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LARGE NARCISSUS FLY CONTROL: THE USE OF CHLORPYRIFOS

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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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LARGE NARCISSUS FLY CONTROL: THE USE OF CHLORPYRIFOS

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RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

SUMMARY

Previous trials in south-west England showed that treating narcissus bulbs with chlorpyrifos in the hot-water treatment (HWT) tank protected the bulbs from attack by large narcissus fly in the following year, although bulb yields were reduced by this treatment. Chlorpyrifos treatments were examined in two trials in eastern England: the first was carried out with bulbs of cultivars Carlton and Dutch Master grown on a site with a history of narcissus fly damage, the second with bulbs of Carlton and Golden Harvest on a site with low natural narcissus fly populations supplemented by the planting of infected bulbs.

The results were:

1. Using chlorpyrifos in HWT consistently gave almost complete protection from narcissus fly attack the next year, but protection did not extend to the second year.

2. Using chlorpyrifos in a post-HWT cold dip gave some protection from narcissus fly, but results were inferior to use in HWT; using it as a spray over bulbs at planting was generally ineffective.

3. Two chlorpyrifos formulations (Dursban 4 and Spannit) gave similar results.

4. The effectiveness of chlorpyrifos treatments in controlling narcissus fly was equal whether bulbs had been stored at ambient temperatures or at 18°C, or had been pre-warmed at 30°C, before HWT.

5. In the first year after treatment, using chlorpyrifos in HWT resulted in a reduced weight of bulbs harvested, unless 30°C pre-warming had been used.

6. Chlorpyrifos in HWT (without pre-warming) also had other detrimental effects on the crop, including more smaller bulbs, fewer and smaller flowers, and shorter stems.

7. Using chlorpyrifos as a cold dip or spray at planting had little adverse effect on the crop.

8. After the usual two-year-down growing cycle, bulb yields (and crop quality generally) were not adversely affected by the previous chlorpyrifos treatment, even if applied in HWT without 30°C pre-warming.

Bulb growers who experience significant problems with large narcissus fly should consider using chlorpyrifos in the HWT tank, which should give almost complete control in the following year. In the second year, other measures will be needed, such as insecticide sprays at egg hatch, or early lifting (before egg laying), but as these techniques are still being

developed the latest advice should be sought at the time. At present the only appropriate chlorpyrifos formulation, Spannit, remains approved only for the 1995 season, but the possibility of specific off-label approval is being investigated and, again, the latest information should be sought.

Previously, based on one-year-down trials, the use of 30°C pre-warming before HWT with chlorpyrifos has been considered essential. The two-year-down experiment in the present project showed that, even if crop growth is reduced the year after using chlorpyrifos in HWT, yields recover in the second year of the growing cycle. Hence, for a two-year-down crop, pre-warming is not necessary, although this should be tested on a small scale until further experience is gained.

The main results - bulb yields and percentage of bulbs infected with maggots - are summarised in Figures 1 to 6, which follow.

