Development of Methods for the Use of Ethylene or Ethephon to Improve Early Forcing Performance of Dutch Iris Grown in the Pacific Northwest of the United States

Special Report 836
March 1989

Agricultural Experiment Station
Oregon State University, Corvallis
in cooperation with
USDA
Agricultural Research Service

Summary

Ethylene or ethephon treatment can be used to improve characteristics of Dutch iris bulbs grown in the Pacific Northwest of the United States. Reductions in heat curing requirement and in greenhouse phase, and the improvement in plant form achieved through use of these plant growth regulators suggests that the iris grower should find ways to employ ethylene or ethephon in preparing Dutch iris bulbs for early forcing.

It is likely that growers will need to establish the best treatments for their individual production conditions, but guidelines for the treatment of 'Ideal' and 'Blue Ribbon' are presented below. Of course, other cultivars may require markedly different treatments. Moreover, such factors as weather during the growing season, forcing temperature, light conditions during forcing, plant density during forcing, etc., would be expected to influence performance.

In general, ethylene and ethephon can be used without undue concern about undesirable side effects. Anecdotal reports that ethylene or ethephon treatment could predispose Dutch iris bulbs to infections with Penicillium corymbiferum (blue mold) serious enough to influence forcing performance were not confirmed in a recent study (Doss, Cascante, and Chastagner 1989). Moreover, Dutch iris bulbs were not damaged by exposure to much higher levels of ethylene than those used in the studies discussed in this report (Doss, 1982, unpublished). However, ethylene and ethephon should not be used carelessly, as demonstrated by the effects of excessively high concentrations of ethephon observed in this investigation (see study 3), and the fact that severe defects in the development of other flowerbulb species can result from exposure to ethylene (Rees 1972).

Recommended Treatment Conditions

'Ideal'

Ethephon Dip

Dip freshly harvested bulbs for 1 hour in a solution containing 0.25 to 2.5 g/l ethephon (20° C). Remove and allow bulbs to dry. Heat cure for 3 days at 32° C. Hold at 18° C for 2 weeks (can occur during shipping), precool at 10° C for 6 weeks, and then grow under the usual early forcing conditions.

Ethylene Gas

Expose freshly harvested bulbs to ethylene gas in air at a concentration of 10 to 100 ppm for 24 hrs (20° C). Heat cure for 3 days at 32° C. Hold at 18° C for 2 weeks (can occur during shipping), precool at 10° C for 6 weeks, and then grow under the usual early forcing conditions.

'Blue Ribbon'

Treat identically to 'Ideal', except subject to longer precooling (e.g. 9 weeks) if excessive leafiness is a problem.

Development of Methods for the Use of Ethylene or Ethephon to Improve Early Forcing Performance of Dutch Iris Grown in the Pacific Northwest of the United States[1,2]

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The Pacific Northwest of the United States is an important Dutch iris (*Iris* x *hollandica* Hoog.) growing region (Gould 1967). Bulbs are shipped throughout the United States and Western Europe and are forced either in greenhouses, or, in certain temperate locations, outdoors.

The standard postharvest treatments for early forcing (i.e. forcing to flower for the Christmas and New Year markets, or shortly thereafter) of Dutch iris vary depending on the region where the bulbs are produced (Halevy and Shoub 1964, Kimura and Stuart 1972, Gould *et al*. 1974, Durieux 1975, Kamerbeek *et al*. 1980, Doss 1981). In the United States, 'Ideal', a widely grown cultivar, is usually treated by holding bulbs at 32° C for 10 or more days

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[1] This report is taken, in part, from a thesis submitted to Oregon State University by Xenia M. Cascante in partial fulfullment of the requirements for the degree of Master of Science.

[2] The authors acknowledge financial support from the Fred C. Gloeckner Foundation, and the Washington State Bulb Commission. The careful preparation of the photograph ready manuscript by Marian Thompson is is also appreciated.

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immediately after harvest (Gould *et al*. 1974). After this "heat curing," bulbs are stored at 18° C for at least 2 weeks. This "stabilization" treatment sometimes occurs during shipping. Finally, the bulbs are "precooled" at 10° C for 6 weeks. Another widely grown cultivar, Blue Ribbon (also known as 'Professor Blaauw') is treated in a similar fashion, but it is often precooled for longer than 6 weeks, and is sometimes held for 2 weeks at 17 to 18° C after precooling (Durieux and Schipper 1977, Gould and Byther 1979).

Even with these temperature treatments, flower losses can occur due to blindness (failure to initiate flowers) or blasting (premature cessation of flowerbud development). Recently, several researchers (Imanishi and Fortanier 1982, De Munk 1984, De Munk and Duineveld 1986) have confirmed earlier work (Stuart *et al*. 1966) showing that a treatment with ethylene can decrease the incidence of these disorders, and can substitute either totally or in part for the heat curing treatment. Others (Swart and Schipper 1982, Le Nard et *al*. 1983, Cascante and Doss 1988) have shown that treatment with ethephon [(2-chloroethyl) phosphonic acid], an ethylene-releasing agent, acts in a way similar to ethylene treatment.

Reported here are the results of several studies undertaken to investigate the forcing response of the two major Dutch iris cultivars grown in North America to ethylene gas or ethephon dip treatments. The objective of the work was to develop methods for the commercial use of these materials by Dutch iris growers.

Materials and Methods

In a series of experiments carried out over several years, the effects of variables including growth regulator concentration, heat curing duration, time of growth regulator treatment, bulb size, harvest date, and precooling duration on Dutch iris forcing performance were evaluated. When used, ethylene was given for a 24 hour period using a flow-through system with gas concentrations prepared using the method of Saltveit and Dilley (1977).[4] For dips, ethephon solutions were prepared using deionized water. Unless otherwise indicated, a dipping period of 1 hour was used. Both ethylene and ethephon treatments were given at 20° C.

All storage treatments were given in unlighted growth chambers set at 85% relative humidity. The temperature for heat curing was 32° C. Temperatures for stabilization and precooling were 18° and 10° C, respectively. Bulbs were stabilized for 2 weeks, and, unless otherwise noted, precooled for 6 weeks prior to planting.

Two cultivars, Ideal and Blue Ribbon, were used for most studies. Bulbs were obtained either from a grower in Mt. Vernon, Washington, or, in one case, harvested from an experimental plot in Corvallis, Oregon.

All treatments used similar greenhouse conditions. Bulbs were grown with five replications (pots) per treatment. Three bulbs were planted in Redi-Earth ® (a peat-vermiculite potting medium) in 16 cm x 14 cm (H x W) plastic pots. Water was provided as needed, and supplemental fertilization with modified Hoagland's solution (Downs and Hellmers 1975) was given once per week. Greenhouse temperature was maintained between 16° and 21° C. Three 400

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4 The methods employed in this study allow for precise control of ethylene concentration, but are too involved for large scale use. Bulb growers can establish appropriate gas concentrations by injection of ethylene into a sealed chamber of known volume.

watt high intensity sodium lamps, suspended 1 m above each 1 x 4 m greenhouse bench, were on from 0600 until 2200 hours daily. They delivered a photon flux density of 115 $\mu E\ m^{-2}\ sec^{-1}$ and supplemented the natural light.

In each study the following variables were evaluated: (a) days-to-flowering (greenhouse phase), (b) leaf number, (c) leaf height (soil surface to tip of the uppermost leaf), and (d) stalk height (soil surface to the tip of the flower bud). Percent flowering, if influenced by treatment, was also analyzed.

Reported here are the results of six separate studies, carried out as described below:

1. **Effect of ethylene concentration and heat curing duration.**
   Bulbs, 10 to 11 cm in circumference, were exposed to four concentrations of ethylene gas (0, 0.8, 8, 80 ppm in air) before 0, 7, 14, or 21 days of heat curing. After ethylene and heat curing treatments, bulbs were stabilized, precooled, and planted.

2. **Effect of duration and sequence of ethephon dip treatment and heat curing duration.**
   Bulbs, 10 to 11 cm in circumference, were dipped into water containing 0.5 g/l ethephon for either 0, 1, 8, or 24 hours. Heat curing for 3 or 7 days was given either before or after the dips. A treatment receiving dips but no heat curing was also included. After dipping and heat curing, bulbs were stabilized, precooled, and planted.

3. **Effect of ethephon concentration and heat curing duration.**
   Bulbs, 10 to 11 cm in circumference, were dipped for 1 hour into solutions containing 0.0, 0.25, 0.5, 2.5 or 5.0 g/l ethephon. They were then given either 0, 3, or 6 days of heat curing, then stabilized, precooled, and planted.

4. **Effect of bulb size, heat curing duration and growth regulator treatment.** Bulbs of three size ranges, 8/9, 9/10, and 10/11 (where a/b defines a size range with a bulb circumference larger than a cm but smaller than b cm), were treated either with 80 ppm ethylene, 0.5 g/l ethephon, or left untreated. They were then heat cured for 0, 3, 6, or 12 days. After heat curing, bulbs were stabilized, precooled, and planted.

5. **Effect of harvest date and growth regulator treatment.** Bulbs (10 to 11 cm in diameter with 'Ideal', 11 cm or larger with 'Blue Ribbon') harvested on four dates in 1986 (June 5, July 3, July 31, or August 28) from an experimental plot in Corvallis were treated either with 80 ppm ethylene, 0.5 g/l ethephon, or left untreated. They were then heat cured for 3 ('Ideal') or 6 ('Blue Ribbon') days, then stabilized, precooled, and planted.

6. **Effect of growth regulator treatment and precooling duration with cultivar Blue Ribbon.** 'Blue Ribbon' bulbs, 10 to 11 cm in circumference were treated with either 80 ppm ethylene or 0.5 g/l ethephon. They were then heat cured for 6 days, then stabilized and precooled for either 6, 9, or 12 weeks prior to planting.

Results and Discussion

1. **Effect of ethylene concentration and heat curing duration.** One of the important effects of ethylene treatment of Dutch iris is the promotion of earlier flowering than that seen without treatment (Stuart *et al*. 1966, Imanishi and Fortanier 1982, De Munk 1984). Treatment with ethylene, of Pacific Northwest grown bulbs, reduced the number of days

from planting until flowering (greenhouse phase) of both cultivars (Tables 1 and 2, Figures 1a and 2a).

With 'Ideal', both ethylene and heat curing had a significant effect on the greenhouse phase (Table 1, Fig. 1a). Heat curing for any length of time resulted in significantly earlier flowering than that seen with no heat curing, but comparison of heat curing durations using the least significant difference method revealed no difference in earliness of flowering between 7, 14, and 21 days. Similarly, treatment of 'Ideal' with ethylene caused flowering to occur earlier than it did with no ethylene treatment. With respect to greenhouse phase, there was no difference between treatments with 0.8, 8, and 80 ppm ethylene within any level of heat curing.

Analysis of variance revealed a significant interaction between ethylene treatment and heat curing with respect to greenhouse phase (Table 1), as shown by the reduction in effectiveness of ethylene treatment with longer heat curing durations (Figure 1). That is, prolonged periods of heat curing can substitute for ethylene treatment and vice versa (De Munk 1984, Schipper 1984). In this regard, earlier work showed that treatment with ethylene had no significant effect on forcing performance of 'Ideal' iris if the bulbs had already received a 10-day heat curing treatment (Cascante and Doss, 1984, unpublished).

With respect to forcing performance of Dutch iris, variables of importance in addition to earliness to flower are leaf number, leaf height, and (flower) stalk height. Plants with fewer and shorter leaves are more valuable in the florist trade than plants with more numerous longer leaves. Flowers borne on long stalks are more attractive than those borne on short stalks.

Treatment of 'Ideal' iris with ethylene resulted in plants with fewer leaves than plants not treated with ethylene (Table 1, Figure 1B). Heat curing, in contrast, did not have a significant effect on leaf number.

