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PRE-WARMING OF NARCISSUS, PRIOR TO HOT-WATER TREATMENT, IN LINCOLNSHIRE

UNDERTAKEN FOR THE HDC

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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PRE-WARMING OF NARCISSUS, PRIOR TO HOT-WATER TREATMENT, IN LINCOLNSHIRE

Summary

Bulbs of narcissus cv Carlton were lifted from the field at Kirton on 15 June, 29 June and 13 July 1988. Batches of bulbs were given hot-water treatment (HWT) at various dates up to late-September, and HWT was preceded by storage at ambient temperature, or 18°C for 14 days (partial pre-warming), or 30°C for 7 days (full pre-warming); following full pre-warming, bulbs were pre-soaked at ambient tempertures before HWT at 46°C, otherwise 44.4°C HWT was used, without pre-soaking. Additional control batches were not given HWT. Foliage and flower performance were recorded in 1989 and 1990 and bulb yields were determined after lifting in 1990.

In the first year, flower numbers were much reduced when HWT was given after 17 August following ambient storage or after 31 August following full pre-warming, but were only slightly reduced even with very late HWT (28 September) following partial pre-warming. Affected plots produced shorter leaves and flower stems. Flower damage was severe following early HWT, and stunted plants were produced following late HWT, especially following ambient storage. There were some interactions with lifting date.

In the second year, flower production was relatively consistent across the treatments, although the most severely affected plots still showed reduced flower counts and some stunting.

Bulb yields were much reduced following late HWT, particularly when full pre-warming was used. Partial pre-warming reduced the adverse effects of late HWT to a large extent. Percentage weight increases varied from 180 percent in the best treatments to less than 10 percent in the poorest. In the poorer treatments (late HWT with no or full pre-warming), a high proportion of the lift was in the smaller bulb grades.

Introduction

Hot-water treatment (HWT) is used to control diseases and pests, especially stem nematode, in narcissus. Each year many stocks are damaged because of low ambient temperatures prior to HWT or because the treatment has been applied too early or too late: storage below 18°C before HWT can increase damage, and the ideal time for HWT is soon after stage Pc (ie, trumpet of flower initials visible on dissection of the bud). The damage can range from unmarketable first-year flowers, through marked or stunted foliage, to severe shoot and root damage and consequent loss of bulb yield (ADAS, 1985). Flower damage can be reduced by using a pre-warming bulb treatment (one week at 30°C), although when this is applied pre-soaking and a higher HWT temperature (46°C) must be used to combat the resistant nematode "wool" stage which is produced. The use of 30°C pre-warming makes the date of HWT less critical, usefully extending the HWT season, and making the date of reaching stage Pc less important as a marker for the earliest safe date for HWT (Tompsett, 1982). If 30°C pre-warming is not used, even relatively small increases in pre-HWT storage temperature enhance growth: in south-west and eastern England, mean daily air temperatures are normally sub-optimal for bulb storage, and storage at 17-18°C for two weeks will counter the effects of cool weather; this treatment does not require pre-soaking or increased HWT temperature (Tompsett, 1982).

Most previous trials on this topic have been conducted in the south-west, where the outdoor flower crop has always been important. As outdoor flowers are now more commonly taken from crops in eastern England, in the present trial pre-warming was investigated under Lincolnshire conditions. HWT was evaluated, at a wide range of dates, in combination with pre-warming (30°C) or partial pre-warming (18°C) prior to HWT. The relatively damage-sensitive cultivar Carlton was used, and both flower and bulb losses were assessed.

Materials and methods

Plant material

Bulbs of Narcissus cultivar Carlton were used from a stock grown at HRI Kirton following good commercial practice. Portions of the stock were lifted on 15 June, 29 June and 13 July 1988 and graded immediately to provide adequate bulbs of grade 10-12 cm (circumference, slotted riddles) for the trial (about 0.2 t per date). On the day following lifting, the allocated bulbs were dipped in aqueous thiabendazole with formaldehyde and non-ionic wetter (as 5 litre Storite Clear Liquid, 5 litre commercial formalin and 620 ml Agral/1000 litres) for 30 minutes at ambient temperatures. After dipping, bulbs were dried in bulk boxes on a drying wall at 35°C for five days, after which drying and storage was continued at ambient temperatures in a shed, using fans over the boxes, until bulbs were required for treatments. Samples were dissected at intervals to determine internal stage of development: bulbs from all three lifting dates reached Stage Pc (paracorolla initial visible) on 4 August 1988.

Pre-warming and hot-water treatments

Bulbs were allocated in triplicate, 50 bulb batches for each treatment. Treatments consisted of ambient storage, partial pre-warming or full pre-warming prior to carrying out HWT at two-weekly intervals from 6 July to 28 September, using all practicable combinations for each of the three lifting dates.

Ambient storage consisted of continued storage as before, partial pre-warming of a 14-day period at 18°C before HWT, and full pre-warming of a seven-day period at 30°C before HWT.

After ambient storage and partial pre-warming, HWT comprised a three-hour dip at 44.4°C; after full pre-warming, bulbs were dipped for three hours at ambient temperatures followed by HWT for three hours at 46°C. Ambient and HWT dips contained thiabendazole, formaldehyde and non-ionic wetter (as above). After HWT, bulbs were dried and stored under fans at ambient temperatures.

An additional treatment consisted of bulbs stored at ambient temperatures which did not receive HWT.

Monthly mean (ambient) temperatures at Kirton over the June to September 1988 period (13.5, 15.5, 16.0 and 13.3°C, respectively) were very close to the 20-year averages.

Field growing

During ambient storage, each batch of 50 bulbs was weighed and placed in a length of tubular nylon netting (Netlon Oriented 1, 3.8 m long), using clips to distribute bulbs evenly, ready for planting in the field.

Bulbs were planted in ridges on 30 September 1988. The trial area had been previously ridged and the plots (each consisting of a 1.9 m long length of ridge) marked in, giving a planting density of 15 t/ha with ridges at 0.71 m centres; at planting each net was laid double in the ridge bottom, and the ridges split back.

Cultural details in the field were as given in Appendix, Table A.

Field observations

The number of flowers per plot was recorded on 30 March 1989 and 17 April 1990, along with the stem and leaf lengths of 20 central plants (where available) per plot. The extent of shoot damage was scored on 22 March 1989. A photographic record of typical plots was kept.

The dates of first and 100 per cent flowering were recorded.

Harvesting and recording

On 23 July 1990 the foliage was flailed off and the trial lifted. Bulbs were dried under fans at ambient temperature, removed from the netting and cleaned by hand, and graded, recording the number and weight of bulbs in 2-cm grade bands.

Design and statistical analysis

The experiment was of a randomised block design, with three replicate blocks. The trial was unbalanced because of the different range of HWT dates available to the three lifting dates. The trial area was edged with guard plants.