Fig.1. Experiment 1: Carlton, one-year-down

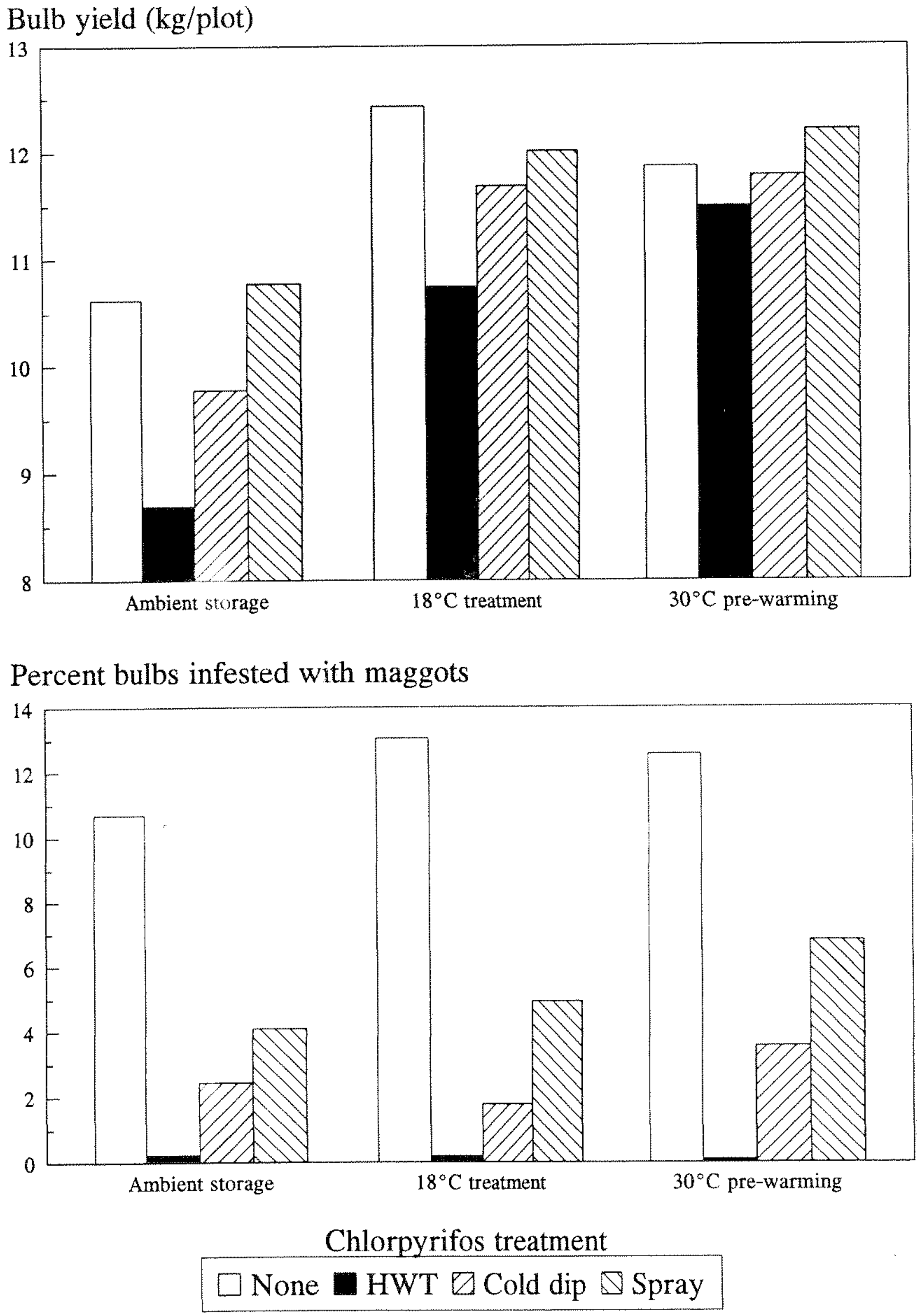

Fig.2. Experiment 1: Dutch Master, one-year-down

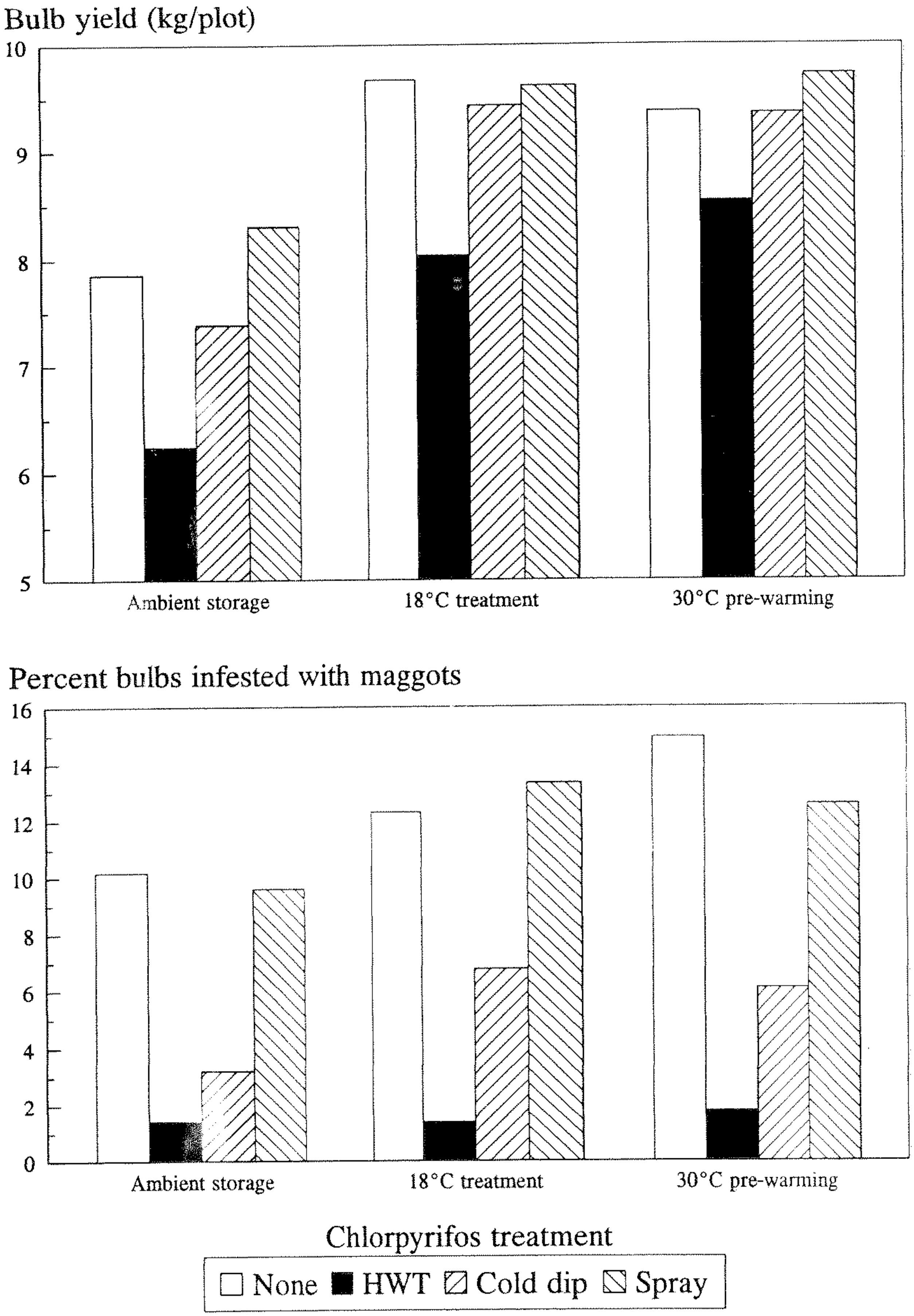

Fig.3. Experiment 2: Carlton, first year

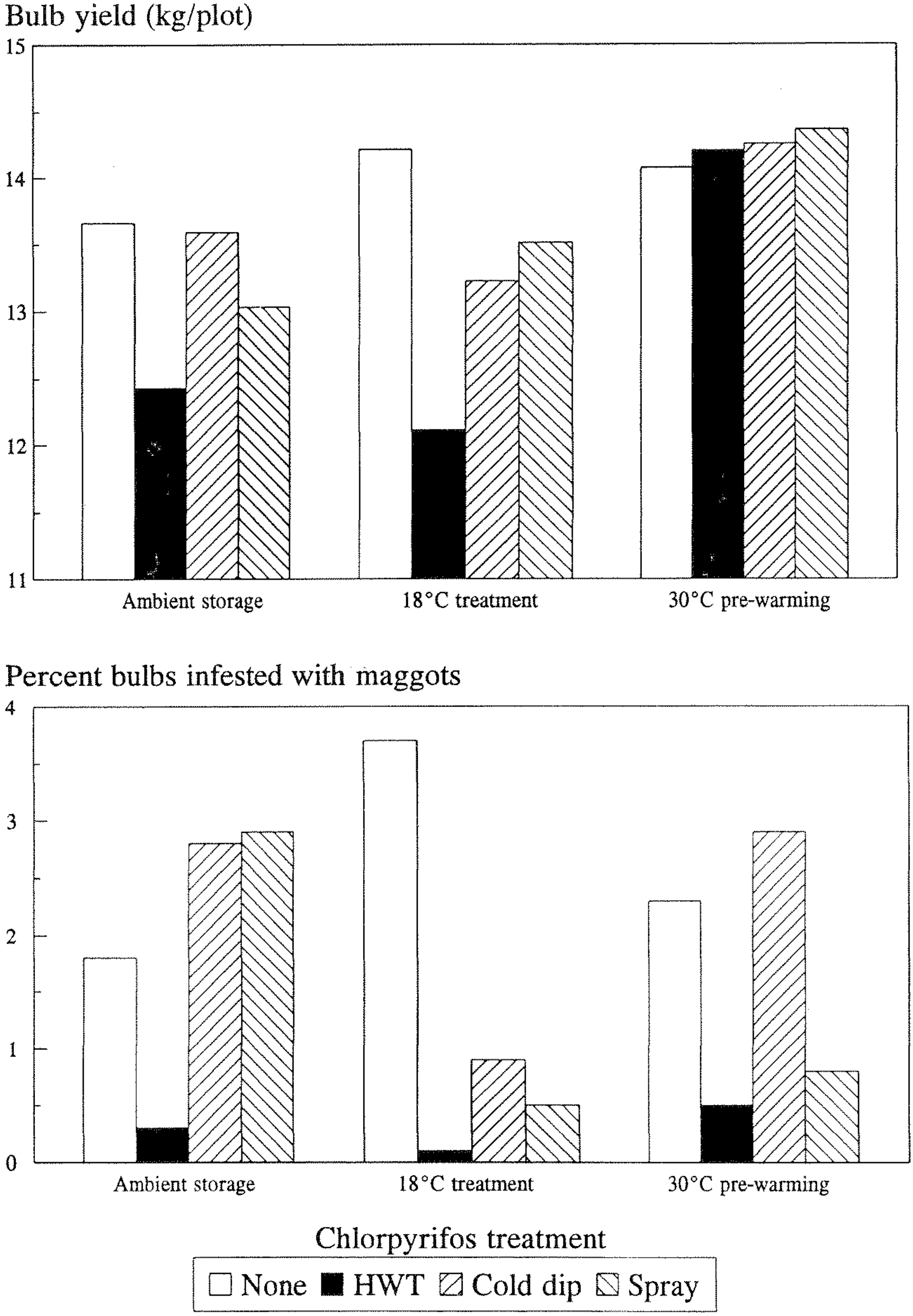

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Fig.4. Experiment 2: Carlton, second year