A reduction in leaf height was also achieved through ethylene treatment (Table 1, Figure 1C). In contrast, heat curing appeared to increase leaf height.

Stalk height of 'Ideal' iris was reduced by ethylene treatment (Table 1, Figure 1D); whereas, heat curing had the opposite effect. The interaction of ethylene treatment and heat curing was not significant.

'Blue Ribbon' responded to ethylene treatment and heat curing much as did 'Ideal' (Table 2, Figure 2). With this cultivar, treatment with 8 or 80 ppm ethylene was more effective in reducing greenhouse phase than was treatment with 0.8 ppm. Furthermore, ethylene treatment did not have a significant effect on stalk height.

With both cultivars, when overall plant performance is considered, the advantage of using an ethylene treatment is clearly demonstrated. Ethylene treatment causes plants to flower earlier and to possess fewer and shorter leaves than untreated plants. Such iris are more valuable in the florist trade than later flowering, excessively leafy plants. Moreover, energy savings are realized with ethylene treatment because of a reduction in heat curing requirement, decrease in the greenhouse phase, and because plants possessing fewer and shorter leaves can be grown at greater density and with lower light intensity than plants not showing the effects of ethylene treatment (De Munk 1984, Schipper 1984).

Complete elimination of heat curing of bulbs treated with ethylene would not be desirable, because of the positive effects of ethylene treatment and heat curing given in combination. Nevertheless, a reduction in heat curing requirement can be obtained by treating bulbs with ethylene.

Table 1. Effect of ethylene concentration and heat curing duration on forcing performance of 'Ideal' iris.

Treatment Means

ethylene (ppm)	heat curing (days)	DAYSFL[1]	LFNO	MXLFHT	STKHT
0.0	0	65.2	5.8	51.3	49.1
0.0	7	60.7	5.9	49.3	50.4
0.0	14	57.1	5.7	48.3	47.7
0.0	21	54.9	5.5	51.9	52.3
0.8	0	52.1	5.1	41.7	43.6
0.8	7	51.2	5.1	43.6	48.5
0.8	14	50.3	5.0	44.6	46.7
0.8	21	50.5	5.1	46.6	48.1
8.0	0	51.5	5.4	39.7	43.1
8.0	7	49.4	5.3	43.5	49.3
8.0	14	49.7	5.0	43.9	46.1
8.0	21	51.8	5.6	50.3	51.8
80.0	0	53.8	5.1	41.9	44.1
80.0	7	51.4	5.1	45.5	49.4
80.0	14	51.5	5.3	45.5	47.9
80.0	21	51.0	5.5	48.3	49.5

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	10.2	2.2^{ns}	0.00	0.5^{ns}	65.6	8.9**	95.9	8.9**
Heat	3	57.0	4.7**	0.00	1.0^{ns}	11.4	15.1**	118.7	11.0**
Ethylene	3	351.0	73.3**	0.07	19.9**	62.0	22.0**	35.3	3.3*
Ethylene x Heat	9	21.9	4.7**	0.08	2.3*	18.0	2.4**	9.6	0.9^{ns}
Error	60	4.7	-	0.04	-	7.4	-	10.8	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

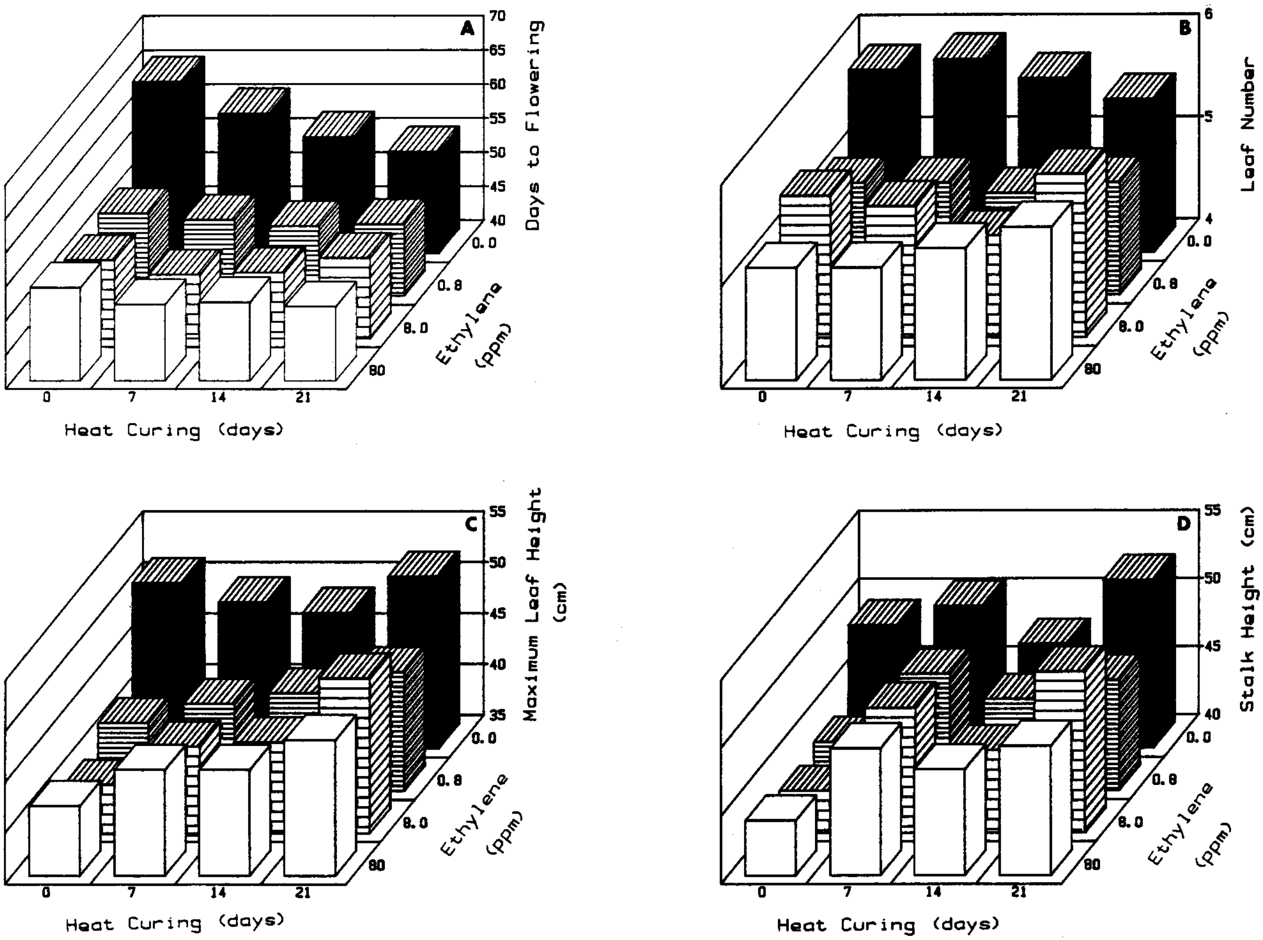

Figure 1. Effect of ethylene concentration and heat curing duration on forcing performance of 'Ideal' iris.

Table 2. Effect of ethylene concentration and heat curing duration on forcing performance of 'Blue Ribbon' iris.

Treatment Means

ethylene (ppm)	heat curing (days)	DAYSFL[1]	LFNO	MXLFHT	STKHT
0[2]	0	99.2	7.5	98.8	54.8
0	7	97.4	7.4	101.7	40.1
0	14	86.8	7.0	94.0	44.1
0	21	81.7	6.9	89.4	35.3
0.8	0	89.3	6.4	91.5	43.6
0.8	7	77.6	6.8	83.2	41.9
0.8	14	74.4	6.6	81.2	37.2
0.8	21	74.0	6.7	81.6	38.3
8.0	0	79.1	6.0	76.9	41.1
8.0	7	69.7	5.9	77.2	46.3
8.0	14	70.2	6.1	77.9	34.3
8.0	21	71.1	6.3	80.3	42.8
80	0	78.5	6.0	82.9	42.8
80	7	68.9	5.9	80.5	42.2
80	14	68.2	5.9	75.7	31.3
80	21	70.6	6.4	78.1	37.9

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	92.7	1.6^{ns}	0.2	1.0^{ns}	415.3	7.0**	149.7	1.4^{ns}
Heat	3	1305.5	22.0**	0.4	2.7^{ns}	300.7	5.0**	534.1	5.1**
Ethylene	3	3590.4	60.5**	9.6	56.4**	2736.3	46.0**	60.0	0.6^{ns}
Ethylene x Heat	9	258.9	4.4**	0.4	2.6**	160.1	2.7*	142.7	1.4^{ns}
Error	60	59.3	-	0.2	-	59.4	-	104.9	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

[2] Values for plants given no heat curing and no ethylene treatment are pooled from 3 other experiments and were not used in analysis of variance.

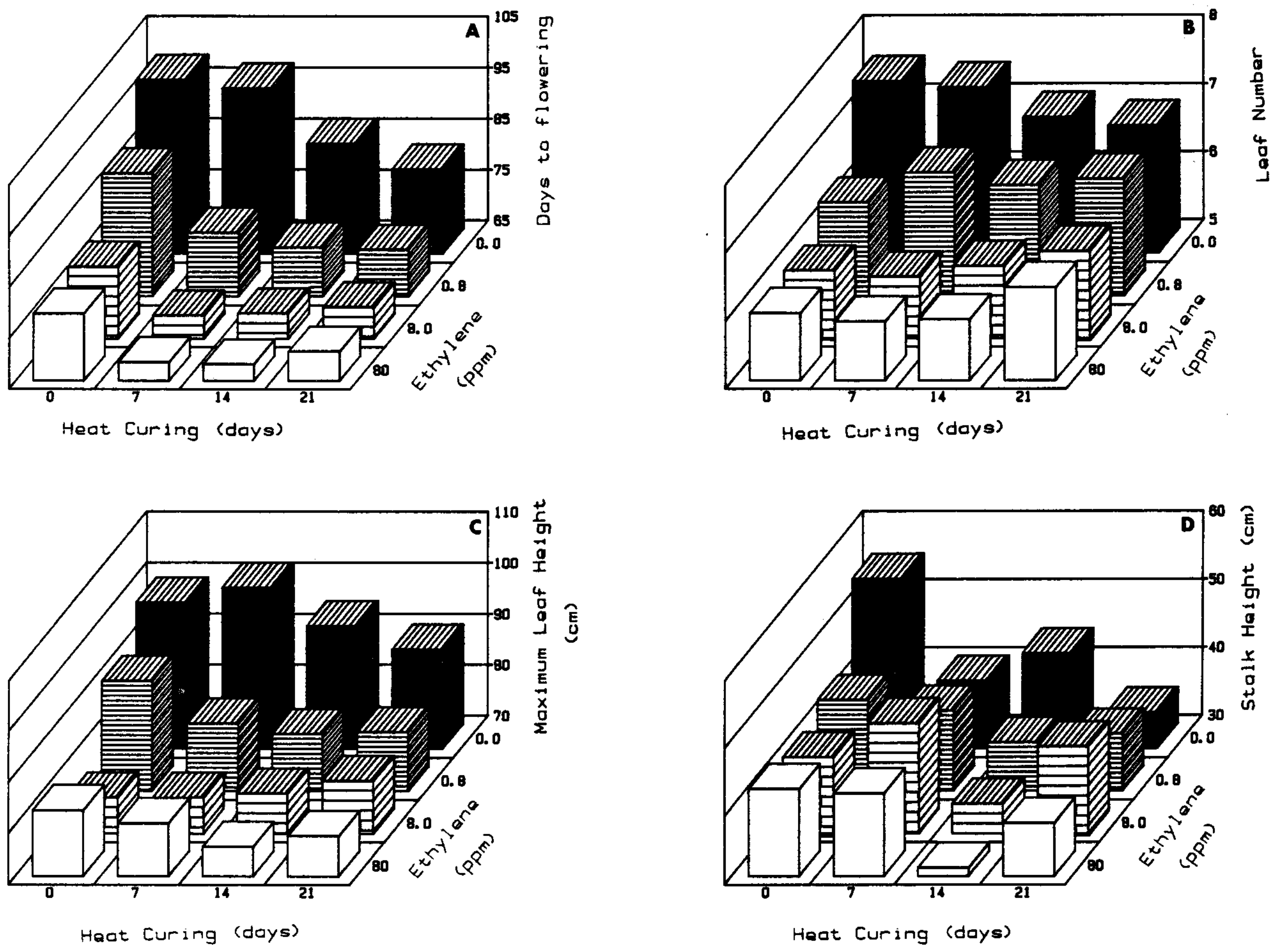

Figure 2. Effect of ethylene concentration and heat curing duration on forcing performance of 'Blue Ribbon' Iris. (Note: Bars showing response of plants given no heat curing and no ethylene treatment represent averages computed using data pooled from 3 experiments.)