Data were subjected to the analysis of variance where appropriate. Although raw (untransformed) values are given in the tables, conclusions were drawn from analyses of transformed data where this improved precision. Quoted total bulb yields were adjusted for initial variations in weights plants in plots and for positional effects in the field.

Results

Flower and foliage records, year 1

Full results are shown in Appendix Table B. Flowering date was delayed by about a week in plants which received late HWT (September), compared with early HWT.

In the case of ambient-stored and fully pre-warmed plots, flower numbers (Figure 1) were drastically reduced when HWT was carried out after 17 August (ambient stored) or after 31 August (full pre-warmed), while in partially pre-warmed plots there was only a slight reduction in flower numbers with later HWT, even up to 28 September. These effects applied equally to the three lifting dates. Statistically, there were more flowers from the second lifting date than for first or third lifts. Flower diameter varied only between 88 and 110 mm in the various treatments, with no effects of treatment and no reduction of size in otherwise poorly performing plots.

Fig.1 Lifting date, pre-warming, HWT date and flower number (Year 1)

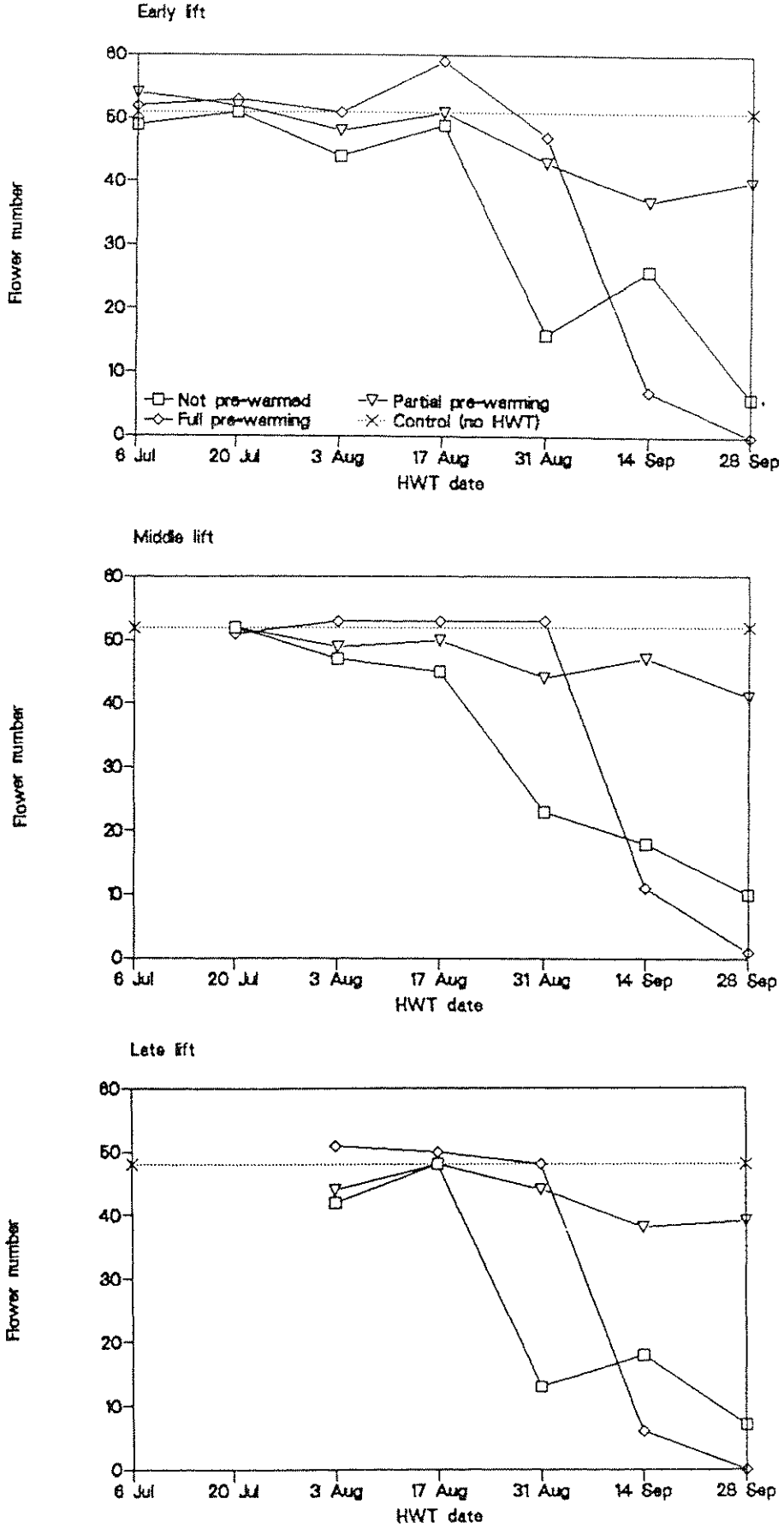
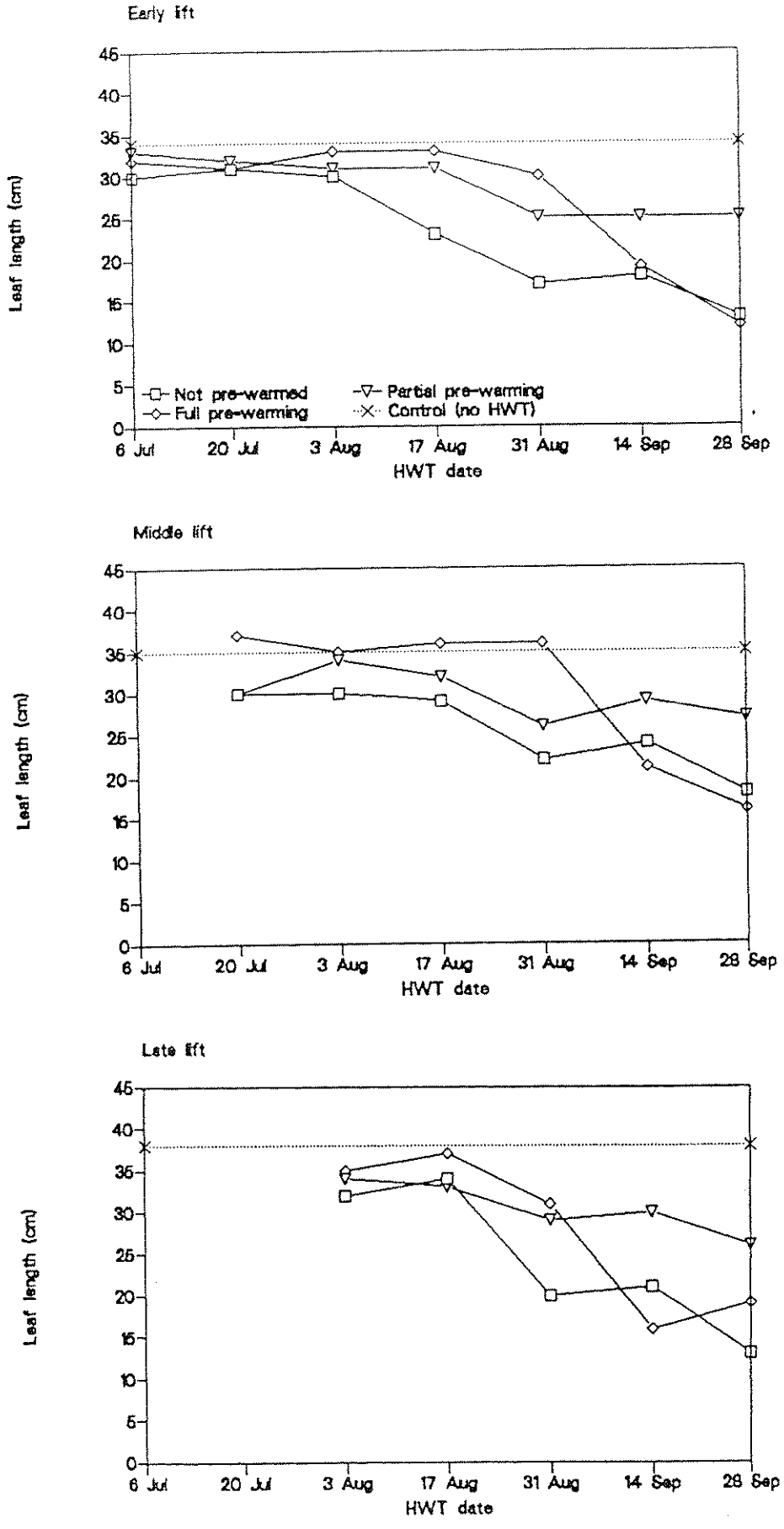