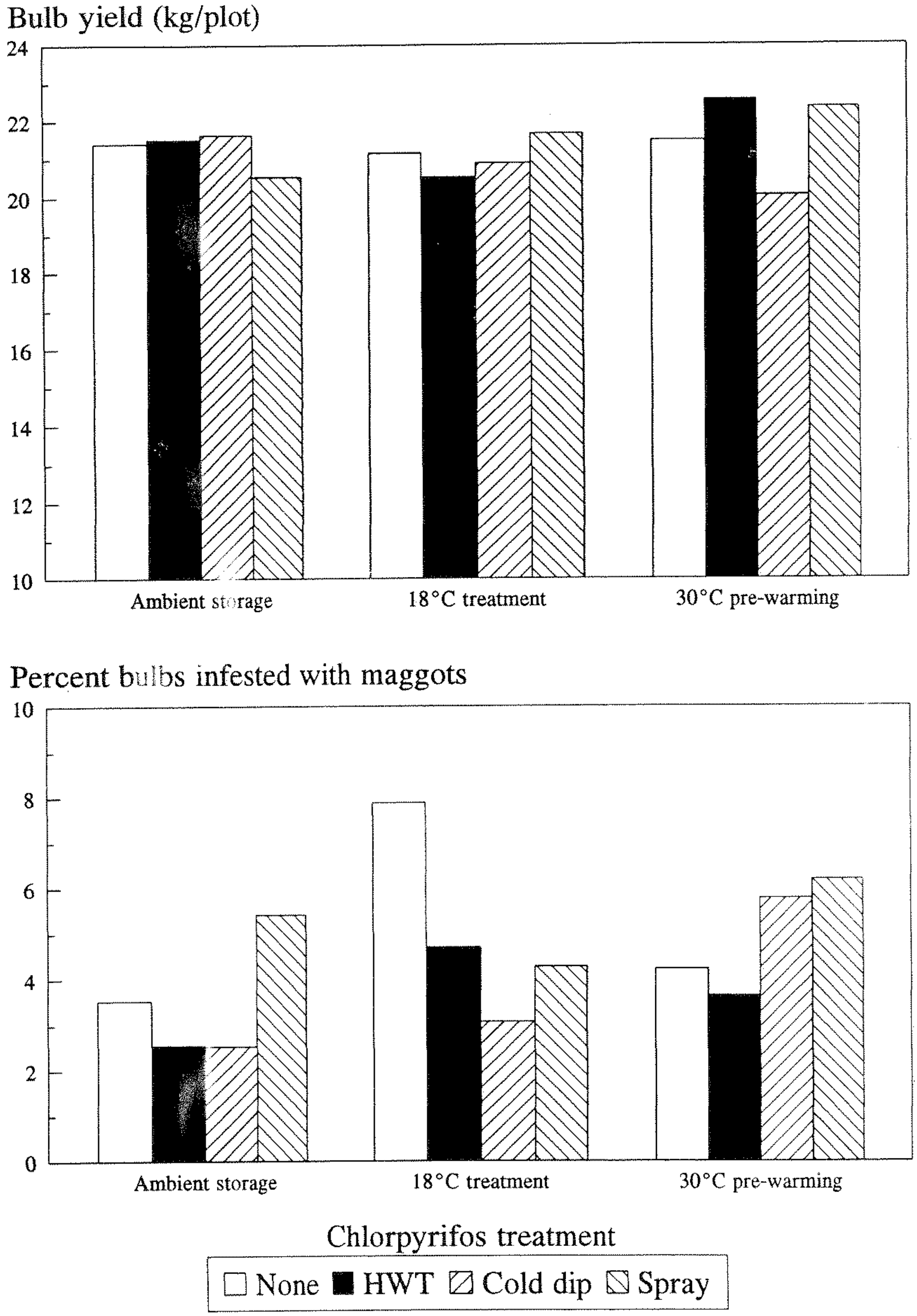


Fig 5. Experiment 2: Golden Harvest, first year

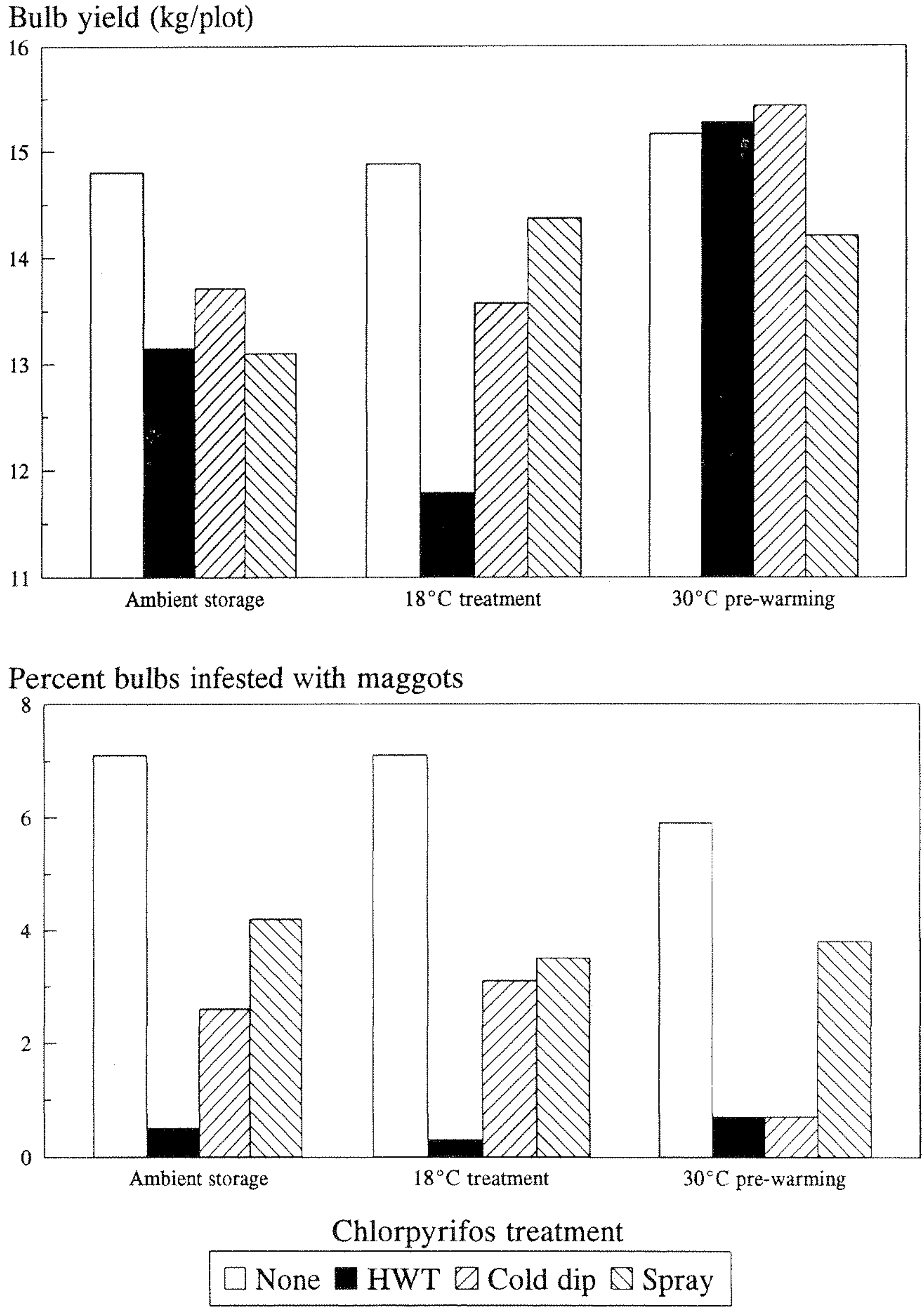
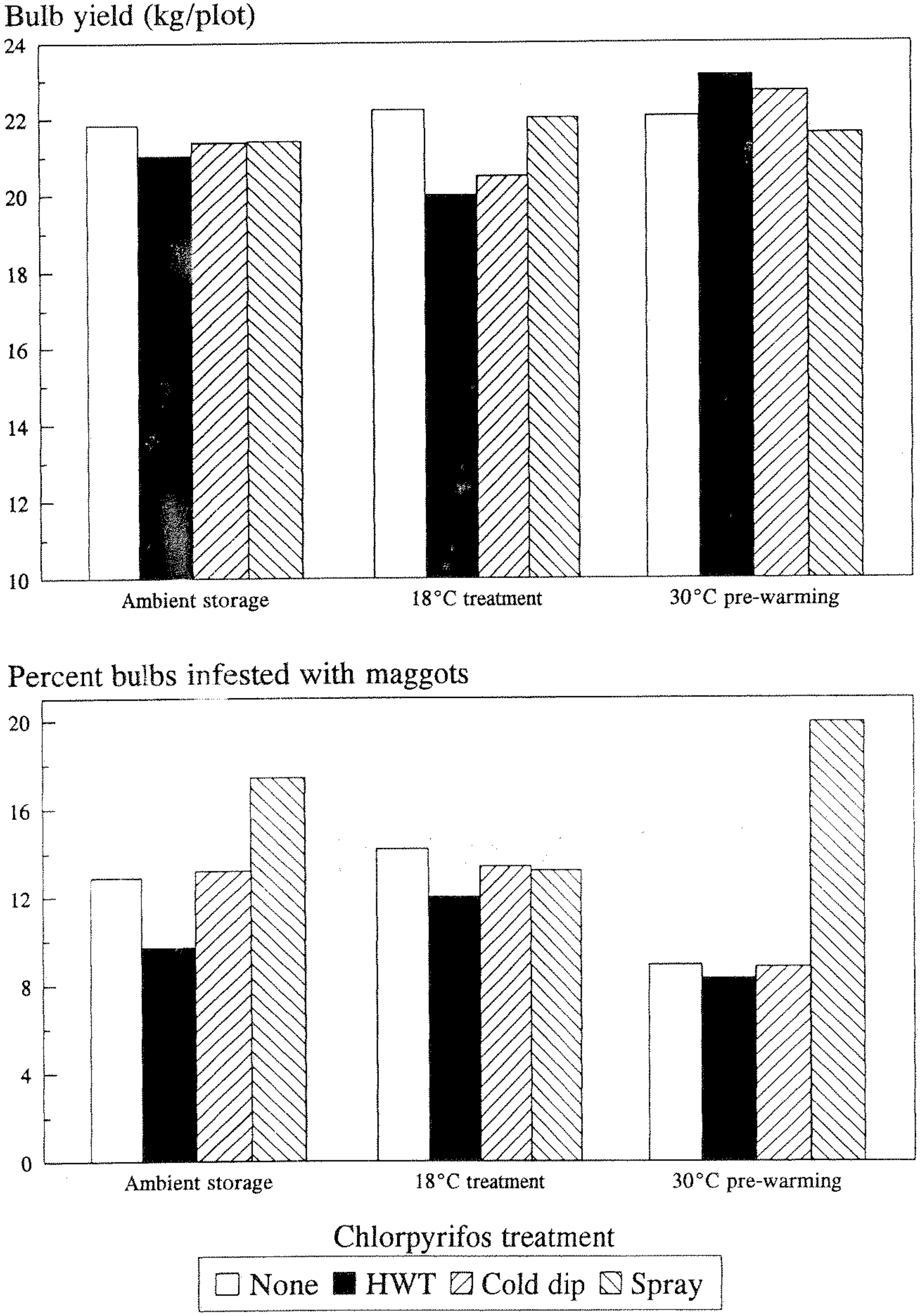