2. **Effect of duration and sequence of ethephon dip and heat curing duration.** Several investigators have reported that treatment of Dutch iris bulbs by dipping in a solution of ethephon, an ethylene-releasing compound, can influence forcing performance in a way similar to exposure to ethylene gas (Le Nard 1982, Stuart and Schipper 1982, Le Nard et al. 1983); that is, by bringing about earlier and more uniform flowering and by reducing leaf number and leaf height. This was confirmed with Pacific Northwest grown bulbs. Both 'Ideal' and 'Blue Ribbon' responded to a dip in ethephon in much the same way as they responded to an ethylene gas treatment (Tables 3 and 4, Figures 3 and 4).

As noted earlier there was no enhanced performance of 'Ideal' iris after treatment with ethylene when bulbs received 10 days of heat curing prior to exposure to the gas. In contrast, in a study where ethephon dips were given either before or after 3 or 7 days of heat curing, improvement in the forcing performance of 'Ideal' bulbs was noted (Table 3). That is, dipping resulted in a reduction in greenhouse phase regardless of whether dips were given before or after the heat curing treatments.

Dip durations of 1, 8, or 24 hours were equally effective in improving forcing performance (Figure 3), suggesting that 1 hour is an adequate dipping period. Three days of heat curing was as effective as seven days in reducing greenhouse phase.

With 'Blue Ribbon' the dipping sequence had a significant effect on greenhouse phase and leaf number (Table 4). In general, dipping prior to heat curing resulted in shorter greenhouse phases and fewer leaves (Table 4, Figure 4). For example, bulbs given a 1 hour dip prior to 3 days of heat curing exhibited an average greenhouse phase of 75 days and produced plants with an average of 6 leaves (Table 4, Figures 4A and 4C); whereas, bulbs heat cured for 3 days prior to a 1 hour dip were in the greenhouse 81 days and produced plants with 6.5 leaves.

With 'Blue Ribbon', as with 'Ideal', there was little difference in forcing performance of bulbs given dips of 1, 8, and 24 hours, and the responses to 3 or 7 days of heat curing were similar.

Although a dip treatment can be effective after a short heat curing period with 'Ideal, the reduced effectiveness of a post-heat-curing dip with 'Blue Ribbon' suggests that, for the sake of simplicity, dips be given prior to heat curing. There is no advantage in increasing dip duration beyond 1 hour. Although an ethephon dip can substitute, in part, for prolonged storage at high temperature, best results will probably be obtained when a short period of heat curing (e.g. 3 days) is given in addition to an ethephon treatment.

Table 3. Effect of ethephon dip (0.5 g/l) duration and sequence and length of heat curing on forcing performance of 'Ideal' iris.

Treatment Means

ethephon (ppm)	heat curing (days)	DAYSFL[1]	LFNO	MXLFHT	STKHT
0	0	64.7	6.0	51.6	49.2
0	3	64.2	5.8	51.7	50.0
0	7	59.7	5.7	45.9	50.1
1	0	53.6	5.1	43.9	49.1
1	3	50.2	5.1	42.9	47.0
1	7	49.3	5.0	43.0	48.9
8	0	53.6	5.0	43.3	48.7
8	3	50.3	5.1	42.2	47.9
8	7	50.5	5.2	42.6	47.5
24	0	56.3	5.4	44.2	51.9
24	3	49.3	5.0	41.3	47.1
24	7	50.0	5.1	44.3	50.3

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	69.3	6.8**	0.00	0.7^{ns}	115.0	17.9**	54.8	8.1**
Dip	3	980.0	96.4**	0.16	80.0**	404.2	63.1**	25.1	3.7**
Heat	2	240.4	23.6**	0.01	3.7*	22.0	3.4*	31.6	4.7*
Seq[2]	1	0.0	0.0^{ns}	0.00	2.2^{ns}	6.9	1.1^{ns}	11.6	1.7^{ns}
Dip x heat	6	23.7	2.3*	0.01	3.3**	20.7	3.2**	16.1	2.4*
Dip x seq	3	6.9	0.7^{ns}	0.00	0.4^{ns}	5.1	0.8^{ns}	7.0	1.0^{ns}
Heat x seq	2	4.7	0.5^{ns}	0.00	0.4^{ns}	0.9	0.1^{ns}	16.1	2.4^{ns}
Dip x heat x seq	6	5.0	0.5^{ns}	0.00	1.8^{ns}	3.0	0.5^{ns}	2.5	0.4^{ns}
Error	92	10.2	-	0.00	-	6.4	-	6.8	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXFLHT = maximum leaf height (cm); STKHT = stalk height (cm).

[2] seq = sequence at which ethephon dips were given (before or after heat curing treatments)

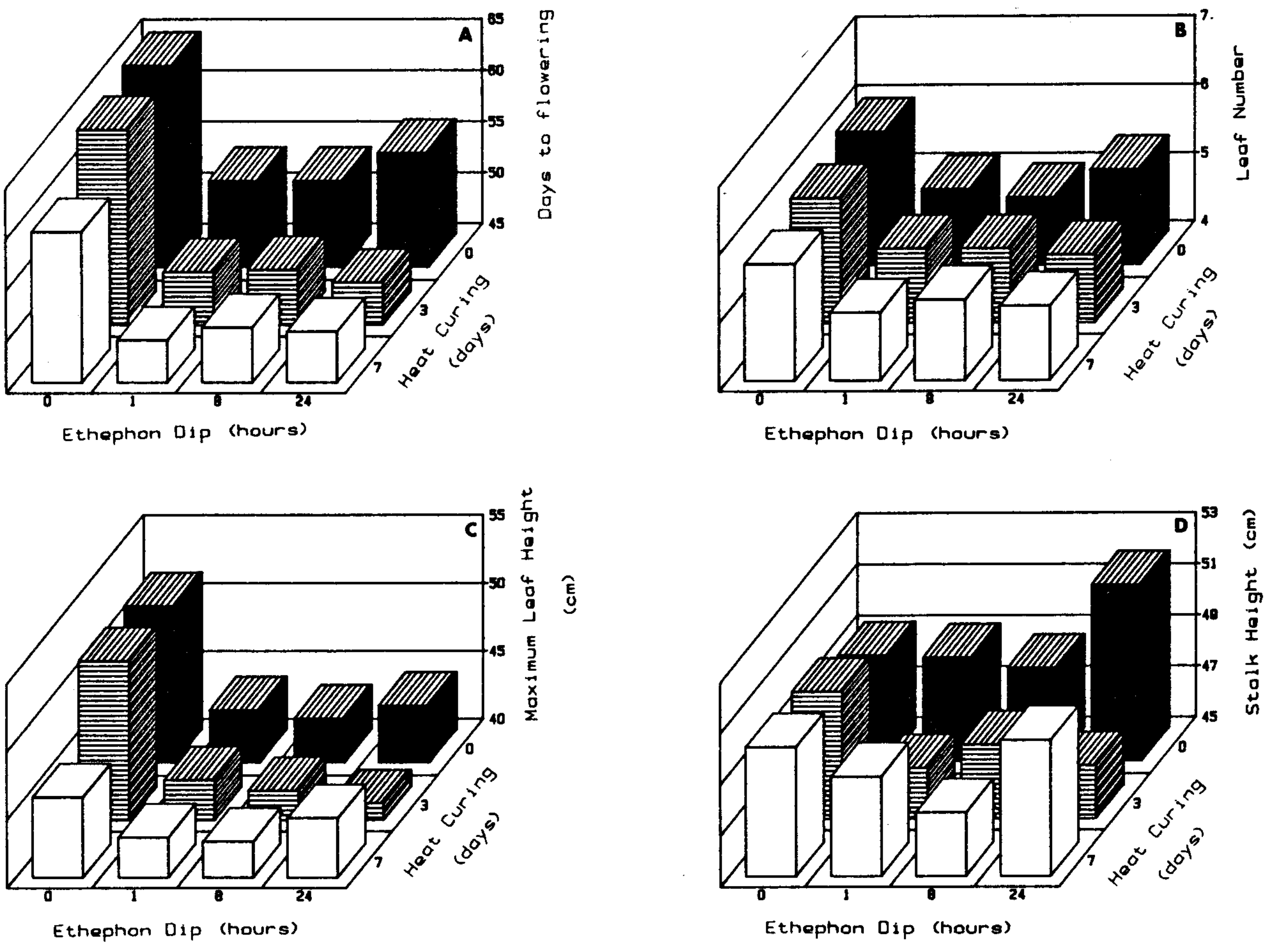

Figure 3. Effect of ethephon dip (0.5 g/l) duration and length of heat curing on forcing performance of 'Ideal' iris.

Table 4. Effect of ethephon dip (0.5 g/l) duration and sequence and length of heat curing on forcing performance of 'Blue Ribbon' iris.

Treatment Means

ethephon dip[1,3] (hours)	heat curing (days)	DAYSFL[2]	LFNO	MXLFHT	STKHT
0	0	94.8	7.7	102.4	60.6
1	0	81.8	6.4	79.4	55.2
8	0	80.0	6.3	81.3	51.4
24	0	86.9	6.8	86.2	51.4
1	3	74.8	6.1	77.5	46.0
8	3	76.7	6.3	79.1	50.1
24	3	76.4	6.3	87.6	58.7
1	7	73.2	6.1	80.4	51.4
8	7	72.1	6.1	76.9	50.7
24	7	79.4	6.8	87.4	53.2
0	3	95.5	7.2	108.1	51.9
1	3	80.9	6.5	80.4	46.8
8	3	94.9	7.4	103.4	49.5
24	3	81.0	6.9	84.5	53.4
0	7	88.9	7.4	102.6	53.7
1	7	78.6	6.8	84.5	55.2
8	7	74.9	6.2	77.9	55.3
24	7	73.0	6.3	79.5	52.9

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	125.7	7.8**	0.2	1.1ns	210.7	3.4**	117.8	2.8*
Dip	3	532.1	33.1**	2.0	12.6**	1565.1	25.4**	44.9	1.1ns
Heat	2	347.1	21.6**	0.0	0.3ns	225.3	3.6*	45.1	1.1ns
Seq[3]	1	543.9	33.9**	2.6	15.9**	231.5	3.7ns	0.3	0.0ns
Dip x heat	6	85.0	5.3**	0.6	3.6**	113.0	1.8ns	60.8	1.4ns
Dip x seq.	3	111.5	7.0**	0.2	1.2ns	323.2	5.2**	21.2	0.5ns
Heat x seq	2	218.3	13.6**	1.2	7.3**	302.2	4.9**	32.9	0.8ns
Dip x heat x seq.	6	2.1	0.1ns	0.0	0.0ns	24.8	0.4ns	0.0	0.0ns
Error	57	16.0	-	0.16	-	61.6	-	6.2	-

1 Values for plants given no heat curing and no ethephon treatment are pooled from 3 other experiments and were not used in analysis of variance.