Fig.2 Lifting date, pre-warming, HWT date and leaf length (Year 1)



Stem length was reduced in most hot-water treated plots, compared with non-treated controls, but the extent of this reduction varied with treatments. In ambient-stored bulbs, the effect occurred in all treatments, but particularly in plots hot-water treated on 31 August or later. In fully pre-warmed plots, stems were very short only with the latest (September) HWT dates. In partially pre-warmed plots, the effect of HWT date was weaker but shorter stems were more pronounced for the last lifting date (13 July) than for other dates. In general, the effects on leaf length were similar. (Figure 2).

Flower damage (ragged perianth segments and distorted petals and trumpet) was more severe for the earlier HWT dates. In ambient-stored plots, damaged flowers occurred in HWT dates up to and including 31 August (or 17 August for the last lifting date only). In fully pre-warmed plots the first two lifting dates showed damage up to 3 August HWT date only, whereas in the last lifting date damage occurred with HWT up to 14 September. In partially pre-warmed plots, damage occurred with HWT up to 3 August (first two lifting dates) or 17 August (last lifting date).

Stunted, distorted leaves occurred mainly in the later HWT treatments. For ambient-stored bulbs, damaged occurred with HWT on 31 August or later for the first lifting date, but much earlier for the second (3 August) and third lifting dates (17 August). Fully pre-warmed plots showed leaf damage only when HWT was given in September. In partially pre-warmed plots, leaf damage occurred with HWT on 31 August or later in bulbs from the first lifting date and on 28 September only in those from the second lifting date, but throughout the whole range of HWT dates for the latest lifting date.

Flower and foliage records, year 2

Appendix Table C shows the relevant data for year two. While there were some minor differences in flowering date between treatments, flowering period was more consistent than in the previous year. Reduced flower counts (see Figure 3) were still evident in the most severely affected treatments of the previous year, the statistically significant effects being the same as in the first year. Flower size was unaffected by treatment (overall mean, 11 cm). Stem and leaf lengths were relatively consistent, although the effects of very late HWT still persisted with some shorter growth. In year two, flowers and foliage were normal and without damage.

Bulb yields - weights

Total bulb yields (by weight) are given in full in Appendix Table D and summarised in Figure 4. For all three lifting dates, late HWT greatly reduced yields, the effect being most marked following full pre-warming and least marked after partial pre-warming. There was no evidence for enhanced yields following any HWT treatment over controls which did not receive HWT.

Fig.3 Lifting date, pre-warming, HWT date and flower number (Year 2)