Fig 6. Experiment 2: Golden Harvest, second year



LARGE NARCISSUS FLY CONTROL: THE USE OF CHLORPYRIFOS

EXPERIMENTAL SECTION

INTRODUCTION

The large narcissus fly (*Merodon equestris*) has been a problem to bulb growers in south-west England for many years. The adult, resembling a bumble bee, is active in the south-west in warm sunny weather, starting in May. Fifty to 75 eggs are laid singly at the base of healthy plants in May to June, and hatch after about 10 days. The larva enters the bulb by tunnelling the basal plate, feeding initially on the basal plate tissue and then on the central part of the bulb, including the growing shoot, producing a granular mass of frass. The maggot characteristically occurs singly, and is greyish in colour with a short, dark chocolate-brown breathing tube. When bulbs are lifted at the normal time (June to July), damage is not obvious unless the basal plate is carefully examined to find the small entry tunnel. By late-summer the maggot is 1 to 2 cm long. Maggots leave the bulbs the following spring, beginning in early-March, pupate just below the soil surface, and the adult hatches after about 5 weeks. Some larvae with delayed development may pass two winters in the bulb. Descriptions of the insect and its life cycle can be found in, for example, Lane (1984) and Conijn and Koster (1990).

Larvae of the large narcissus fly in the bulb can be killed by a short hot-water treatment (HWT), for example, 1 hour at 43.5°C (Lane, 1984), and so will be killed by routine HWT. Re-infestation in spring is the problem. Experiments in the 1950's showed that aldrin and dieldrin effectively controlled the pest, when applied as a dip after HWT or as a band-spray at planting (Woodville, 1955, 1958, 1960). Aldrin band-spray treatment became the standard procedure in the south-west, offering complete protection for the two-year growing cycle (Tompsett, 1973). This continued until the withdrawal of aldrin in 1989, following concerns about the persistence of the material in the environment. The loss of this highly effective insecticide led to an urgent quest for alternative insecticides or other methods of control. At the same time, there was concern in the bulbs industry that the large narcissus fly was increasing in eastern England; this was attributed variously to a run of warm summers, climatic change, the routine exchange of bulbs between the two bulb-growing areas of England, or to local problems associated with more sheltered sites which favour the fly.

Projects funded by both the HDC levy and by MAFF, although wide-ranging, concentrated on two areas: alternative chemical treatments timed to control key developmental stages (involving the development of narcissus fly forecasts), and non-chemical alternatives (such as cultural control). This work has been described elsewhere (eg, Tones, 1994). As a 'fire brigade' measure, pending the completion of the longer-term studies, interest was also directed at the use of chlorpyrifos as a pre-planting treatment.

MAFF-funded trials at ADAS Starcross and the former Rosewarne Experimental Horticulture Station had indicated that chlorpyrifos, added to the HWT tank or given as a post-HWT cold dip, controlled large narcissus fly in the first year. Using chlorpyrifos in HWT led to reduced bulb yields in most cultivars tested, whereas a cold dip treatment was not generally phytotoxic; however, the damaging effects of chlorpyrifos in HWT were largely preventable by pre-warming bulbs (for 1 week at 30°C) before HWT (Tompsett, 1990; Tones and Tompsett, 1990). Good control of large narcissus fly following the application of chlorpyrifos to bulbs at planting was also reported in the Netherlands (Koster and Conijn, 1987).

The present Project was set up to examine the use of chlorpyrifos in HWT under the cultural and climatic conditions in eastern England. The objectives were:

1. to determine whether storage of bulbs for 14 days at 18°C before HWT (which can reduce normal HWT damage) would substitute for standard, 30°C pre-warming in reducing chlorpyrifos damage in HWT;

2. to check that chlorpyrifos was effective when combined with thiabendazole and formaldehyde in HWT;

3. to compare applications of chlorpyrifos in HWT with a post-HWT cold dip and with spraying over bulbs at planting time;

4. to compare the two chlorpyrifos formulations (Dursban 4 and Spannit).

Two experimental approaches were taken in the project. In the first experiment (1991-92), the bulb stocks and trial site used were chosen for their history of large narcissus fly infestation. In the second experiment (1992-94), healthy bulb stocks were used on a site with low natural narcissus fly infestations, where adult flies could be introduced. Preliminary reports of the project have already been published (Hanks, 1993, 1994).

MATERIALS AND METHODS

Experiment 1

Plant material Two stocks of narcissus, cultivars Carlton and Dutch Master, were identified as having a history of infestation with large narcissus fly (*Merodon equestris*), and 650 kg bulbs (12-15 cm grade) of each variety were transported to HRI Kirton on 13 August 1991, following lifting, grading and drying. For each variety, 72 plots of 8 kg each were allocated for further treatments, excluding obviously rotted bulbs (which were found especially in cv Dutch Master). Bulbs were stored at 16°C (the 20-year mean monthly temperature for August). During storage, plots of bulbs were placed in 7 m-long lengths of tubular nylon netting (Netlon Oriented 1) to facilitate later planting and lifting.

Six additional trays of bulbs (100 bulbs each) of each cultivar were allocated for initial assessment of large narcissus fly infestation levels. These were untreated and were stored at ambient temperatures until 13 December 1991, when they were bisected lengthwise and the numbers of bulbs with maggots and (or) bulb rots were recorded. Bulb rots were classified as basal, neck or whole-bulb rot.

Treatments Prior to hot-water treatment (HWT) on 2 September 1991, bulbs were either kept at 16°C ('ambient storage'), were stored at 18°C for the last 2 weeks before HWT ('18°C treatment'), or were stored at 30°C for the last 1 week before HWT ('30°C pre-warming'). For each of these three storage regimes, chlorpyrifos (as either Dursban 4 or Spannit) was applied (1) in HWT, (2) as a post-HWT cold dip, (3) as a spray over the bulbs at planting, or (4) not at all (control), as described below.

Following ambient storage or 18°C treatment, HWT consisted of a 3 hour dip at 44.4°C; following 30°C pre-warming, HWT consisted of a 3 hour dip at 46°C, preceded by a 3 hour dip at ambient temperatures ('pre-soaking'), following standard practice. Pre-soak tanks contained aqueous formaldehyde plus non-ionic wetter (as 5 litres commercial formalin (38 to 40% ai) and 620 ml Power Non-ionic Wetter/1000 litres). HWT tanks contained aqueous formaldehyde and wetter (as above) plus thiabendazole (as 5 litres Storite Clear Liquid (260 g ai/litre; MSD Agvet) / 1000 litres) ('standard HWT'), plus, where appropriate, chlorpyrifos (as 5 litres Dursban 4 (480 g ai/litre; Dow Elanco) or Spannit (480 g ai/litre; PBI) /1000 litres).

For one group of treatments, standard HWT was followed immediately by a 15 minute dip at ambient temperatures in aqueous chlorpyrifos (as 10 litres Dursban 4 or Spannit (see above) / 1000 litres).

Following HWT and cold dip treatments, bulbs were dried and stored under fans at ambient temperatures, keeping distinct chemical treatments separate.

The trial was planted, adjacent to commercial narcissus stocks, on 3 October 1991 at a fen peat site in Norfolk known to have a history of large narcissus fly attack. The trial area was ridged out and plots (each consisting of a 7 m-long length of ridge) were marked in, according to the trial plan. At planting, each net of bulbs was laid in the ridge bottom and the ridges split back. With ridges at 76 cm centres, this gave a planting density of 15 t/ha. For one group of treatments, aqueous chlorpyrifos (0.142 litres of either Dursban 4 or Spannit per 10 litres) was sprayed in a 20 cm-wide band over the bulbs in the furrows before they were covered, applying 38 ml solution per metre run, equivalent to 1.9 litres Dursban 4 or Spannit in 500 litres/ha overall (or 7.1 litres Dursban 4 or Spannit in 500 litres per treated ha, ie measuring the rate in the 20 cm band, an amount of active ingredient equivalent to the earlier aldrin recommendation.)