2 DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

3 seq = sequence at which ethephon dips were given (before or after heat curing treatments)

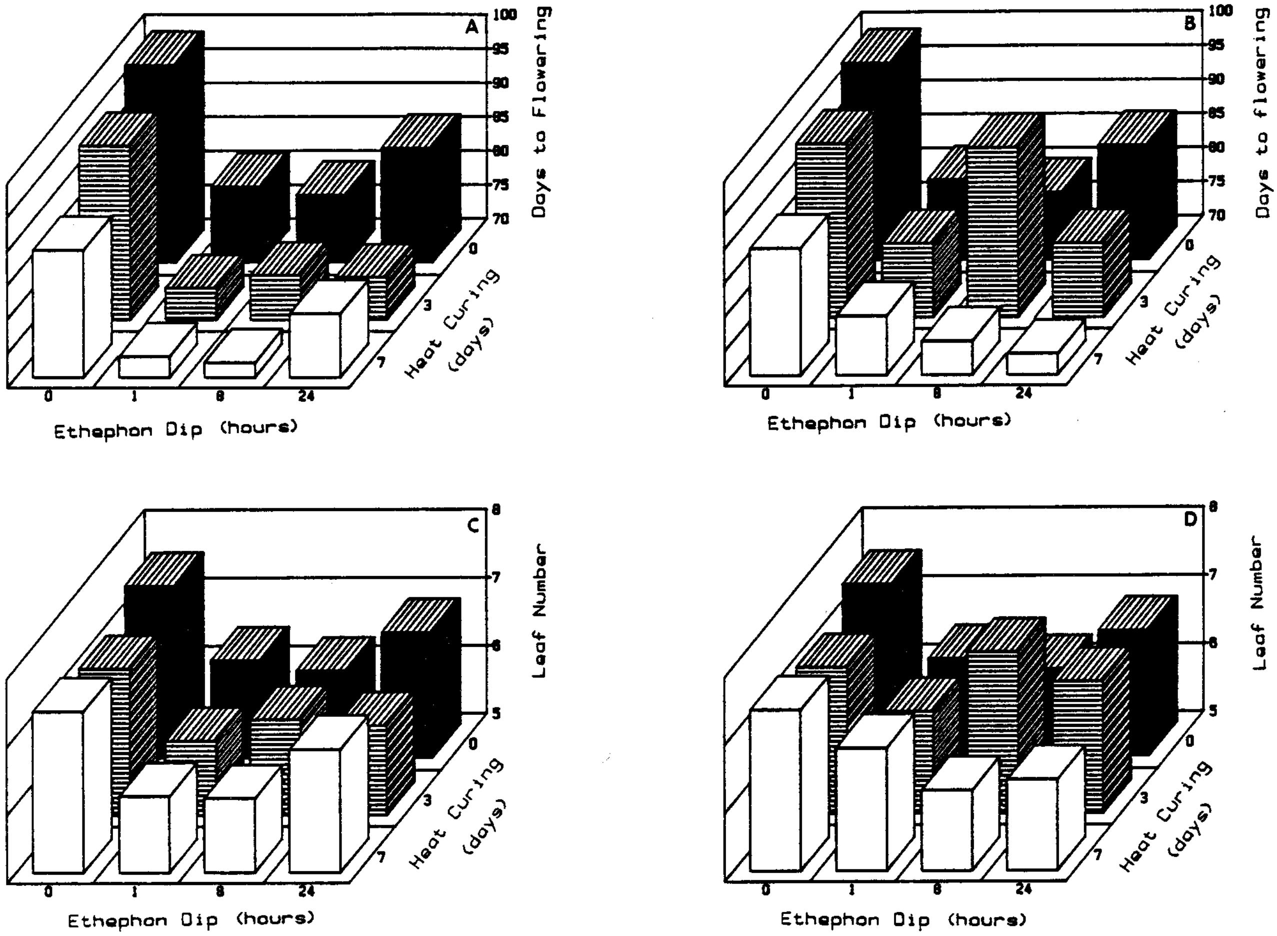

Figure 4. Effect of ethephon dip (0.5 g/l) duration and sequence and length of heat curing on forcing performance of 'Blue Ribbon' iris. (Note: Bars showing response of plants given no heat curing and no ethephon treatment represent averages computed using data pooled from three experiments.)

3. Effect of ethephon concentration and heat curing duration.[5]

Once it was established that an ethephon dip could improve forcing performance of Pacific Northwest grown Dutch iris, studies were conducted to find the optimal ethephon concentrations and heat curing durations. With both cultivars, improved forcing performance was observed with ethephon concentrations ranging from 0.25 to 2.5 g/l.

'Ideal' bulbs dipped in 0.25 g/l ethephon and not heat cured flowered 11 days earlier than bulbs dipped in water (Table 5, Figure 5A). Bulbs given 3 days of heat curing after a dip in 0.25 g/l ethephon exhibited the shortest greenhouse phase, 45 days. With 'Ideal' no advantage was seen with ethephon concentrations higher than 0.25 g/l, or heat curing durations longer than 3 days with respect to any of the variables examined (Table 5, Figure 5). In fact, treatment with the highest level of ethephon, 5.0 g/l, caused a longer greenhouse phase and shorter stalk height.

With 'Blue Ribbon', as with 'Ideal', greenhouse phase was reduced by treating bulbs with ethephon (Table 6, Figure 6). With respect to flowering time, there were no significant differences between treatments with ethephon at 0.25, 0.5 and 2.5 g/l. Similarly, with 'Blue Ribbon' no advantage of a 6-day heat curing period over the 3-day period was noted. 'Blue Ribbon' plants forced from bulbs dipped in 2.5 g/l ethephon produced significantly shorter leaves than those forced from bulbs dipped in lower concentrations. This reduction in leaf height resulted in a plant more acceptable to the florist trade. Treatment with ethephon at

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5 Note: Results of this study have been published elsewhere, and are included here with permission, Cascante and Doss 1988.

5.0 g/l also reduced leaf height, but, in addition, caused an undesirable reduction in percent flowering (Table 6, Figure 6E).

Results of this study were consistent with the study discussed previously showing that an ethephon dip treatment can substitute for an ethylene gas treatment in enhancing early forcing performance of Pacific Northwest grown Dutch iris. Because most flower bulb growers have facilities for dipping bulbs to control pests (Rees 1972), it may be easier for them to dip bulbs in ethephon than to expose them to ethylene gas. The latter treatment requires somewhat specialized facilities not always available on the bulb farm.

Table 5. Effect of ethephon dip concentration and heat curing duration on forcing performance of 'Ideal' iris.

Treatment Means

Ethephon conc. (g/l)	heat curing (days)	DAYSFL[1]	LFNO	MXLFHT	STKHT
0.00	0	58.4	5.7	56.2	54.6
0.00	3	56.9	5.9	56.5	53.7
0.00	6	57.7	5.9	56.4	55.3
0.25	0	47.7	5.0	49.1	51.6
0.25	3	44.6	5.2	49.2	53.8
0.25	6	46.6	5.5	48.6	53.7
0.50	0	47.3	5.0	47.3	53.5
0.50	3	46.8	5.0	49.6	52.0
0.50	6	47.6	5.2	52.0	56.6
2.50	0	51.1	5.1	41.3	52.0
2.50	3	51.3	5.2	40.7	50.0
2.50	6	48.5	5.3	42.7	53.5
5.00	0	55.2	4.7	35.3	44.8
5.00	3	51.7	5.5	37.1	47.9
5.00	6	51.8	5.0	38.4	47.6

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	15.5	2.5*	0.1	1.1^{ns}	26.1	3.4*	17.1	2.0^{ns}
Conc	4	317.9	51.8**	1.5	12.9**	860.6	111.7**	148.5	17.8**
Heat	2	21.9	3.6*	0.6	5.0**	19.4	2.5^{ns}	29.8	3.6*
Conc x heat	8	6.5	1.0^{ns}	0.1	1.3^{ns}	6.1	0.8^{ns}	9.6	1.25^{ns}
Error	56	6.1	-	0.1	-	7.7	-	8.6	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

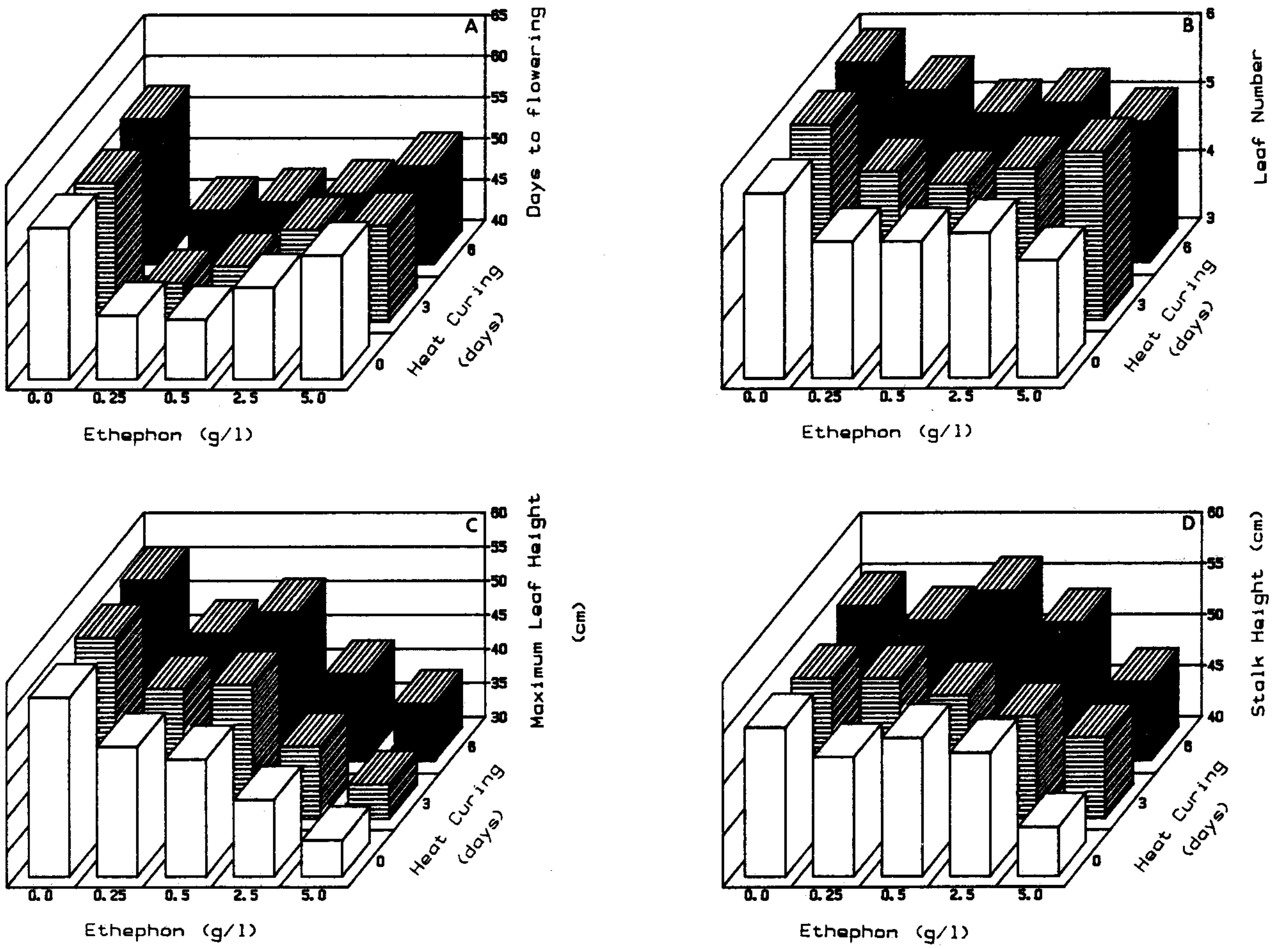

Figure 5. Effect of ethephon dip concentration and heat curing duration on the forcing performance of 'Ideal' iris.