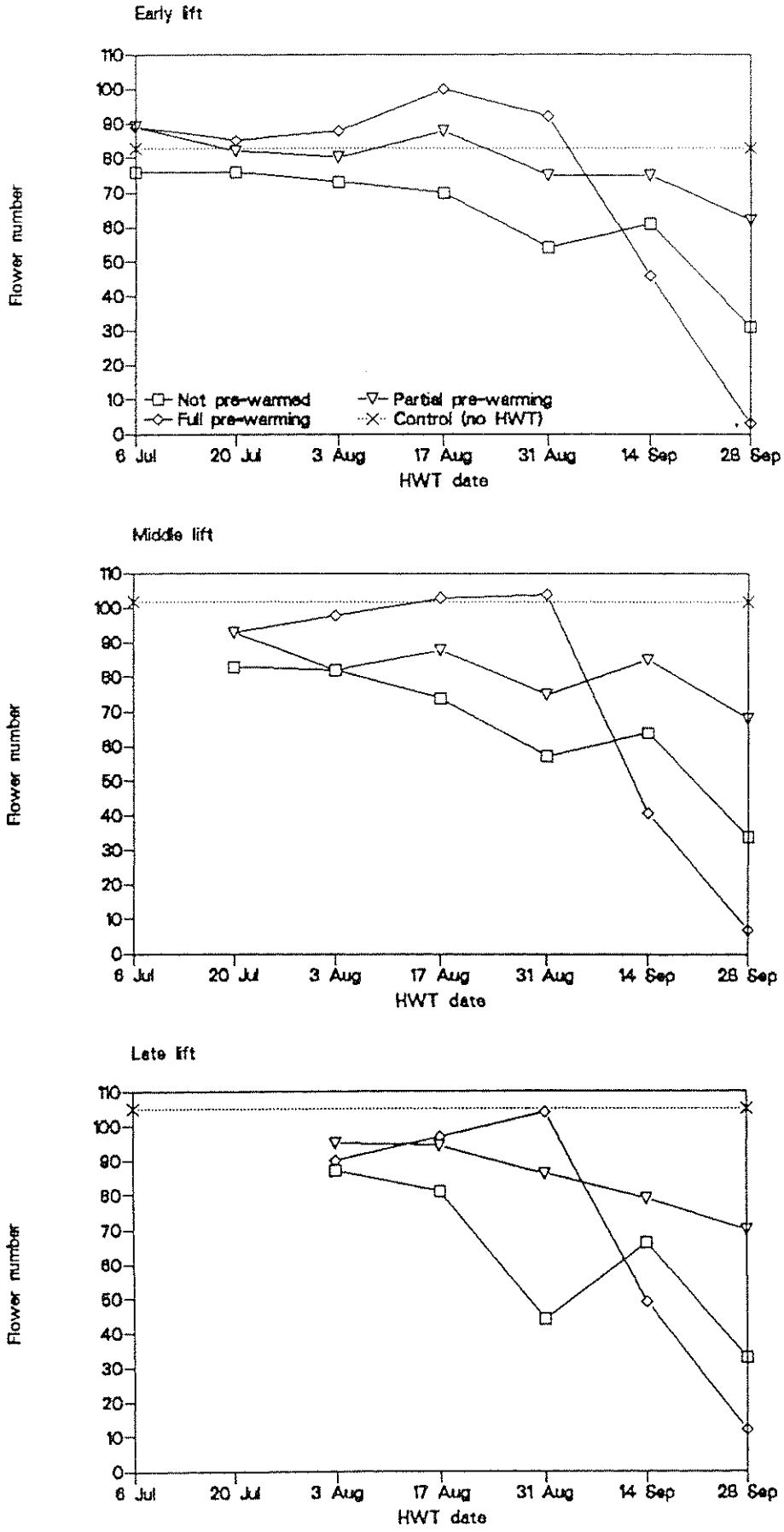
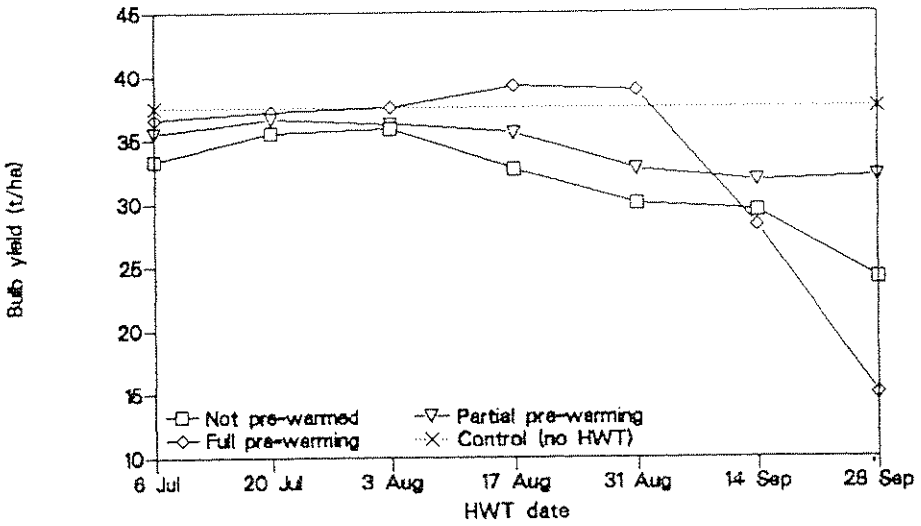
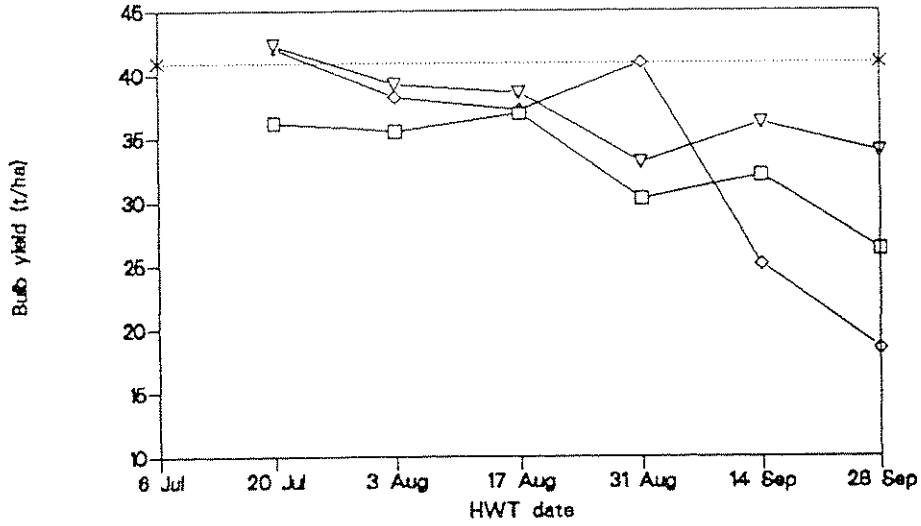


Fig.4 Lifting date, pre-warming, HWT date and bulb yield

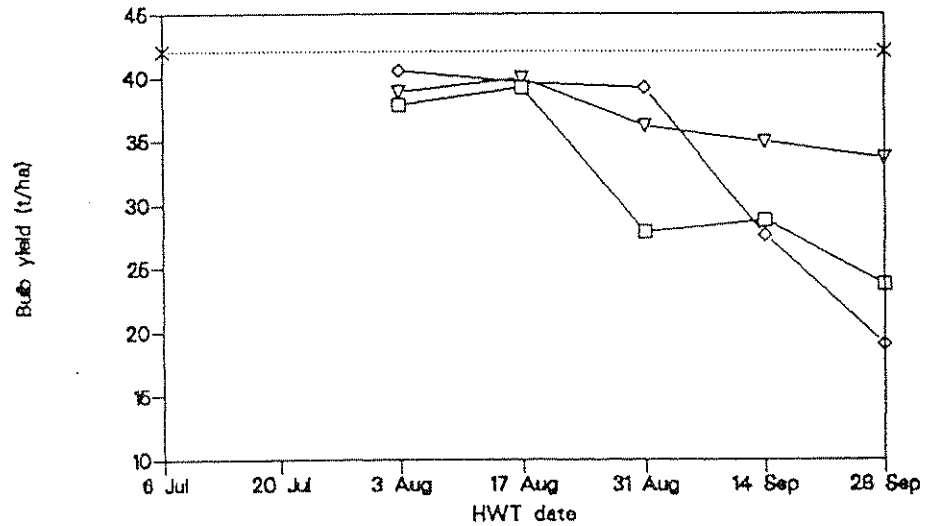
Early lift



Middle lift



Late lift



For the early lifting date, there was no evidence for yield reductions following early HWT, but there were significant reductions when HWT was carried out on 17 August or later without pre-warming, on 31 August or later with partial pre-warming, or on 14 September or later with full pre-warming. Although full pre-warming allowed later HWT than other treatments, very late HWT following full pre-warming had very severe effects on yields; in contrast, the effects of late HWT after partial pre-warming were relatively mild.

For the middle lifting date, all HWT dates reduced yields when used without pre-warming, slightly up to mid-August dates and more severely thereafter; following partial pre-warming, yields were reduced significantly when HWT was given on 31 August or later, and, following full pre-warming, on 14 September or later. As noted for the early lifted bulbs, the effects of late HWT after full pre-warming were severe and, after partial pre-warming, slight.