Husbandry followed the farmer's normal commercial practice. The trial followed a pea crop, and no fertilisers were applied (possibly resulting in a nutrient-deficient situation as independent soil analyses indicated a $P_2 0_5$ index of 3 and a $K_2 0$ index of 2). Weed control consisted of glyphosate pre-emergence, cyanazine post-emergence and, following die-down and re-ridging in August, glyphosate. Although early-season weed control was satisfactory, control broke down late in the growing season, with extensive weed cover developing especially in the area occupied by cv Carlton, grasses and volunteer peas being the main weeds. Fungicides were applied as a five-spray programme from early-March, including benomyl, mancozeb and chlorothalonil.

For one group of treatments, carbofuran (as 2.5 g Yaltox (5% w/w; Bayer) granules / metre row) was applied along the bulb ridges on 15 June 1992. This date corresponded to the time of peak large narcissus fly egg hatch for the area, as forecast by the HRI/HDC model.

Observations, harvesting and recording The condition of the crop was checked at intervals. Flower numbers and quality were recorded in spring 1992.

The trial was lifted on 14 October 1992, to allow maximum development of large narcissus fly maggots. Bulbs were surface dried under fans at ambient temperatures, then cleaned by hand. Bulbs were graded during the week beginning 19 October 1992. Numbers and weights in grades were recorded, after obviously diseased and damaged bulbs had been taken out. In the tables, bulb yields are also expressed as percentage weight increase, ie, the weight increase from planting to harvest as a percentage of planted weight. Diseased and damaged bulbs were bisected lengthwise, and the number with maggots recorded. All apparently sound bulbs were stored in bulb trays at ambient temperatures for later assessments.

In mid-November all bulbs were bisected lengthwise, and the numbers with large narcissus fly larvae and (or) bulb rots (basal, neck or whole-bulb rot) recorded.

Design and statistical analysis The experiment was of a randomized block design, with three replicate blocks. For each of the three storage treatments, there was a control (no chlorpyrifos), a control which received carbofuran, and six chlorpyrifos treatments forming a factorial structure (Dursban or Spannit x HWT, cold dip or spray), giving 24 treatment combinations in all. Planted ridges were separated by a blank (unplanted) ridge, and there were 1 m-long gaps between plots along a planted ridge. Each variety was planted in a separate area, and the data for each variety were analysed separately. Data were subjected to analysis of variance as appropriate.

Experiment 2

Plant material Narcissus bulbs of cultivars Carlton and Golden Harvest were lifted from the field at HRI Kirton in July 1992, dried and graded, and bulbs of grade 12-14 cm were allocated for the experiment. As in Experiment 1, for each cultivar, 8 kg lots of bulbs were allocated for experimental treatments and 100-bulb lots were allocated for initial assessment of narcissus fly infestation. Initial bulb storage was as described for Experiment 1, and initial narcissus fly assessments were made on 5 November 1992.

Treatments Storage, HWT, cold dip, spray and associated treatments were applied as described for Experiment 1. HWT was carried out on 19 August 1992 and the trial was planted in a coarse silty marine alluvial soil at HRI Kirton on 16 September 1992. Low numbers of large narcissus fly were present at this site, numbers being boosted in the trial area by planting infested bulbs at intervals. Adult flies were observed to be active in the trial area during late-May and June 1993.

Husbandry followed normal HRI practices. The trial followed salad crops, and, after soil analysis, P_20_5 and K_20 were applied as base fertilisers pre-planting. Nitrogen was applied pre-emergence in December 1992, at MAFF recommended rates. Weed control consisted of diquat + paraquat pre-emergence in each year and following die-down and re-ridging in summer, chlorpropham + linuron pre-emergence and bentazone post-flowering in 1992/93, and cyanazine pre-emergence and chlorpropham + linuron early-post-emergence in 1993/94.

Fungicides were applied as a three-spray programme from early-February, using iprodione, chlorothalonil and vinclozolin.

Observations, harvesting and recording Procedures were generally as for Experiment 1. Lifting dates were 6 July 1993 (one-year-down plots) and 29 September 1994 (two-year-down plots). After grading all bulbs were retained for post-storage assessments of narcissus fly infestations, which were carried out on 26 November 1993 and 26 October 1994.

Design and statistical analysis The experiment was set up as described for Experiment 1. However, in order to gain data on first- and second-year effects, it was decided in winter 1992/93 that half the plots would be lifted in 1993 and half in 1994. The spring carbofuran treatment (used in Experiment 1) was not applied, and, on the basis of the results of Experiment 1 (which indicated little difference between the effects of Dursban 4 and Spannit), appropriate Dursban 4 and Spannit treatments were bulked; this effectively doubled the replication of control and chlorpyrifos treatments, and plots from equivalent treatments were allocated at random for lifting after one or two years. Data for each year were analysed separately.

RESULTS

Experiment 1

Initial bulb assessments Untreated bulbs assessed after ambient storage had low numbers of large narcissus fly maggots in cv Dutch Master (less than 1% bulbs affected), and none in cv Carlton.

The same samples had a high percentage of rotted bulbs, 18 per cent in cv Dutch Master (of which neck rot accounted for 79%), and a lower level (6%) in cv Carlton. The rots found were characteristic of those associated with *Fusarium oxysporum* f. sp. *narcissi.*

Field observations As expected in the year following HWT, flower numbers and stem (scape) length were reduced in ambient-stored bulbs compared with 18°C-treated bulbs, and, especially, with 30°C pre-warmed bulbs. Chemical treatments did not appear to affect flower production. Other aspects of crop growth appeared normal.

Bulb yields Yields of marketable and unmarketable bulbs are summarised in Tables 1 (Carlton) and 2 (Dutch Master). In these tables, the figures given are the marginal means for corresponding Dursban 4 and Spannit treatments (ie, the acreage of the Dursban 4 and Spannit treatments for each storage treatment), as there were no significant effects due to formulation on the variables presented.

Overall, bulb yields were poor, especially in cv Dutch Master, probably due to the effects of bulb rots, narcissus fly attack, weed competition and other seasonal factors. At harvest, bulb weights were lower in ambient-stored bulbs than in bulbs treated at 18 or 30°C before HWT. Yields were generally lower in bulbs treated with chlorpyrifos than in controls, and especially where chlorpyrifos had been applied in HWT. There was a clear detrimental effect of applying chlorpyrifos in HWT combined with ambient pre-HWT storage: this effect was lessened when 18°C treatment and, especially, 30°C pre-warming, were used.

Yields of bulbs in individual grades are shown in Tables 3 and 4. Statistically significant effects were mainly due to storage temperature and chlorpyrifos treatments. In Carlton, the most obvious effect was a loss of yield in the large size grades (eg, 16-18 cm) following ambient storage and chlorpyrifos treatment in HWT or a cold dip. In Dutch Master, similar effects can be seen (eg, in the 8-10 and 14-16 cm grades).

The number of marketable bulbs harvested per plot was unaffected by treatments in cv Carlton, while in Dutch Master fewer bulbs were harvested from ambient stored plots than from plots given 18 or 30°C storage. At grading, the number of bulbs rejected due to disease or damage (rotting and large narcissus fly) was small, overall 3 and 5 per cent for Carlton and Dutch Master, respectively, with few statistically significant effects, although there were more unmarketable bulbs from ambient-stored plots in cv Carlton and less unmarketable bulbs where chlorpyrifos had been used in Dutch Master. Overall, those rejected bulbs found on examination to contain larvae amounted to <1 and 2 per cent, respectively, for the two cultivars, of the total bulbs lifted: even with these low numbers, it was clear there were less maggots when chlorpyrifos had been used in HWT.

Narcissus fly assessments Post-storage assessments (Tables 5 and 6) showed a high proportion of damaged bulbs, mostly as a result of narcissus fly infestation. The tables also show the total number of bulbs with maggots (ie, combining the grading and storage assessments). In Carlton, the effects of pre-HWT storage treatments on the number of bulbs with larvae were not significant, but chlorpyrifos treatment had pronounced effects. In Dutch Master, there were significant effects due to storage temperatures, but these were less significant than those due to chlorpyrifos treatments. The figures in these Tables are the marginal means for corresponding storage treatments (ie, the average of ambient, 18°C and 30°C storage treatments for each chlorpyrifos treatment).

In Carlton, controls which received no chlorpyrifos had 11 to 12 per cent of bulbs with maggots (marginal means across storage treatments), whereas about 5 per cent were affected in chlorpyrifos spray treatments, 1 to 3 per cent in cold dip treatments, but virtually none when either Dursban 4 or Spannit were applied in HWT. Spannit was more effective than Dursban 4 when used as a cold dip. In Dutch Master the corresponding percentages of bulbs with maggots were 11 to 12 per cent (controls), 9 to 13 per cent (spray), 4 to 6 per cent (cold dip) and 1 to 2 per cent (HWT). Applying carbofuran at egg-hatch did not significantly or consistently control large narcissus fly.

