Co., Milpitas, Calif.). During the 7 days of rooting under mist and for the next 2 weeks, plants received incandescent lighting from 2200 to 0200 hr (2 µmol m–2 s–1). Plants were pinched 16 days after the start of propagation. After 3 weeks, the plants were moved to a minimum night 17°C greenhouse with daily radiation of about 1166 to 1545 µmol m–2 s–1. Black cloth was applied to the plants from 1630 to 0830 hr daily 21 days after the start of propagation and continued until the flower buds showed color.

Paclobutrazol 0.5 mg a.i. each of drenches, gels, and capsules were applied 16 days after propagation started. Drenches were aqueous solutions poured (120 ml per 15-cm pot) on the medium surface. To facilitate tablet, gel, and capsule treatment in the root zone, a 5-cm-deep hole was punched in the medium in the middle of each pot. Tablets were cast from mixtures of plaster-of-paris, water, and paclobutrazol powder to produce a 2.5-cm³ cube. Gels were made from hydrogel (Viterra, Nepera Chemical Co., Harriman, N.Y.) and 10 cm³ of gel was injected into the medium with a hypodermic syringe. Gelatin No. 000 capsules were filled with a mixture of dried non-fat milk and paclobutrazol powder for capsule treatments. Spray treatments were applied one month after propagation started, when new shoots were 2.5 cm long, using a low-temperature high-volume sprayer to apply a 50 ppm (about 0.5–0.75 mg a.i. per pot) spray until runoff. A check was included, with treatments being applied in a randomized complete block design with five replications.

Each experiment was analyzed separately with data on plant height, plant area (diameter of plant measured perpendicularly in two directions and multiplied together), and flowers per plant being collected when 50% of the flowers were open. Three rootballs were picked at random and vertically sliced to determine the presence and condition of the tablets, gels, and capsules at the end of each experiment. Means were separated with Duncan’s multiple range test after analysis of variance.

Paclobutrazol drenches and capsules consistently retarded height in all experiments. Plant heights were retarded most by paclobutrazol drenches (Table 1). The second most effective treatments were capsules containing paclobutrazol. Tablet- and gel-treated plants were shorter than untreated plants in two out of three of the experiments. The inconsistent performance of tablets and gels in experiments may be attributed to chemical or physical bonding by these forms, resulting in a slower release or in less paclobutrazol released; however, other causes, such as environment, could be involved. Paclobutrazol sprayed plants did not differ in height from untreated plants in two experiments, confirming results of other workers (2, 5). Erratic height control with paclobutrazol sprays has been attributed to poor spray coverage, poor absorption and translocation by the leaves, or failure to reach the plant stem (2).

When paclobutrazol was used as a drench, plant area retardation was 61% to 66% (Ta-