For the late-lifted bulbs, similar responses were seen: without pre-warming, moderate reductions in yield were seen with HWT on or after 31 August, with partial pre-warming slight reductions with HWT on 14 September or later, and, with full pre-warming, severe reductions with HWT on 14 September or later.

Yields were, overall, poorer in early-lifted bulbs than in mid- or late-lifted bulbs. As the plots were equal in grades and weights prior to treatment, this effect was not related to bulb size at lifting.

Table D shows yield as percentage weight increase: this varied from about 180 percent in the best treatment to less than 10 percent in the poorest.

The distribution of bulb yield (by weight) to grades is also shown in Table D. The effect of treatments was clearly seen in the grade-out: for the poorest treatments (late HWT following no pre-warming or full pre-warming) over 50 percent of the yield was in bulbs of <10 cm grade, with little, if any, yield in the largest (16-18 cm) grade; in earlier HWT and partial pre-warmed treatments the grade-out was more balanced, with the bulk of the yield in 12-14 and 14-16 cm grades.

Strictly speaking, conclusions about statistical significance should be based on transformed values (see Materials and Methods). The relevant figures are given in Appendix Table E, where the total yields have also been adjusted for initial (planted) plot weight and for positional effects in the field. These refinements, however, did not affect the outcome of the trial.

Bulb yields - numbers

Total number of bulbs and their distribution to grades is given in Appendix Table F. Due to the high correlation between weight and numbers in each grade, a formal analysis of bulb numbers by grade was unnecessary. Transformed values (for statistical purposes) are given for total numbers in Appendix Table E.

The results showed that more bulbs were lifted following late HWT with no or full pre-warming; this is related to the larger proportion of bulbs in the smaller grades in these treatments, which gave poor yields measured by weight.

Discussion

HWT is a demanding technique, both on the dipping equipment, which must have accurate and well monitored temperature control, and other physical attributes, and on the grower, who, if crop damage is to be avoided, must treat bulbs in the short period between full flower differentiation and root initial growth. Pre-warming bulbs before HWT guards against flower damage in the succeeding crop, and appears to make the exact date of HWT less critical; partial pre-warming, which involves storing bulbs only slightly above typical ambient temperatures, is a further aid to obtaining good results with HWT. In the present trial, the effects of pre-warming, both full and partial, were examined over a wide range of HWT dates.

The striking effect of treatments on the yield of flowers in the first season was that, while for ambient stored and fully pre-warmed bulbs there was a sharp cut-off (17 or 31 August, respectively) after which few flowers were obtained, for partly pre-warmed bulbs, flower numbers declined only gradually with later HWT, so that even with the latest HWT date flower counts had decreased by only about 20 percent. Treatments which gave fewer flowers also had shorter stems and leaves.

Damaged flowers occur when HWT is applied too early. For the first two lifting dates of the present trial, damaged flowers occurred up to and including HWT dates of 31 August, without pre-warming, but only up to 3 August when pre-warming (either full or partial) was used. There appeared to be an interaction between lifting date and pre-warming treatment, in-as-much as, for the third lifting date, non pre-warmed bulbs seemed less sensitive to early HWT damage and pre-warmed bulbs more sensitive; the reason for this finding is not obvious.

Severely stunted shoots were a feature of late HWT, and there again appeared to be an interaction with lifting date. In ambient-stored and partially pre-warmed bulbs from the first lifting date, damage occurred in bulbs treated 31 August or later, but only from 14 September onwards when full pre-warming was used. For the second lifting date, damage occurred with most HWT dates for ambient-stored bulbs, but only in September when pre-warming was used. For the third lifting date results were similar, except that only full pre-warming was effective in preventing damage.

HWT damage persisted in the more severe cases to flower losses in the second season and to reduced bulb yields. Bulb yields corresponded roughly with first-season flower yields. Progressively later HWT led to increasing loss of yield, but when partial pre-warming was used the effects of very late HWT were less severe.

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APPENDIX

Table A Outline of cultural and related treatments in the field

Soil texture:	Mixed fine silty and clayey marine alluvium ("40 Acres 3" field)
Previous cropping:	1986 Spring barley 1987 Winter wheat 1988 Short-term grass
Soil analysis:	pH 7.9 P_2O_5 index 3 K_2O index 2 Mg index 4
Fertilisers:	120 kg N, 38 kg P_2O_5 and 172 kg K_2O/ha (as 16:5:23) applied in base July 1988
Cultivations:	Ploughed July 1988 Cultivated (Lely Roterra) and ridged July 1988 Re-ridged October 1989
Insecticides:	None applied
Fungicides:	Vinclozolin (as 100 ml Ronilan/100 l, aerial application) applied 3 March, 17 March, 12 April and 27 April 1989 Vinclozolin (as 100 ml Ronilan/100 l, HV spray) applied 7 March, 17 March and 28 March 1990
Herbicides:	Diquat + paraquat (as 5.6 l Farmon PDQ/ha) applied 1 August, 11 October and (as 3.0 l/ha) 22 December 1988 Chlorpropham + linuron (as 11.2 l Profalon/ha) applied 22 December 1988 Diquat + paraquat (as 5.6 l Farmon PDQ/ha) applied 8 November and (as 3.0 l/ha) 7 December 1989 Chlorpropham + linuron (as 11.2 l Profalon/ha) applied 4 January 1990
Irrigation:	None applied

Table B Effect of lifting date, pre-warming and HWT on flowering performance of Carlton narcissus in its first year

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March)		Flower count per plot	Flower diam (cm)	Stem length (cm)	Leaf length (cm)	Damage score*	
			First	Full					Flower	Leaf
15 June	Untreated	-	13	30	51	10	38	34	0	0
	None/ HWT	6 July	10	23	49	10	32	30	2	0
		20 July	10	23	51	9	36	31	2	0
		3 Aug	10	23	44	11	29	30	2	0
		17 Aug	10	23	49	10	29	23	0	0
		31 Aug	13	30	16	11	21	17	1	1
		14 Sept	13	30	26	9	15	18	0	1
		28 Sept	17	23	6	10	24	13	0	1
	Partial/ HWT	6 July	10	23	54	11	34	33	2	0
		20 July	10	23	52	10	34	32	2	0
		3 Aug	10	23	48	10	37	31	1	0
		17 Aug	10	30	51	10	35	31	0	0
		31 Aug	13	30	43	10	27	25	0	1
		14 Sept	13	30	37	10	28	25	0	0
		28 Sept	13	30	40	10	28	25	0	1
	Full/ HWT	6 July	10	23	52	10	35	32	0	0
		20 July	10	23	53	9	38	31	0	0
		3 Aug	10	20	51	10	40	33	2	0
		17 Aug	10	23	59	10	38	33	0	0
		31 Aug	10	23	47	10	36	30	0	0
		14 Sept	13	30	7	9	28	19	0	1
		28 Sept	20	30	0	-	-	12	0	1