Experiment 2

Initial bulb assessments No narcissus fly maggots were found at the initial assessment of untreated bulbs. Less than 1 per cent of bulbs had rots.

Field observations - year 1 Results are given in Tables 7 and 8 for the two cultivars. In both cultivars there were more flowers following 30°C storage than when ambient or 18°C storage was used before HWT, but the effect was much more marked in cv Golden Harvest. In Carlton neither the storage treatment nor the interaction between storage and chlorpyrifos treatments significantly affected flower numbers, whereas in Golden Harvest numbers were further reduced when chlorpyrifos had been given in HWT or as a cold dip. Flower diameter was slightly reduced in Carlton when chlorpyrifos had been applied as a cold dip, while in Golden Harvest flowers were larger following 30°C pre-warming, and slightly smaller when chlorpyrifos had been applied (by any method). Stem length was greater in both cultivars when a 30°C treatment had been used, and was slightly reduced (in Carlton only) when chlorpyrifos had been applied in HWT. The number of flowers with symptoms of HWT damage decreased with 30°C pre-warming in Golden Harvest, but, inexplicably, not in Carlton. In Golden Harvest there were a significant number of necrotic (shrivelled) buds (14 per plot overall), but these were not affected by the experimental treatments; shrivelled buds were virtually absent (<1 per plot) in Carlton.

There were no obvious differences between treatments in dates of flowering or senescence.

Bulb yields - one-year-down plots Bulb yields are shown in Tables 9 and 10. For both cultivars, bulb weights after one year's growth were satisfactory following 30°C pre-warming, irrespective of whether chlorpyrifos was used or not; following ambient or 18°C storage, yields were much reduced when chlorpyrifos had been used in HWT, and slightly reduced when chlorpyrifos had been used in a cold dip or as a spray (performance of Golden Harvest was sometimes poor after spray treatment). The total number of bulbs harvested was greater in both varieties when chlorpyrifos had been used as a cold dip or (in Golden Harvest only) in HWT.

The distribution of bulb yield to grades is shown in Tables 11 and 12. For Carlton, grade-out was similar for all treatments; in Golden Harvest, although grade-out was variable, there were no clear effects of storage or chlorpyrifos treatments.

Very few unmarketable bulbs (<1 per plot in Carlton and <2 per plot in Golden Harvest) were present at grading. This was not related to treatment.

Narcissus fly assessments - one-year-down plots The total numbers of unmarketable bulbs and of those infested with maggots (determined at the end of storage) are shown in Tables 9 and 10. Overall, 2 and 5 per cent of bulbs of Carlton and Golden Harvest, respectively, were unmarketable due to rots or to fly, mostly the latter. The numbers of infested bulbs were not affected by storage treatment, but there was a major effect of chlorpyrifos treatment. In controls of Carlton, the percentage of affected bulbs was 2 to 4 per cent, compared with 1 to 3 per cent for chlorpyrifos spray or cold dip applications and <1 per cent for application in HWT. For Golden Harvest, the corresponding figures were 6 to 7 per cent (controls), 4 per cent (spray), 1 to 3 per cent (cold dip) and, again, <1 per cent for HWT application.

Field observations - year 2 Flowering performance is shown in Tables 13 and 14. In both cultivars, the enhanced number of flowers following 30°C pre-warming was the only effect persisting to the second year. There were no significant effects of treatment on flower diameter or stem length. Flowers were normal with, overall, less than 1 per cent shrivelled buds. There were no clear differences between treatments in dates of flowering or senescence.

Bulb yields - two-year-down plots Results are given in Tables 15 and 16. In both varieties, the weight harvested was greater from bulbs which had received 30°C pre-warming, but the effect was statistically significant only in Golden Harvest. Bulb yields were not affected by previous chlorpyrifos treatments. The total number of bulbs harvested was greater following HWT or cold dip application of chlorpyrifos in Golden Harvest, but in Carlton although there were some just statistically significant effects of treatments on bulb numbers, these were thought not to be of practical significance.

The distribution of bulbs to grades is shown in Tables 17 and 18. There were no obvious differences between treatments.

Very few unmarketable bulbs (<1 per plot) were present at grading.

Narcissus fly assessments - two-year-down plots The percentage of bulbs unmarketable (determined at the end of storage) are given in Tables 15 and 16. Most unmarketable bulbs were infested with maggots. In individual treatments the percentage of bulbs affected varied from 3 to 8 in Carlton and from 7 to 17 in Golden Harvest, but these differences were not statistically significant.

DISCUSSION

Previous trials in south-west England showed that chlorpyrifos applied in HWT can largely prevent large narcissus fly attacks in the following year. The present project confirmed the value of this treatment under eastern England conditions: in four crops (with narcissus fly infestations in untreated plots ranging from 2-4 to 11-12%), the number of infested bulbs was reduced to <1 per cent. Cold dips and sprays (over bulbs at planting) of chlorpyrifos were much less effective, although giving some narcissus fly control.

Growers with serious narcissus fly problems should consider the use of chlorpyrifos in the HWT tank. At present Spannit is the only formulation of chlorpyrifos approved for use in bulb dips, and this use will be revoked after 31 March 1996. The material is therefore only available for the 1995 season, but requirements for a specific off-label approval (SOLA) are being discussed, and work may be undertaken within the HDC-funded SOLA programme. As the large narcissus fly continues to be a source of concern not only in south-west England but also, increasingly, in the east, vigorous support for a SOLA for Spannit is needed.

Using chlorpyrifos in the HWT tank (and to a much lesser extent as a post-HWT cold dip) results in a significant loss of yield if bulbs are lifted after one year's growth. Experiment 1 showed that pre-warming bulbs (for 1 week at 30°C) before HWT prevented this damaging effect. A two week storage period at 18°C, before HWT, which is known to lessen the adverse effects of HWT itself, was not effective in preventing chlorpyrifos damage. When bulbs were grown on the normal two-year-down cycle (Experiment 2), previous chlorpyrifos treatment did not affect final bulb yields, indicating compensatory growth in the second year when growth in the first was relatively poor. For two-year-down growing, therefore, pre-warming would appear to be unnecessary: however, as this is based on a single trial, using chlorpyrifos in HWT without pre-warming should be tested on a pilot scale, until further experience has been gained. Chlorpyrifos in HWT also caused some losses in flower numbers and quality in the year of treatment.

Chlorpyrifos applied in HWT does not prevent fly infestation in the second year after treatment, when other measures will be needed. Measures could include insecticide sprays to kill flies before they lay eggs, or early lifting (before egg hatch). Although early lifting may seem to be impractical, this might be needed only for susceptible stocks, and possibly only in certain years, depending on weather conditions. As these techniques are still being developed, growers should seek the latest advice at the time.

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Table 1 Effect of storage and chlorpyrifos treatments on bulb yield in cv Carlton (Experiment 1). The figures shown are marginal means for Dursban 4 and Spannit treatments, as formulation differences were not significant.

Storage and chlorpyrifos treatment		Marketable yield (no. or weight of bulbs)			Unmarketable yield (no./plot)	
		kg/plot	% weight increase	no./plot	Total	With maggots
Ambient storage						
Control		10.48	31	198	8.7	2.3
Control (+ Yaltox)		10.77	35	199	4.7	0.7
HWT		8.69	9	206	6.5	0.5
Cold dip		9.77	22	201	7.7	1.3
Spray		10.77	35	203	6.8	1.1
18°C storage						
Control		12.75	59	201	6.3	3.1
Control (+ Yaltox)		12.11	51	203	7.3	2.0
HWT		10.75	34	200	6.3	0.2
Cold dip		11.68	46	203	4.3	0.7
Spray		12.01	50	200	5.3	1.0
30°C pre-warm						
Control		11.29	41	194	6.7	3.3
Control (+ Yaltox)		12.43	55	202	6.3	1.1
HWT		11.49	44	210	4.7	0.2
Cold dip		11.78	47	201	5.3	1.1
Spray		12.20	53	206	4.3	1.3
SED (46 df)	(1)[a]	0.605	7.6	7.5	1.91	1.07
	(2)	0.524	6.6	6.5	1.65	0.93
	(3)	0.428	5.4	5.3	1.35	0.76
Significance[b]						
Storage temperatures(A)		***	***	NS	*	-[c]
Controls v chlorpyrifos(B)		*	*	NS	NS	
A x B		NS	NS	NS	NS	
Dursban v Spannit(C)		NS	NS	NS	NS	
HWT v cold dip x spray(D)		***	***	NS	NS	
A x C		NS	NS	NS	NS	
A x D		NS	NS	NS	NS	
C x D		NS	NS	NS	NS	
A x C x D		NS	NS	NS	NS	

[a]Use SED(1) for comparisons between controls, (2) for comparisons between controls and chlorpyrifos treatments, and (3) for comparisons between chlorpyrifos treatments.
[b]this indicates the significance of the different experimental factors, eg storage or chlorpyrifos treatments: NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.
[c]No analysis of variance carried out due to sparsity of data for this variable.