Table 6. Effect of ethephon dip concentration and heat curing duration on forcing performance of 'Blue Ribbon' iris

Treatment Means

Ethephon conc (g/l)	heat curing (days)	DAYSFL[1]	LFNO	MXLFHT	STKHT
0.00	0	99.4	7.5	100.2	54.4
0.00	3	99.7	7.3	105.4	57.6
0.00	6	93.7	7.4	92.9	55.7
0.25	0	85.8	6.4	85.6	49.8
0.25	3	72.8	6.5	76.5	53.7
0.25	6	79.9	6.7	81.8	56.1
0.50	0	83.8	6.6	77.4	51.8
0.50	3	74.0	6.7	76.1	50.4
0.50	6	72.9	6.3	67.9	52.1
2.50	0	95.5	6.7	68.2	55.6
2.50	3	71.7	6.1	46.1	49.8
2.50	6	77.3	6.4	59.4	52.4
5.00	0	96.8	5.3	50.3	51.7
5.00	3	80.4	5.4	43.7	47.9
5.00	6	76.6	6.5	41.7	47.0

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT	
Source	df	MS	F	MS	F	MS	F	MS	F
Replication	4	26.3	0.6^{ns}	0.2	1.2^{ns}	13.2	0.1^{ns}	10.9	0.5^{ns}
Conc	4	871.3	10.8**	4.6	12.6**	6752.9	74.0**	92.4	4.0**
Heat	2	951.6	20.5**	0.3	0.9^{ns}	339.5	3.8*	2.1	0.0^{ns}
Conc x heat	8	153.6	3.3**	0.5	1.3^{ns}	214.0	2.4*	42.3	1.8**
Error	56	46.3	-	0.4	-	90.2	-	23.0	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

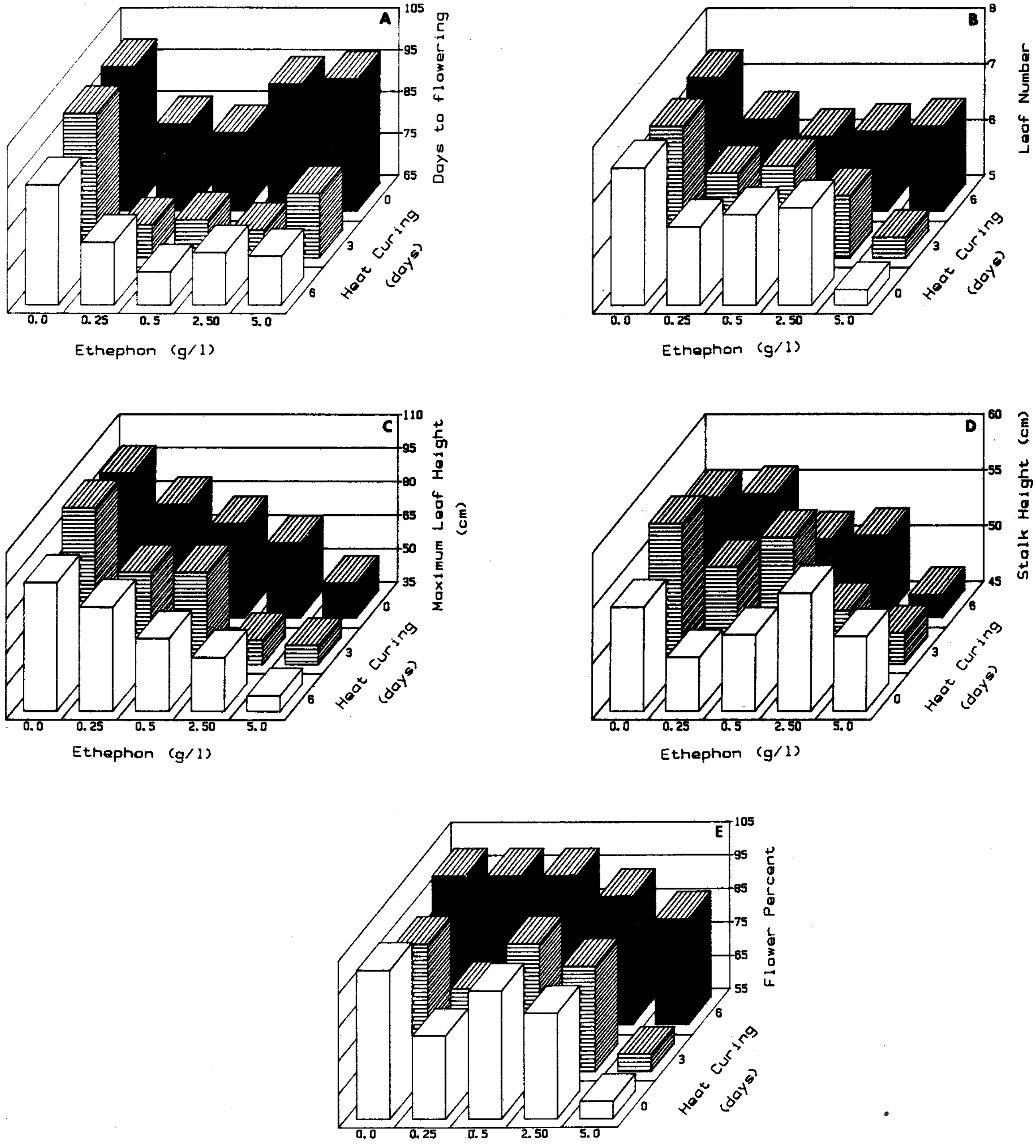

Figure 6. Effect of ethephon dip concentration and heat curing duration on the forcing performance of 'Blue Ribbon' iris.

4. Effect of bulb size, heat curing duration, and growth regulator treatment.

Smaller Dutch iris bulbs are slower and more difficult to bring into flower than larger bulbs (Blaauw 1934, Kamerbeek 1965, Doss and Christian 1979, Doss 1981). Very small bulbs (less than about 6.5 cm in circumference) fail to flower under any conditions (Rees 1972). Treatments that could enhance the forcing performance of bulbs smaller than those normally used for early forcing would be useful to the Dutch iris grower and forcer.

Pacific Northwest grown bulbs of 'Ideal' and 'Blue Ribbon' of 3 size ranges, 8 to 9, 9 to 10, and 10 to 11 cm in circumference, flowered earlier after treatment with either ethylene or ethephon than untreated bulbs (Tables 7 and 8, Figures 7 and 8). The heat curing and growth regulator treatments interacted with a significant effect on greenhouse phase with both cultivars. That is, growth regulator treatment reduced the effect of heat curing. In contrast to earlier studies (Doss 1981, Imanishi and Fortanier 1982), there was no significant difference in greenhouse phase between bulb sizes with 'Ideal' (Table 7, Figure 7). With 'Blue Ribbon', the usual pattern of longer greenhouse phase with smaller bulb sizes was observed (Table 8, Figure 8A).

Although there was high percent flowering of bulbs receiving a growth regulator treatment, about 50 percent blindness (failure of flower initiation) was seen with the smallest bulbs receiving neither growth regulator treatment nor sufficient heat curing (Tables 7 and 8). As noted above, small bulbs often fail to flower. Leaf number and leaf height were reduced by growth regulator treatment.

Results of these studies further support the idea that treatment with ethylene or ethephon can improve forcing performance of Pacific Northwest grown Dutch iris. Heat curing increases percent flowering of bulbs smaller than those usually used for early forcing (Doss 1981). Growth regulator treatment can partially substitute for heat curing in bringing about this effect. However, when considering all the variables that measure forcing performance, this study suggests that optimum performance will be achieved with some combination of growth regulator treatment and heat curing.

Table 7. Influence of growth regulators, heat curing duration, and bulb size on forcing performance of 'Ideal' iris.

Treatment Means

Plant growth regulator	Heat curing (days)	bulb size	DAYSFL[1]	LFNO	MXLFHT	STKHT	FLPCT
None	0	8/9	61.7	5.4	46.7	46.4	47.7
None	0	9/10	64.7	5.9	52.0	47.4	100.0
None	0	10/11	62.4	6.0	50.6	48.1	100.0
None	3	8/9	60.2	5.4	46.3	46.6	80.0
None	3	9/10	61.3	5.6	50.2	47.3	100.0
None	3	10/11	61.3	5.9	51.9	52.7	80.0
None	6	8/9	58.9	5.5	44.5	45.1	86.7
None	6	9/10	61.6	5.5	47.7	47.4	93.3
None	6	10/11	61.1	6.0	49.1	50.4	100.0
None	12	8/9	58.4	5.3	47.7	44.5	93.3
None	12	9/10	57.7	5.6	48.6	47.7	100.0
None	12	10/11	56.1	5.7	49.8	50.5	100.0
Ethephon	0	8/9	58.1	5.0	42.1	42.7	93.3
Ethephon	0	9/10	56.9	5.1	43.0	44.9	100.0
Ethephon	0	10/11	54.4	5.1	42.7	46.5	100.0
Ethephon	3	8/9	53.6	4.3	38.0	40.3	100.0
Ethephon	3	9/10	51.5	4.7	40.0	44.5	100.0
Ethephon	3	10/11	48.6	4.8	41.7	47.6	100.0
Ethephon	6	8/9	52.1	5.0	40.5	43.1	93.3
Ethephon	6	9/10	51.0	5.0	42.7	47.7	100.0
Ethephon	6	10/11	48.1	5.1	42.5	48.1	100.0
Ethephon	12	8/9	51.6	5.0	42.5	44.7	100.0
Ethephon	12	9/10	49.3	5.0	44.5	48.2	100.0
Ethephon	12	10/11	47.1	5.0	44.5	49.1	100.0
Ethylene	0	8/9	54.3	5.0	39.8	42.1	100.0
Etheylene	0	9/10	52.7	5.0	40.9	42.1	100.0
Etheylene	0	10/11	50.7	5.1	41.8	47.0	93.3
Ethylene	3	8/10	53.5	5.0	40.7	43.7	100.0
Ethylene	3	9/10	51.1	5.0	41.3	43.7	100.0
Ethylene	3	10/11	49.2	5.1	39.9	44.9	100.0
Ethylene	6	8/9	51.9	5.0	39.2	42.7	100.0
Ethylene	6	9/10	51.9	5.0	41.0	44.8	100.0
Ethylene	6	10/11	48.7	5.1	41.7	47.1	100.0
Ethylene	12	8/9	51.1	5.0	42.5	43.5	100.0
Ethylene	12	9/10	50.6	5.0	44.2	46.1	100.0
Ethylene	12	10/11	48.0	5.2	46.1	50.5	100.0

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT		FLPCT	
Source[2]	df	MS	F	MS	F	MS	F	MS	F	MS	F
Replication	4	10.5	0.3^{ns}	0.0	0.4^{ns}	10.7	0.3^{ns}	61.1	2.6^{ns}	0.02	0.9^{ns}
Bulb size (B)	2	86.7	2.5^{ns}	1.0	12.3**	114.8	2.9^{ns}	299.4	12.7**	0.10	5.3*
Main plot error	8	34.2	-	0.1	-	37.9	-	22.2	-	0.02	-
Heat curing (H)	3	196.1	28.7**	0.3	5.5*	50.9	5.3**	26.0	3.5*	0.04	2.1^{ns}
H x B	6	3.9	0.6^{ns}	0.1	0.9^{ns}	2.3	0.2^{ns}	9.0	1.2^{ns}	0.04	2.1^{ns}
Subplot error	36	7.6	-	0.1	-	10.0	-	6.7	-	0.01	-
Growth regulator (G)	2	1654.3	193.3**	9.3	168.8**	992.3	129.1**	152.7	20.4**	0.20	12.4**
G x B	4	37.7	4.4**	0.2	3.2**	10.9	1.4^{ns}	8.5	1.1^{ns}	0.09	6.1**
G x H	6	24.4	2.8**	0.3	5.6**	35.2	4.6**	20.7	2.8**	0.02	1.3^{ns}
G x H x B	12	4.4	0.5^{ns}	0.0	1.0^{ns}	7.6	1.0^{ns}	8.5	1.1^{ns}	0.03	2.3**
Sub-subplot error	96	8.6	-	0.0	-	7.7	-	7.5	-	0.01	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm); FLPCT = flower percent.