Continued

Table B (continued)

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March)		Flower count per plot	Flower diam (cm)	Stem length (cm)	Leaf length (cm)	Damage score*	
			First	Full					Flower	Leaf
29 June	Untreated	-	10	23	52	10	40	35	0	0
	None/ HWT	20 July	10	23	52	10	34	30	2	0
		3 Aug	10	23	47	10	22	30	1	1
		17 Aug	10	30	45	10	28	29	1	1
		31 Aug	13	30	23	10	19	22	1	1
		14 Sept	20	30	18	10	16	24	0	1
		28 Sept	20	30	10	10	14	18	0	1
	Partial/ HWT	20 July	10	23	52	11	34	30	2	0
		3 Aug	6	23	49	11	28	34	1	0
		17 Aug	10	23	50	11	38	32	0	0
		31 Aug	13	23	44	10	33	26	0	0
		14 Sept	17	23	47	10	28	29	0	0
		28 Sept	13	30	41	10	31	27	0	1
	Full/ HWT	27 July	6	20	51	11	40	37	2	0
		3 Aug	10	23	53	11	39	35	2	0
		17 Aug	10	23	53	10	37	36	0	0
		31 Aug	10	23	53	10	37	36	0	0
		14 Sept	20	30	11	10	25	21	0	1
		28 Sept	20	30	1	-	-	16	0	1

Continued

Table B (continued)

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March)		Flower count per plot	Flower diam (cm)	Stem length (cm)	Leaf length (cm)	Damage score*	
			First	Full					Flower	Leaf
13 July	Untreated	-	6	20	48	11	42	38	0	0
	None/ HWT	3 Aug	6	20	42	11	29	32	2	0
		17 Aug	10	30	48	11	29	34	1	1
		31 Aug	13	30	13	10	25	20	0	1
		14 Sept	13	30	18	10	13	21	0	1
		28 Sept	13	30	7	10	20	13	0	1
	Partial/ HWT	3 Aug	10	23	44	11	25	34	1	1
		17 Aug	6	20	48	10	28	33	1	0
		31 Aug	10	30	44	11	23	29	0	1
		14 Sept	10	30	38	10	29	30	0	1
		28 Sept	13	30	39	11	27	26	0	1
	Full/ HWT	3 Aug	10	20	51	10	39	35	2	0
		17 Aug	10	23	50	11	41	37	1	0
		31 Aug	10	23	48	10	39	31	1	0
		14 Sept	10	30	6	11	32	16	1	1
		28 Sept	20	30	0	10	36	19	0	1
	SED		-	-	0.1	-		-	-	-

*Flower damage assessed as 0 (undamaged), 1 (damaged perianth segments) or 2 (distorted perianth and trumpet); leaf damaged assessed as 0 (undamaged) or 1 (leaves stunted and distorted).

Table C Effect of lifting date, pre-warming and HWT on flowering performance of Carlton narcissus in its second year

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March) First	Flowering date (March) Full	Flower count per plot	Stem length (cm)	Leaf length (cm)
15 June	Untreated	-	11	19	83	41	40
	None/ HWT	6 July	11	19	76	39	41
		20 July	8	23	76	37	40
		3 Aug	11	19	73	41	42
		17 Aug	11	23	70	34	36
		31 Aug	8	19	54	38	37
		14 Sept	11	19	61	35	39
		28 Sept	11	19	31	38	37
	Partial/ HWT	6 July	8	19	89	39	39
		20 July	8	19	82	39	37
		3 Aug	11	19	80	37	38
		17 Aug	11	19	88	38	38
		31 Aug	11	19	75	38	40
		14 Sept	11	19	75	39	40
		28 Sept	8	19	62	38	36
	Full/ HWT	6 July	11	19	89	36	36
		20 July	11	19	85	39	39
		3 Aug	11	19	88	40	38
		17 Aug	8	19	100	42	43
		31 Aug	11	23	92	42	39
		14 Sept	11	23	46	37	38
		28 Sept	16	19	3	36	35

Continued

Table C (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March) First	Flowering date (March) Full	Flower count per plot	Stem length (cm)	Leaf length (cm)
29 June	Untreated	-	11	19	102	42	43
	None/ HWT	20 July	11	19	83	39	36
		3 Aug	11	19	82	37	38
		17 Aug	11	19	74	39	39
		31 Aug	8	19	57	39	41
		14 Sept	11	23	64	37	38
		28 Sept	11	23	34	36	38
	Partial/ HWT	20 July	11	19	93	39	43
		3 Aug	8	19	82	40	40
		17 Aug	11	19	88	38	36
		31 Aug	11	19	75	37	38
		14 Sept	8	19	85	42	46
		28 Sept	11	23	68	40	43
	Full/ HWT	20 July	11	19	93	38	41
		3 Aug	8	19	98	36	42
		17 Aug	11	19	103	39	44
		31 Aug	11	23	104	39	40
		14 Sept	11	19	41	37	37
		28 Sept	16	23	7	37	37

Continued

Table C (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Flowering date (March) First	Flowering date (March) Full	Flower count per plot	Stem length (cm)	Leaf length (cm)
13 July	Untreated	-	8	19	105	42	39
	None/ HWT	3 Aug	8	19	87	37	40
		17 Aug	8	19	81	40	39
		31 Aug	8	19	44	40	37
		14 Sept	8	19	66	39	44
		28 Sept	8	19	33	37	39
	Partial/ HWT	3 Aug	8	19	95	40	41
		17 Aug	8	19	94	39	38
		31 Aug	8	23	86	42	41
		14 Sept	8	19	79	38	37
		28 Sept	8	19	70	40	39
	Full/ HWT	3 Aug	11	19	90	44	45
		17 Aug	8	19	97	40	39
		31 Aug	11	19	104	40	38
		14 Sept	11	23	49	38	39
		28 Sept	16	23	12	35	38
SED			-	-	0.2	-	-

Table D Effect of lifting date, pre-warming and HWT on bulb yields and grade-out (by weight) of Carlton narcissus

Lifting date	Pre-warming/ HWT	HWT date	Total yield (kg/plot)	Percentage weight in grades <8	8-10	10-12	12-14	14-16	16-18	Percentage weight increase
15 June	Untreated	-	4.94	7	11	10	20	38	15	177
	None/ HWT	6 July	4.67	4	10	14	30	30	12	180
		20 July	4.60	8	12	15	24	35	7	159
		3 Aug	4.72	8	12	14	19	28	19	171
		17 Aug	4.50	9	17	16	31	24	3	123
		31 Aug	4.00	16	20	25	29	9	2	104
		14 Sept	3.95	13	17	28	22	15	5	103
		28 Sept	3.13	25	28	31	13	2	1	77
	Partial/ HWT	6 July	4.81	7	13	15	26	32	7	139
		20 July	4.70	7	11	11	32	31	8	173
		3 Aug	4.74	8	13	12	24	31	11	169
		17 Aug	4.85	7	14	14	24	26	15	146
		31 Aug	4.46	8	15	21	23	28	5	116
		14 Sept	4.28	12	15	20	26	22	5	118
		28 Sept	4.27	10	17	21	28	18	6	130
	Full/ HWT	6 July	4.75	6	13	10	23	34	13	178
		20 July	4.85	5	13	12	25	34	12	186
		3 Aug	4.91	6	16	12	23	34	9	173
		17 Aug	5.41	4	14	20	24	24	15	166
		31 Aug	5.25	5	14	19	24	26	12	166
		14 Sept	3.75	26	26	27	15	6	1	98
		28 Sept	1.97	35	37	23	4	1	0	8