Table 2 Effect of storage and chlorpyrifos treatments on bulb yield in cv Dutch Master (Experiment 1). The figures shown are marginal means for Dursban 4 and Spannit treatments, as formulation differences were not significant.

Storage and chlorpyrifos treatment		Marketable yield (no. or weight of bulbs)			Unmarketable yield (no./plot)	
		kg/plot	% weight increase	no./plot	Total	With maggots
Ambient storage						
Control		8.07	1	213	5.7	1.0
Control (+ Yaltox)		7.65	-4	221	11.3	4.7
HWT		6.24	-22	204	6.0	0.5
Cold dip		7.38	-8	213	2.8	0.8
Spray		8.31	4	205	4.7	2.5
18°C storage						
Control		9.77	22	237	3.3	2.0
Control (+ Yaltox)		9.57	20	225	7.3	2.7
HWT		8.03	0	226	3.7	0
Cold dip		9.43	18	229	4.3	2.3
Spray		9.62	20	227	7.3	3.0
30°C pre-warm						
Control		10.04	26	239	5.0	2.0
Control (+ Yaltox)		8.70	9	212	11.0	8.3
HWT		8.53	7	230	2.8	0.3
Cold dip		9.35	17	225	2.2	1.3
Spray		9.72	22	231	4.5	2.8
SED (46 df)	(1)[a]	0.624	7.8	10.5	3.91	2.60
	(2)	0.541	6.8	9.1	3.38	2.25
	(3)	0.442	5.5	7.4	2.76	1.84
Significance[b]						
Storage temperatures(A)		***	***	***	NS	-[c]
Controls v chlorpyrifos(B)		*	*	NS	**	
A x B		NS	NS	NS	NS	
Dursban v Spannit(C)		NS	NS	NS	NS	
HWT v cold dip x spray(D)		***	***	NS	NS	
A x C		*	*	***	NS	
A x D		NS	NS	NS	NS	
C x D		NS	NS	NS	NS	
A x C x D		NS	NS	NS	NS	

[a]Use SED(1) for comparisons between controls, (2) for comparisons between controls and chlorpyrifos treatments, and (3) for comparisons between chlorpyrifos treatments.
[b]this indicates the significance of the different experimental factors, eg storage or chlorpyrifos treatments: NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.
[c]No analysis of variance carried out due to sparsity of data for this variable.

Table 3 Effect of storage and chloryprifos treatments on bulb grade-out in cv Carlton (Experiment 1). The figures shown are marginal means for Dursban 4 and Spannit treatments

Storage and chlorpyrifos treatment	Percentage of marketable weight in grades						
	<8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm	>18cm
Ambient storage							
Control	1	7	20	23	36	12	2
Control (+ Yaltox)	1	7	23	24	30	15	1
HWT	2	11	26	28	27	5	0
Cold dip	1	8	24	26	31	9	1
Spray	1	7	22	23	35	11	1
18°C storage							
Control	1	5	17	16	32	26	3
Control (+ Yaltox)	1	6	19	18	37	18	2
HWT	1	6	20	23	32	16	2
Cold dip	1	6	20	21	33	18	2
Spray	1	5	20	17	35	19	3
30°C pre-warm							
Control	1	5	22	19	31	20	3
Control (+ Yaltox)	1	5	19	18	31	25	2
HWT	1	7	20	21	34	15	2
Cold dip	1	6	19	20	33	20	2
Spray	1	6	20	16	38	18	2
Significance[a]							
Storage temperatures(A)	NS	**	NS	*	***	***	-[b]
Controls v chlorpyrifos(B)	NS	NS	NS	NS	NS	***	
A x B	NS	NS	NS	NS	*	*	
Dursban v Spannit(C)	NS	NS	NS	NS	NS	NS	
HWT v cold dip x spray(D)	**	NS	NS	*	***	**	
A x C	NS	NS	NS	NS	NS	NS	
A x D	NS	NS	NS	NS	NS	NS	
C x D	NS	NS	NS	NS	NS	NS	
A x C x D	NS	NS	NS	NS	NS	NS	

[a]Significance levels based on analysis of variance of weights per plot; NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.
[b]no analysis of variance carried out due to sparsity of data for this variable.

Table 4 Effect of storage and chloryprifos treatments on bulb grade-out in cv Dutch Master (Experiment 1). The figures shown are marginal means for Dursban 4 and Spannit treatments

Storage and chlorpyrifos treatment	Percentage of marketable weight in grades						
	<8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm	>18cm
Ambient storage							
Control	8	11	13	26	33	8	1
Control (+ Yaltox)	8	14	14	25	31	7	0
HWT	9	10	24	37	20	1	0
Cold dip	7	13	16	28	31	6	0
Spray	6	12	12	25	34	11	0
18°C storage							
Control	5	14	17	20	32	12	0
Control (+ Yaltox)	5	9	12	32	37	5	0
HWT	6	8	23	36	23	3	0
Cold dip	6	7	17	34	32	4	0
Spray	6	8	16	30	34	7	0
30°C pre-warm							
Control	5	5	15	39	32	3	0
Control (+ Yaltox)	7	12	11	22	38	8	2
HWT	6	6	24	36	26	3	0
Cold dip	5	5	17	36	32	5	0
Spray	5	6	16	34	32	6	1
Significance[a]							
Storage temperatures(A)	NS	***	***	***	***	NS	-[b]
Controls v chlorpyrifos(B)	NS	***	***	NS	**	NS	
A x B	NS	**	NS	***	NS	NS	
Dursban v Spannit(C)	NS	NS	NS	NS	NS	NS	
HWT v cold dip x spray(D)	NS	NS	***	NS	***	***	
A x C	*	NS	NS	NS	NS	NS	
A x D	NS	NS	NS	NS	NS	NS	
C x D	NS	NS	NS	*	NS	NS	
A x C x D	NS	NS	NS	NS	NS	NS	

[a]Significance levels based on analysis of variance of weights per plot; NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.
[b]No analysis of variance carried out due to sparsity of data for this variable.

Table 5 Effect of storage and chlorpyrifos treatments on post-storage bulb assessments in cv Carlton (Experiment 1). The figures are marginal means for ambient, 18°C and 30°C storage, as storage treatment differences were not significant. Percentages analysed as transformed values (logit (x + 0.5)), with non-transformed percentages in parenthesis.

Storage and chlorpyrifos treatment	Unmarketable bulbs (% of stored bulbs) Total unmarketable		Unmarketable bulbs (% of stored bulbs) With maggots		Total with maggots (% of all lifted bulbs)	
Control	-1.7	(15.5)	-1.9	(12.5)	-1.8	(13.5)
Control (+ Yaltox)	-1.7	(15.0)	-2.1	(10.9)	-2.1	(10.7)
HWT + Dursban	-4.5	(0.8)	-	(0.1)	-	(0.3)
HWT + Spannit	-4.6	(0.7)	-	(0)	-	(0)
Cold dip + Dursban	-3.1	(4.2)	-3.4	(2.9)	-3.2	(4.0)
Cold dip + Spannit	-3.7	(2.2)	-4.2	(1.1)	-4.1	(1.2)
Spray + Dursban	-2.8	(5.4)	-3.0	(4.7)	-2.9	(5.2)
Spray + Spannit	-2.8	(6.4)	-3.0	(5.0)	-2.9	(5.4)
SED	0.21 (46 df)		0.22 (34 df)		0.22 (34 df)	
Significance[a]						
Storage temperatures(A)	NS		NS		NS	
Controls v chlorpyrifos(B)	***		***		***	
A x B	NS		NS		NS	
Dursban v Spannit(C)	NS		**		**	
HWT v cold dip x spray(D)	***		***		***	
A x C	NS		NS		NS	
A x D	NS		NS		NS	
C x D	NS		*		**	
A x C x D	NS		NS		NS	

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 6 Effect of storage and chlorpyrifos treatments on post-storage bulb assessments in cv Dutch Master (Experiment 1). The figures are marginal means for ambient, 18°C and 30°C storage, as storage treatment differences were not significant. Percentages analysed as transformed values (logit (x + 0.5)), with non-transformed percentages in parenthesis.