[2] Treatments were arranged in a split-split plot design, with bulb sizes as main plots, heat curing days as subplots, and growth regulators as sub-subplots.

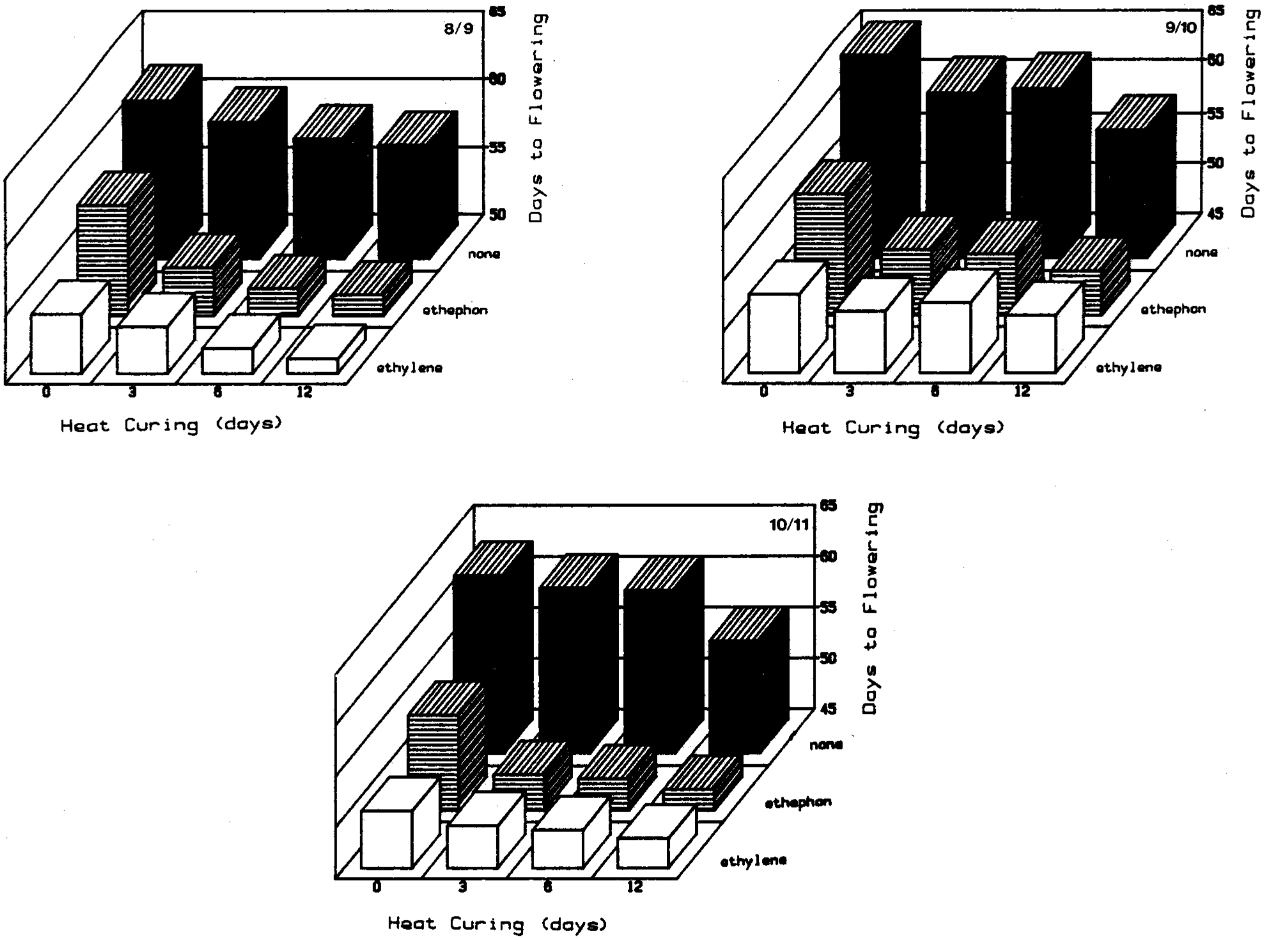

Figure 7. Greenhouse phase of different bulb sizes of 'Ideal' iris given several combinations of growth regulator and heat curing treatments. Bulb size is indicated in upper right hand corner of each graph.

Table 8. Influence of growth regulators, heat curing duration, and bulb size on forcing performance of 'Blue Ribbon' iris.

Treatment Means

Plant growth regulator	heat curing (days)	bulb size	DAYSFL[1]	LFNO	MXLFHT	STKHT	FLPCT
None	0	8/9	111.2	8.0	113.4	65.2	53.3
None	0	9/10	104.6	8.0	108.2	60.3	86.7
None	0	10/11	99.0	7.6	97.4	55.3	93.3
None	3	8/9	104.7	7.6	105.2	61.9	80.0
None	3	9/10	97.1	8.0	96.2	60.5	100.0
None	3	10/11	94.1	7.6	97.9	54.3	100.0
None	6	8/9	101.0	7.5	102.5	64.1	78.6
None	6	9/10	92.5	7.4	91.2	59.1	93.3
None	6	10/11	93.3	7.9	96.1	61.5	100.0
None	12	8/9	95.7	7.6	94.2	63.7	80.0
None	12	9/10	84.5	7.0	81.5	59.5	100.0
None	12	10/11	77.9	7.0	81.0	58.3	100.0
Ethephon	0	8/9	101.1	7.7	102.7	65.3	93.3
Ethephon	0	9/10	92.9	7.1	90.5	57.2	93.3
Ethephon	0	10/11	80.4	6.3	75.5	51.6	100.0
Ethephon	3	8/9	89.2	7.0	82.3	58.2	80.0
Ethephon	3	9/10	80.8	6.6	78.9	54.1	93.3
Ethephon	3	10/11	77.6	6.5	73.5	49.7	100.0
Ethephon	6	8/9	82.5	6.4	78.6	47.8	80.0
Ethephon	6	9/10	74.6	6.1	74.3	51.3	100.0
Ethephon	6	10/11	73.3	6.2	69.9	47.5	100.0
Ethephon	12	8/9	76.3	6.2	71.8	54.2	85.7
Ethephon	12	9/10	71.9	6.1	73.4	55.3	93.3
Ethephon	12	10/11	68.4	6.3	70.1	53.6	93.3
Ethylene	0	8/9	81.9	6.0	79.0	49.0	100.0
Ethylene	0	9/10	76.2	6.0	74.7	43.0	100.0
Ethylene	0	10/11	76.1	5.9	75.9	42.7	100.0
Ethylene	3	8/9	77.9	5.9	73.5	45.6	100.0
Ethylene	3	9/10	73.7	5.9	75.6	43.5	100.0
Ethylene	3	10/11	74.7	6.1	81.6	43.8	93.3
Ethylene	6	8/9	77.8	5.9	74.5	53.4	93.3
Ethylene	6	9/10	71.6	6.0	70.1	46.6	93.3
Ethylene	6	10/11	69.6	6.1	73.5	42.8	93.3
Ethylene	12	8/9	74.2	5.9	68.1	51.3	100.0
Ethylene	12	9/10	70.8	6.0	72.8	50.4	93.3
Ethylene	12	10/11	67.6	6.1	71.8	47.6	93.3

Analysis of Variance

		DAYSFL		LFNO		MXLFHT		STKHT		FLPCT	
Source[2]	df	MS	F	MS	F	MS	F	MS	F	MS	F
Replication	4	88.7	1.1^{ns}	0.1	2.1^{ns}	349.0	3.7*	141.0	1.3^{ns}	0.01	0.6^{ns}
Bulb size (b)	2	1637.3	20.2**	0.4	8.9**	770.6	8.2**	734.1	7.0*	0.18	0.5**
Main plot error	8	81.2	-	0.0	-	94.3	-	104.3	-	0.02	-
Heat curing (H)	3	1873.4	101.3**	2.2	15.4**	1776.4	60.8**	56.1	1.7^{ns}	0.00	0.1^{ns}
H x B	6	27.1	1.5^{ns}	0.4	2.8*	146.5	5.0**	33.9	1.0^{ns}	0.00	0.1^{ns}
Subplot error	36	18.4	-	0.1	-	29.2	-	32.8	-	0.02	-
Growth regulator (G)	2	7774.3	618.7**	40.7	382.3**	9044.5	274.5**	2719.3	108.9**	0.06	3.4*
G x B	4	68.4	5.4**	0.5	5.1**	333.1	10.1**	11.4	0.5^{ns}	0.06	3.5**
G x H	6	139.3	11.1**	0.8	7.1**	222.1	6.7**	69.2	2.8**	0.02	0.9^{ns}
G x H x B	12	26.3	2.1^{ns}	0.2	2.2**	55.5	1.7^{ns}	21.4	0.9^{ns}	0.00	0.3^{ns}
Sub-subplot error	96	12.6	-	0.1	-	32.9	-	25.0	-	0.02	-

1 DAYSFL = days until flowering; LFNO = leaf number per plant; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm); FLPCT = flower percent.

2 Treatments were arranged in split-split plot design, with bulb sizes as main plots, heat curing days as subplots, and growth regulators as sub-subplots.