Continued

Table D (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Total yield (kg/plot)	Percentage weight in grades <8	8-10	10-12	12-14	14-16	16-18	Percentage weight increase
29 June	Untreated	-	5.58	6	11	13	16	36	20	170
	None/ HWT	20 July	4.92	9	13	13	30	27	8	135
		3 Aug	4.92	7	12	13	30	27	11	131
		17 Aug	5.01	11	12	17	25	26	10	143
		31 Aug	4.21	17	25	26	17	11	4	93
		14 Sept	4.32	19	26	21	24	9	2	106
		28 Sept	3.59	25	27	25	16	6	0	76
	Partial/ HWT	20 July	5.68	5	15	9	16	35	21	171
		3 Aug	5.27	10	13	19	18	33	7	172
		17 Aug	5.26	6	11	12	21	35	15	157
		31 Aug	4.47	14	14	18	26	23	5	120
		14 Sept	4.94	9	13	16	29	24	10	138
		28 Sept	4.60	10	16	23	24	22	4	131
	Full/ HWT	20 July	5.68	6	14	12	16	31	21	171
		3 Aug	5.15	4	14	13	22	33	13	151
		17 Aug	5.11	7	16	13	22	27	14	148
		31 Aug	5.44	7	14	18	24	25	12	168
		14 Sept	3.50	31	28	21	11	7	2	57
		28 Sept	2.55	41	34	17	6	1	0	19

Continued

Table D (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Total yield (kg/plot)	Percentage weight in grades						Percentage weight increase
				<8	8-10	10-12	12-14	14-16	16-18	
13 July	Untreated	-	5.80	6	15	12	14	29	24	166
	None/ HWT	3 Aug	5.21	10	18	12	23	28	9	147
		17 Aug	5.26	7	17	14	20	29	13	150
		31 Aug	3.81	21	27	26	17	7	2	84
		14 Sept	3.92	15	29	23	23	9	1	88
		28 Sept	3.30	22	31	25	16	6	0	51
	Partial/ HWT	3 Aug	5.30	7	16	13	15	30	19	146
		17 Aug	5.35	8	18	12	19	29	13	155
		31 Aug	4.95	12	19	13	18	29	8	143
		14 Sept	4.68	14	17	19	21	25	4	134
		28 Sept	4.57	14	23	17	25	17	4	113
	Full/ HWT	3 Aug	5.55	5	13	14	15	39	15	165
		17 Aug	5.42	8	14	12	20	27	19	154
		31 Aug	5.35	4	16	15	21	27	18	158
		14 Sept	3.72	35	31	23	9	3	0	80
		28 Sept	2.59	31	36	20	7	7	0	24
	SED			-	-	-	-	-	-	14.5

Table E Effect of lifting date, pre-warming and HWT on bulb yields (weights and numbers) of Carlton narcissus; figures are transformed and adjusted values (see text)

Lifting date	Pre-warming/ HWT	HWT date	Bulb yield (kg/plot) in grades and in total							Bulb yield (total no./ plot)
			<8	8-10	10-12	12-14	14-16	16-18	Total	
15 June	Untreated	-	0.57	0.73	0.68	0.99	1.37	0.85	2.25	10.00
	None/ HWT	6 July	0.45	0.67	0.81	1.18	1.18	0.74	2.12	9.65
		20 July	0.60	0.73	0.82	1.06	1.24	0.56	2.19	9.95
		3 Aug	0.67	0.76	0.85	0.89	1.21	0.90	2.20	9.81
		17 Aug	0.63	0.88	0.83	1.18	1.04	0.36	2.10	10.68
		31 Aug	0.79	0.88	1.00	1.07	0.61	0.21	2.01	10.67
		14 Sept	0.73	0.80	1.02	0.94	0.85	0.20	1.99	10.65
		28 Sept	0.88	0.94	0.98	0.61	0.22	0.09	1.80	10.89
	Partial/ HWT	6 July	0.56	0.80	0.85	1.11	1.24	0.56	2.19	10.12
		20 July	0.56	0.72	0.69	1.23	1.21	0.60	2.22	9.91
		3 Aug	0.62	0.77	0.76	1.07	1.21	0.71	2.21	9.86
		17 Aug	0.58	0.83	0.83	1.08	1.11	0.83	2.19	10.54
		31 Aug	0.59	0.82	0.98	1.01	1.11	0.45	2.10	10.24
		14 Sept	0.71	0.79	0.92	1.05	0.97	0.45	2.07	10.60
		28 Sept	0.64	0.86	0.95	1.10	0.85	0.40	2.08	10.34
	Full/ HWT	6 July	0.55	0.79	0.70	1.04	1.27	0.77	2.22	9.94
		20 July	0.47	0.80	0.75	1.09	1.26	0.75	2.24	9.64
		3 Aug	0.54	0.87	0.77	1.07	1.29	0.62	2.25	9.85
		17 Aug	0.49	0.85	1.03	1.13	1.14	0.89	2.30	10.69
		31 Aug	0.49	0.86	0.99	1.12	1.18	0.77	2.29	10.52
		14 Sept	0.98	0.98	1.00	0.74	0.38	0.11	1.95	12.08
		28 Sept	0.82	0.85	0.68	0.23	0.09	0	1.42	10.50