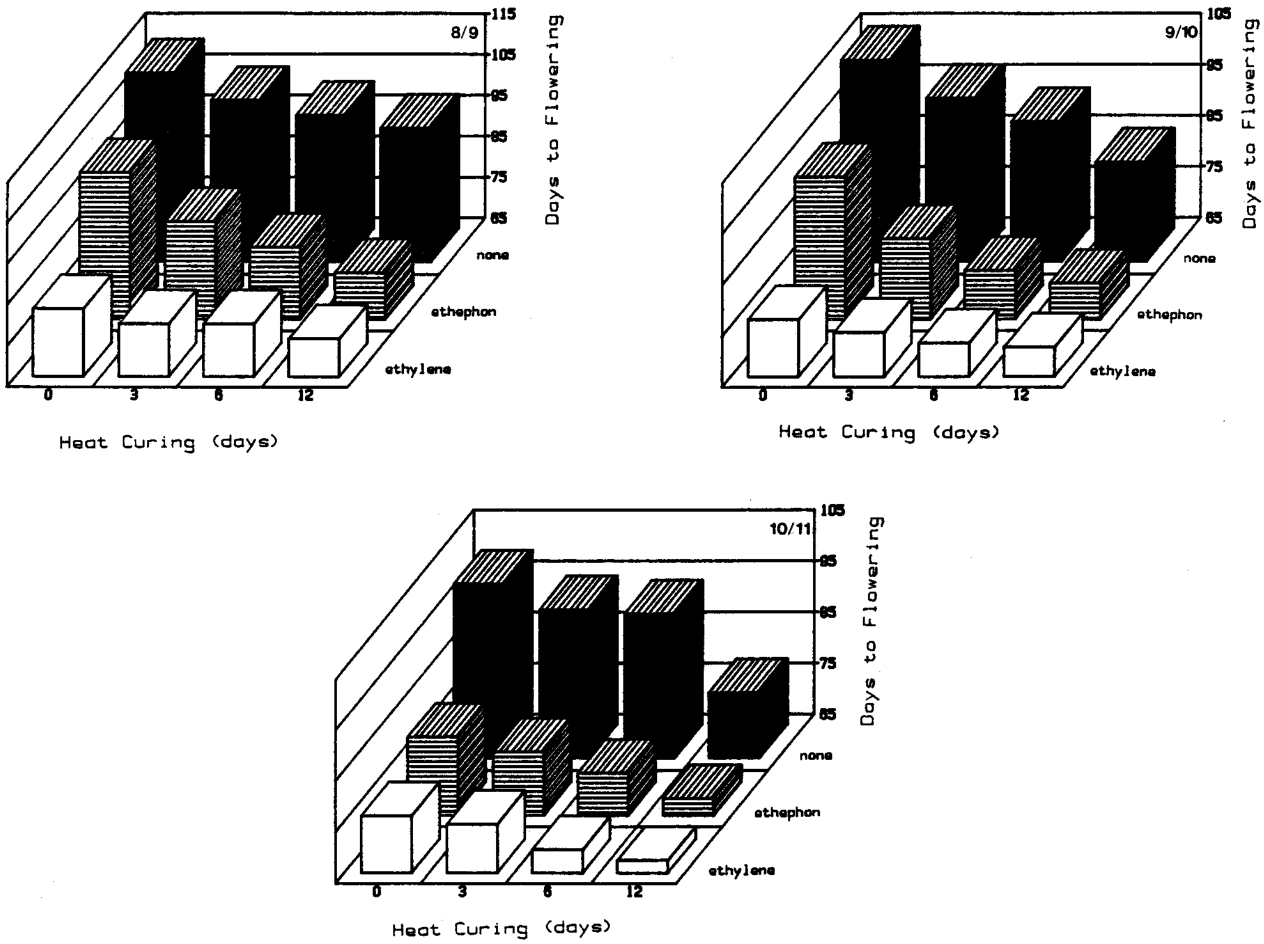

Figure 8. Greenhouse phase of different bulb sizes of 'Blue Ribbon' iris given several combinations of growth regulator and heat curing treatments. Bulb size is indicated in upper right hand corner of each graph.

5. Effect of harvest date and growth regulator treatment.

Harvest date, like bulb size, usually has a prominent effect on forcing performance (Stuart et al. 1955, Doss and Christian 1979, Doss 1981). This proved to be the case in a study where bulbs were harvested over a 4-month period (Tables 9 and 10, Figures 9 and 10).

Bulbs lifted (dug) on June 5 exhibited poor flowering percentage regardless of treatment. The poor flowering performance of 'Blue Ribbon' bulbs lifted July 31 is inexplicable in view of the good flowering percentages exhibited by bulbs lifted on July 3 or Aug. 28.

Growth regulator treatment, while not having a significant effect on percent flowering, did reduce the greenhouse phase. With 'Ideal', there was a significant interaction between growth regulator and harvest date. The greatest reduction in greenhouse phase was caused by growth regulator treatment after early harvest. That is, bulbs from early harvests responded more dramatically to growth regulator treatment than bulbs from later harvests. A similar significant interaction was not noted with 'Blue Ribbon'.[6]

Both cultivars of bulbs lifted on July 3 and treated with either ethylene or ethephon yielded plants with shorter leaves than bulbs harvested later (Figures 9c and 10c). With 'Blue Ribbon,' harvest date had no effect on stalk height. With 'Ideal,' stalk height appeared to increase with later harvest date.

Treatment with ethylene or ethephon cannot eliminate all of the harmful effects of premature harvest on bulb forcing performance.

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[6] With 'Blue Ribbon, severe Fusarium basal rot reduced the number of bulbs on which flowering data was obtained. Only non-diseased bulbs were considered for statistical analysis.

Nevertheless, these growth regulators can be used to good effect with bulbs harvested over a range of dates, and may be useful when bulbs are harvested up to 30 days before the normal lifting date.

Table 9. Influence of harvest date and growth regulator treatment on forcing performance of 'Ideal' iris.

Treatment Means

Growth regulator	Harvest date	DAYSFL[1]	LFNO	MXLFHT	STKHT	FLPCT
none	June 5	177.0	3.5	69.7	58.3	33.3
ethephon		192.5	3.4	64.0	48.0	40.0
ethylene		-	1.8	-	-	-
none	July 3	85.0	7.1	65.1	52.9	86.7
ethephon		46.3	5.0	36.9	45.4	100.0
ethylene		50.6	4.9	39.2	43.6	93.3
none	July 31	61.3	6.3	57.7	47.9	100.0
ethephon		45.0	5.1	40.6	50.9	100.0
etheylene		44.1	5.0	41.0	47.3	93.3
none	Aug. 28	54.6	6.0	51.3	50.6	93.3
ethephon		47.1	5.7	45.6	50.2	100.0
ethylene		46.0	5.9	46.7	50.8	100.0

Analysis of Variance

		DAYSFL		MXLFHT		STKHT			LFNO		PLPCT	
Source	df	MS	F	MS	F	MS	F	df	MS	F	MS	F
Replication	4	27.0	0.4^{ns}	40.1	0.9^{ns}	18.6	1.7^{ns}	4	0.2	0.4^{ns}	0.0	3.1^{ns}
Growth regulator (GR)	2	998.9	15.9**	89.4	21.7**	81.7	6.5*	2	9.4	16.6**	0.0	3.4^{ns}
Main plot error	8	63.0	-	44.7	-	12.6	-	8	0.6	-	0.0	-
Harvest (HV)	3	20025.0	841.8**	363.3	20.3**	31.7	3.0*	3	28.9	49.0**	1.8	78.8**
HV x GR	5	563.0	23.7**	89.8	10.1**	56.7	5.3**	6	1.8	3.1**	0.0	1.8^{ns}
Subplot error	27	23.8	-	17.9	-	10.6	-	36	0.6	-	0.0	-

[1] DAYSFL = days until flowering; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm); LFNO = leaf number per plant; FLPCT = flower percent.

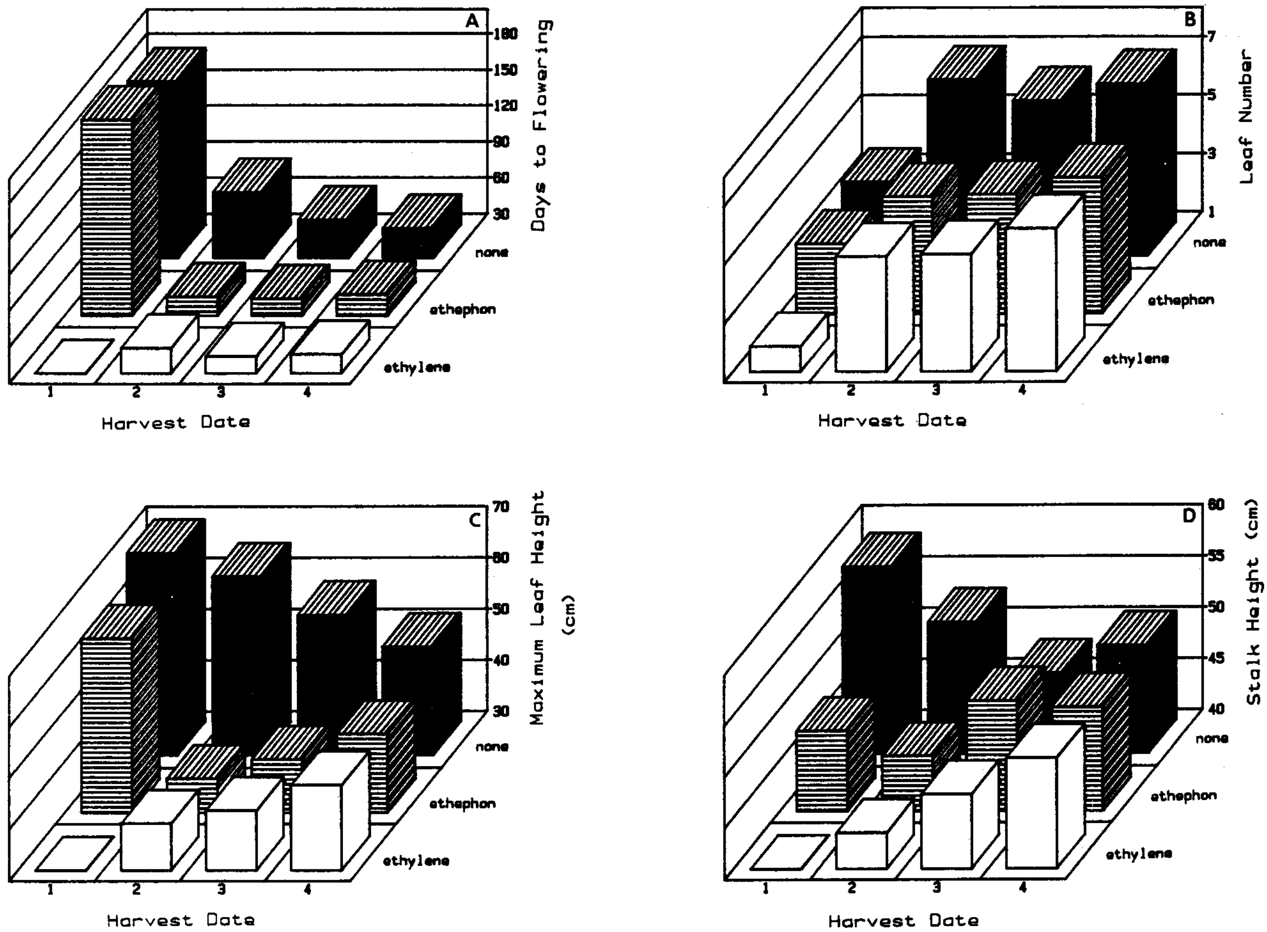

Figure 9. Influence of harvest date and growth regulator treatment on forcing performance of 'Ideal' iris. Harvest dates were 1 = June 5, 2 = July 3, 3 = July 31, 4 = August 28.

Table 10. Influence of harvest date and growth regulator treatment on forcing performance of 'Blue Ribbon' iris.

Treatment Means

Growth regulator	Harvest date	DAYSFL[1]	LFNO	MXLFHT	STKHT	FLPCT
none	June 5	142.0	8.2	105.8	55.2	55.5
ethephon		130.7	8.0	92.0	52.0	80.0
ethylene		126.3	8.0	81.3	44.0	50.0
none	July 3	94.5	7.5	95.0	49.5	100.0
ethephon		62.3	6.0	59.8	48.5	100.0
ethylene		67.5	5.7	58.0	41.7	100.0
none	July 31	96.9	8.4	89.7	48.1	88.9
ethephon		67.0	6.5	65.0	48.0	40.0
ethylene		62.5	6.3	65.2	42.8	66.7
none	Aug. 28	80.2	7.2	87.5	46.0	100.0
ethephon		68.7	6.4	68.4	49.2	100.0
ethylene		68.0	6.3	70.7	43.6	100.0

Analysis of Variance

		DAYSFL		MXLFHT		STKHT		LFNO		FLPCT		
Source	df	MS	F	MS	F	MS	F	MS	F	df	MS	F
Replication	4	41.6	0.9^{ns}	96.7	1.6^{ns}	74.0	1.3^{ns}	0.5	1.9^{ns}	4	0.2	6.9**
Growth regulator (GR)	2	2199.3	49.0**	2669.4	43.3**	182.4	3.1^{ns}	6.7	23.8**	2	0.0	0.2^{ns}
Main plot error	8	44.9	-	61.6	-	58.0	-	0.3	-	8	0.0	-
Harvest (HV)	3	6705.9	40.6**	636.0	11.7**	22.2	0.4^{ns}	2.8	12.6**	3	0.4	7.6**
HV x GR	6	160.2	0.9^{ns}	122.4	2.2^{ns}	35.3	0.7^{ns}	0.7	2.9*	6	0.0	1.4^{ns}
Subplot error	19	165.0	-	54.6	-	49.5	-	0.2	-	23	0.0	-

[1] DAYSFL = days until flowering; MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm); LFNO = leaf number per plant; FLPCT = flower percent.

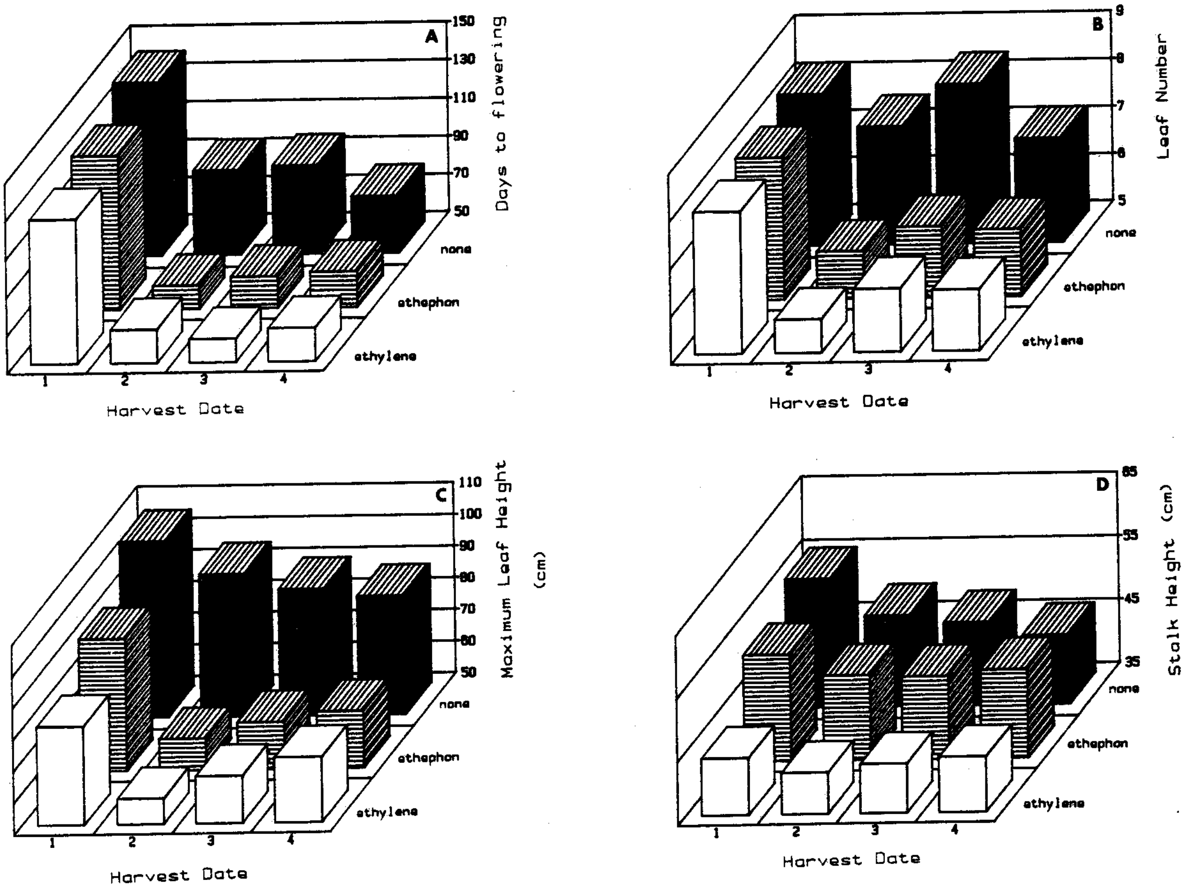

Figure 10. Influence of harvest date and growth regulator treatment on forcing performance of 'Blue Ribbon' iris. Harvest dates were 1 = June 5, 2 = July 3, 3 = July 31, and 4 = August 28.

6. Effect of growth regulator treatment and precooling duration with cultivar 'Blue Ribbon'.

Earlier studies (e.g. see Tables 2, 4, 6, 8 and 10) show that the leaf height of 'Blue Ribbon' plants can be excessive. This effect was apparent even with those treatments that otherwise improved forcing performance. 'Blue Ribbon' bulbs used for early forcing are often subjected to 8 to 10 weeks of precooling to reduce excessive leafiness (Durieux and Schipper 1977, Gould and Byther 1979). Accordingly, a study was conducted to determine what effects variation in the duration of precooling would have on forcing performance of 'Blue Ribbon' iris treated with either ethylene or ethephon.

Precooling duration did not have a significant effect on stalk height of 'Blue Ribbon' iris (Table 11, Figure 11). Flower stalks in this experiment averaged 50 cm, the same as the average for the approximately 1500 stalks measured in the five earlier studies. In these earlier studies, stalk height was less influenced by treatments than was leaf height, suggesting that flower stalk height is probably less subject to control than leaf length.

Leaf height was markedly influenced by precooling duration (Table 11, Figure 11). Longer periods of precooling resulted in plants with shorter leaves and improved appearance. Growth regulator had no effect on leaf height in this study.

Length of precooling period also had a significant effect on greenhouse phase (Table 11, Figure 11). Bulbs precooled for 12 weeks produced flowers, on average, after 51 days in the greenhouse versus 68 days for bulbs precooled 6 weeks. Because longer precooling resulted in a later planting date, the bulbs given 6 weeks of precooling actually produced flowers 25 days earlier than the bulbs precooled for 12 weeks. For this reason, the 9-week precooling period represents a suitable compromise. It yields bulbs that exhibit a greenhouse phase averaging 10 days less than bulbs given 6 weeks of precooling, and they flower approximately 11 days later. Plants grown from bulbs precooled for 9 weeks have a stalk height to leaf height ratio of slightly less than 1 (Figure 11D). Nevertheless, given the droopy leaves of 'Blue Ribbon', such flower stalks are suitable for the florist trade.

It should be noted that leaf height of both 'Blue Ribbon' and 'Ideal' iris is reduced by growth regulator treatment (see Tables 1-10). In particular, leaves of 'Blue Ribbon' plants treated with the two highest concentrations of ethephon (Table 4, Figure 4) were as short as leaves on plants given prolonged periods of precooling. When using ethephon dips, it may be possible to adjust concentrations to levels that will lead to reduced leaf heights, without having undesirable effects on flowering.

Table 11. Effect of growth regulator treatment and precooling duration on forcing performance of 'Blue Ribbon' iris.

Treatment Means

Growth regulator	Precooling duration	DAYSFL[1]	LFNO	MXLFHT	STKHT
ethylene	6	64.9	6.3	65.2	49.1
ethylene	9	56.1	5.8	55.7	50.6
ethylene	12	49.1	5.7	44.7	47.5
ethephon	6	70.2	6.0	69.7	51.8
ethephon	9	59.8	5.9	58.1	53.6
ethephon	12	53.4	5.8	42.7	49.1

Analysis of Variance

Source	df	DAYSFL SS	DAYSFL F	LFNO SS	LFNO F	MXLFHT SS	MXLFHT F	STKHT SS	STKHT F
Replication	4	110.3	3.1*	1.0	0.4^{ns}	447.3	4.9**	83.9	2.3^{ns}
Growth Regulator (GR)	1	141.6	15.8**	0.0	0.0^{ns}	2.3	0.1^{ns}	24.6	2.7^{ns}
Precooling (PR)	2	1278.0	71.2**	0.9	0.8^{ns}	2406.6	53.2**	38.3	2.1^{ns}
GR x PR	2	3.2	0.2^{ns}	0.5	0.5^{ns}	20.6	0.5^{ns}	0.3	0.0^{ns}
Error	20	179.4	-	11.4	-	452.1	-	183.0	-

[1] DAYSFL = days until flowering; LFNO = leaf number per plant, MXLFHT = maximum leaf height (cm); STKHT = stalk height (cm).

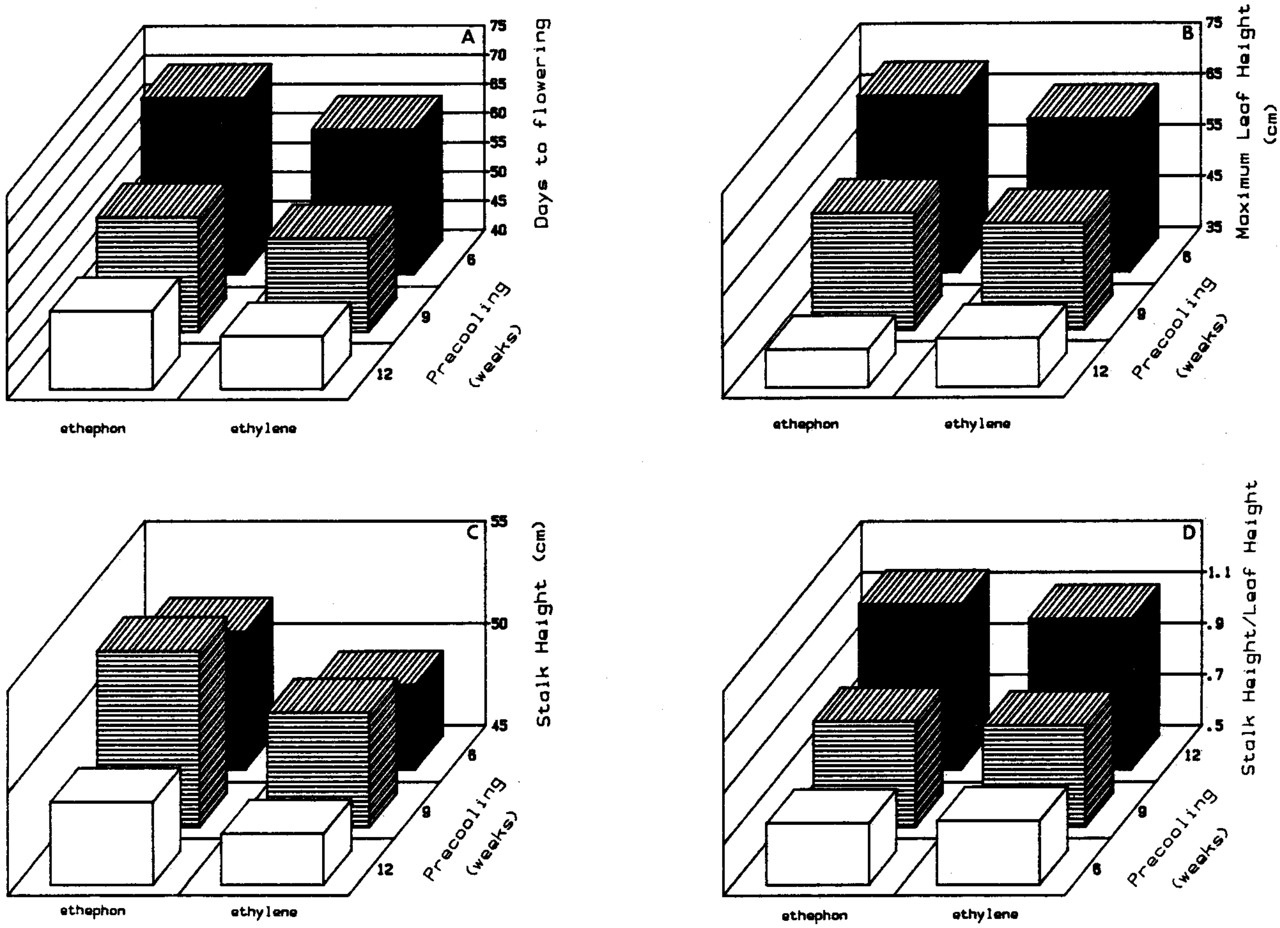

Figure 11. Effect of growth regulator treatment and precooling duration on forcing performance of 'Blue Ribbon' iris.

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