Continued

Table E (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Bulb yield (kg/plot) in grades and in total <8	8-10	10-12	12-14	14-16	16-18	Total	Bulb yield (total no./ plot)
29 June	Untreated	-	0.49	0.78	0.83	0.95	1.41	1.04	2.35	10.38
	None/ HWT	20 July	0.65	0.79	0.79	1.22	1.16	0.63	2.21	10.24
		3 Aug	0.57	0.76	0.81	1.19	1.16	0.70	2.19	10.17
		17 Aug	0.73	0.78	0.90	1.11	1.13	0.68	2.23	10.48
		31 Aug	0.83	1.02	1.04	0.85	0.69	0.33	2.02	11.29
		14 Sept	0.90	1.05	0.96	1.01	0.63	0.21	2.08	11.62
		28 Sept	0.94	0.98	0.96	0.75	0.44	0	1.88	11.43
	Partial/ HWT	20 July	0.64	0.92	0.79	0.98	1.36	0.92	2.39	10.33
		3 Aug	0.71	0.84	0.99	0.98	1.29	0.55	2.30	10.77
		17 Aug	0.57	0.76	0.81	1.04	1.36	0.87	2.28	10.15
		31 Aug	0.78	0.79	0.90	1.07	1.00	0.44	2.11	10.74
		14 Sept	0.64	0.80	0.87	1.19	1.08	0.70	2.21	10.54
		28 Sept	0.67	0.87	1.04	1.03	1.00	0.35	2.14	10.67
	Full/ HWT	20 July	0.58	0.90	0.83	0.94	1.32	1.08	2.38	10.61
		3 Aug	0.47	0.86	0.82	1.04	1.30	0.81	2.27	10.23
		17 Aug	0.60	0.89	0.81	1.06	1.17	0.86	2.24	10.58
		31 Aug	0.62	0.84	0.95	1.13	1.16	0.77	2.35	10.94
		14 Sept	1.05	0.99	0.85	0.61	0.49	0.14	1.84	12.73
		28 Sept	1.01	0.93	0.65	0.37	0.10	0	1.58	11.69

Continued

Table E (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Bulb yield (kg/plot) in grades and in Total <8	8-10	10-12	12-14	14-16	16-18	Total	Bulb yield (total no./ plot)
13 July	Untreated	-	0.55	0.91	0.83	0.90	1.30	1.17	2.38	10.79
	None/ HWT	3 Aug	0.73	0.96	0.79	1.09	1.21	0.63	2.26	11.02
		17 Aug	0.59	0.95	0.85	1.02	1.23	0.80	2.30	10.55
		31 Aug	0.86	1.01	0.99	0.80	0.48	0.15	1.94	11.01
		14 Sept	0.75	1.07	0.95	0.91	0.59	0.12	1.97	11.17
		28 Sept	0.84	1.01	0.90	0.73	0.43	0	1.79	11.01
	Partial/ HWT	3 Aug	0.61	0.91	0.82	0.90	1.25	0.99	2.29	10.58
		17 Aug	0.67	0.98	0.80	1.01	1.24	0.84	2.32	10.86
		31 Aug	0.77	0.97	0.76	0.95	1.20	0.50	2.21	11.17
		14 Sept	0.79	0.89	0.93	0.98	1.07	0.45	2.17	11.48
		28 Sept	0.80	1.02	0.87	1.04	0.89	0.44	2.13	11.22
	Full/ HWT	3 Aug	0.49	0.84	0.89	0.90	1.47	0.92	2.34	10.26
		17 Aug	0.67	0.87	0.79	1.03	1.22	1.01	2.31	10.79
		31 Aug	0.45	0.91	0.88	1.05	1.20	0.96	2.30	10.34
		14 Sept	1.13	1.07	0.92	0.56	0.32	0	1.93	12.74
		28 Sept	0.88	0.96	0.71	0.41	0.40	0	1.60	11.24
	SED		0.090	0.059	0.091	0.100	0.115	0.171	0.062	0.401

Table F Effect of lifting date, pre-warming and HWT on bulb yields and grade-out (by number) of Carlton narcissus

Lifting date	Pre-warming/ HWT	HWT date	Total yield (No./plot)	Percentage numbers in grades					
				<8	8-10	10-12	12-14	14-16	16-18
15 June	Untreated	-	100	24	18	12	17	24	7
	None/ HWT	6 July	93	16	17	18	25	18	6
		20 July	100	23	18	17	18	20	3
		3 Aug	95	19	20	18	16	18	8
		17 Aug	113	24	25	15	22	13	1
		31 Aug	114	32	23	22	17	4	1
		14 Sept	112	29	22	25	15	7	2
		28 Sept	119	46	26	21	6	1	6
	Partial/ HWT	6 July	103	19	22	17	20	19	3
		20 July	99	22	19	13	25	19	3
		3 Aug	98	22	21	15	19	19	5
		17 Aug	110	21	23	16	18	16	6
		31 Aug	105	20	23	22	18	16	2
		14 Sept	113	29	20	19	18	11	2
		28 Sept	107	24	25	20	20	9	2
	Full/ HWT	6 July	99	21	21	12	20	21	5
		20 July	93	14	22	15	21	23	6
		3 Aug	98	18	26	13	19	21	4
		17 Aug	113	16	22	22	20	14	6
		31 Aug	110	15	24	22	19	16	5
		14 Sept	146	50	24	17	7	2	0
		28 Sept	110	61	26	11	1	0	0

Continued

Table F (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Total yield (No./plot)	Percentage numbers in grades					
				<8	8-10	10-12	12-14	14-16	16-18
29 June	Untreated	-	108	17	20	16	15	23	10
	None/ HWT	20 July	105	23	20	14	23	16	4
		3 Aug	103	19	20	15	25	16	5
		17 Aug	110	27	19	17	19	15	4
		31 Aug	127	33	29	20	11	5	1
		14 Sept	136	37	28	16	14	4	1
		28 Sept	130	46	26	17	8	2	0
	Partial/ HWT	20 July	107	15	27	12	14	23	11
		3 Aug	116	26	20	19	14	19	3
		17 Aug	103	19	19	16	18	22	7
		31 Aug	116	34	18	17	17	12	2
		14 Sept	111	23	21	17	20	14	4
		28 Sept	114	26	22	23	17	12	2
	Full/ HWT	20 July	113	21	23	14	13	20	10
		3 Aug	105	14	24	16	18	21	6
		17 Aug	111	22	23	15	18	16	6
		31 Aug	120	21	21	20	18	16	5
		14 Sept	161	57	23	12	4	2	0
		28 Sept	137	65	24	9	2	0	0

Continued

Table F (Continued)

Lifting date	Pre-warming/ HWT	HWT date	Total yield (No./plot)	Percentage numbers in grades					
				<8	8-10	10-12	12-14	14-16	16-18
13 July	Untreated	-	117	21	24	14	12	17	13
	None/ HWT	3 Aug	121	26	26	13	17	15	4
		17 Aug	113	18	28	15	16	17	6
		31 Aug	122	37	29	20	10	4	1
		14 Sept	126	30	33	20	13	4	0
		28 Sept	121	41	31	17	8	3	0
	Partial/ HWT	3 Aug	112	22	25	15	12	18	8
		17 Aug	119	23	27	13	14	17	6
		31 Aug	125	33	25	12	13	15	4
		14 Sept	134	34	21	18	14	12	2
		28 Sept	126	34	28	14	14	8	2
	Full/ HWT	3 Aug	105	14	23	18	13	26	7
		17 Aug	117	28	22	13	14	16	8
		31 Aug	107	13	27	18	18	17	8
		14 Sept	163	57	25	13	4	1	0
		28 Sept	127	58	27	11	3	2	0

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