Storage and chlorpyrifos treatment	Unmarketable bulbs (% of stored bulbs)				Total with maggots (% of all lifted bulbs)	
	Total unmarketable		With maggots			
Control	-1.8	(13.5)	-2.0	(11.3)	-2.0	(11.9)
Control (+ Yaltox)	-1.9	(13.4)	-2.1	(11.8)	-2.0	(13.1)
HWT + Dursban	-3.8	(1.9)	-4.4	(1.1)	-4.2	(1.3)
HWT + Spannit	-3.5	(2.6)	-3.9	(1.8)	-3.9	(1.8)
Cold dip + Dursban	-2.7	(7.0)	-2.8	(6.1)	-2.7	(6.6)
Cold dip + Spannit	-3.2	(4.5)	-3.4	(3.6)	-3.2	(4.1)
Spray + Dursban	-2.2	(10.2)	-2.3	(9.1)	-2.2	(9.6)
Spray + Spannit	-1.8	(15.2)	-1.9	(13.5)	-1.9	(14.1)
SED (46 df)	0.24		0.29		0.26	
Significance[a]						
Storage temperatures(A)	**		*		*	
Controls v chlorpyrifos(B)	***		***		***	
A x B	NS		NS		NS	
Dursban v Spannit(C)	NS		NS		NS	
HWT v cold dip x spray(D)	***		***		***	
A x C	NS		NS		NS	
A x D	NS		NS		NS	
C x D	*		*		NS	
A x C x D	NS		NS		NS	

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 7 Effect of storage and chlorpyrifos treatments on first-year flower production in cv Carlton (Experiment 2)

Storage and chlorpyrifos treatment	Flower number (no./plot)	Flower diameter (mm)	Stem length (mm)	Flowers with HWT damage (no./plot)
<u>Ambient storage</u>				
Control	216	103	315	15
HWT	218	101	305	6
Cold dip	211	101	312	19
Spray	207	103	319	10
<u>18°C storage</u>				
Control	208	105	324	12
HWT	203	102	308	6
Cold dip	210	101	314	11
Spray	212	104	310	9
<u>30°C pre-warm</u>				
Control	229	104	333	27
HWT	217	104	321	23
Cold dip	217	101	348	39
Spray	221	104	340	12
SED (55 df)	7.5	1.1	8.6	6.7
Significance[a]				
storage	**	NS	***	***
chlorpyrifos	NS	***	*	**
interaction	NS	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability

Table 8 Effect of storage and chlorpyrifos treatments on first-year flower production in cv Golden Harvest (Experiment 2)

Storage and chlorpyrifos treatment	Flower number (no./plot)	Flower diameter (mm)	Stem length (mm)	Flowers with HWT damage (no./plot)
Ambient storage				
Control	133	82	310	11
HWT	145	80	300	14
Cold dip	137	81	306	14
Spray	174	80	301	18
18°C storage				
Control	174	83	312	14
HWT	139	80	302	8
Cold dip	143	80	299	15
Spray	160	81	311	19
30°C pre-warm				
Control	209	86	330	2
HWT	220	84	331	5
Cold dip	209	85	333	3
Spray	199	86	332	3
SED (55 df)	13.3	1.1	14.3	4.8
Significance[a]				
storage	***	***	***	***
chlorpyrifos	*	*	NS	NS
interaction	*	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability

Table 10 Effect of storage and chlorpyrifos treatments on bulb yields and post-storage bulb assessments after one year in cv Golden Harvest (Experiment 2). Percentage unmarketable bulbs analysed as transformed values (logit (x+0.5)), with non-transformed percentages in parenthesis

Storage and chlorpyrifos treatment	Marketable yield (no. or weight of bulbs)			Unmarketable bulbs (% of total)	
	kg/plot	% weight increase	no./plot	Total	With maggots
Ambient storage					
Control	14.80	85	243	-2.5 (7.9)	-2.6 (7.1)
HWT	13.15	64	274	-3.5 (2.8)	-4.7 (0.5)
Cold dip	13.71	71	269	-2.9 (4.7)	-3.6 (2.6)
Spray	13.10	64	215	-2.6 (7.0)	-3.3 (4.2)
18°C storage					
Control	14.88	86	254	-2.5 (8.2)	-2.7 (7.1)
HWT	11.79	47	274	-3.6 (2.1)	-4.9 (0.3)
Cold dip	13.57	70	261	-3.3 (3.6)	-3.5 (3.1)
Spray	14.37	80	244	-2.6 (6.3)	-3.6 (3.5)
30°C pre-warm					
Control	15.16	90	242	-2.5 (7.6)	-2.8 (5.9)
HWT	15.27	91	272	-3.4 (2.7)	-4.5 (0.7)
Cold dip	15.43	93	281	-3.8 (2.4)	-4.5 (0.7)
Spray	14.20	78	203	-2.8 (6.0)	-3.2 (3.8)
SED (22 df)	0.486	6.1	18.6	0.41	0.46
Significance[a]					
storage	***	***	NS	NS	NS
chlorpyrifos	***	***	***	***	**
interaction	***	***	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability

Table 12 Effect of storage and chlorpyrifos treatments on bulb grade-out after one year in cv Golden Harvest (Experiment 2)

Storage and chlorpyrifos treatment	Percentage of marketable weight in grades						
	<8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm	>18cm
Ambient storage							
Control	1	6	20	19	30	19	5
HWT	1	6	22	19	30	18	4
Cold dip	1	5	21	19	31	21	2
Spray	1	8	25	29	29	7	1
18°C storage							
Control	2	12	28	27	26	4	1
HWT	1	7	23	22	28	17	2
Cold dip	1	8	24	30	28	9	1
Spray	1	7	25	25	32	9	0
30°C pre-warm							
Control	1	6	26	23	32	11	0
HWT	1	6	18	19	28	22	6
Cold dip	1	7	20	20	29	19	4
Spray	1	4	17	17	26	28	8
Significance[a]							
storage	NS	*	NS	NS	NS	**	NS
chlorpyrifos	*	**	***	**	***	***	**
interaction	NS	NS	NS	NS	*	NS	NS

[a]Significance levels based on analysis of variance of weights per plot; NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 13 Effect of storage and chlorpyrifos treatments on second-year flower production in cv Carlton (Experiment 2)

Storage and chlorpyrifos treatment	Flower number (no./plot)	Flower diameter (mm)	Stem length (mm)
Ambient storage			
Control	299	106	385
HWT	287	107	384
Cold dip	300	107	377
Spray	279	108	410
18°C storage			
Control	274	110	394
HWT	286	106	399
Cold dip	296	107	407
Spray	296	107	388
30°C pre-warm			
Control	308	107	388
HWT	312	110	399
Cold dip	308	108	401
Spray	319	108	401
SED (22 df)	15.4	2.1	11.5
Significance[a]			
storage	*	NS	NS
chlorpyrifos	NS	NS	NS
interaction	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 14 Effect of storage and chlorpyrifos treatments on second-year flower production in cv Golden Harvest (Experiment 2)

Storage and chlorpyrifos treatment	Flower number (no./plot)	Flower diameter (mm)	Stem length (mm)
Ambient storage			
Control	274	104	416
HWT	272	106	417
Cold dip	247	105	436
Spray	281	107	427
18°C storage			
Control	284	107	417
HWT	277	102	420
Cold dip	271	105	413
Spray	280	105	410
30°C pre-warm			
Control	300	105	430
HWT	311	109	431
Cold dip	328	107	438
Spray	276	109	416
SED (22 df)	21.6	2.8	13.3
Significance[a]			
storage	*	NS	NS
chlorpyrifos	NS	NS	NS
interaction	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 15 Effect of storage and chlorpyrifos treatments on bulb yields and post-storage bulb assessments after two years in cv Carlton (Experiment 2). Percentage unmarketable bulbs analysed as transformed values (logit (x+0.5)), with non-transformed percentages in parenthesis

Storage and chlorpyrifos treatment	Marketable yield (no. or weight of bulbs)			Unmarketable bulbs (% of total)	
	kg/plot	% weight increase	no./plot	Total	With maggots
Ambient storage					
Control	21.40	168	348	-3.1(3.7)	-3.2(3.5)
HWT	21.51	169	347	-3.5(3.1)	-3.6(2.6)
Cold dip	21.63	170	365	-3.2(3.4)	-3.5(2.5)
Spray	20.54	157	306	-2.9(6.5)	-3.0(5.4)
18°C storage					
Control	21.15	164	339	-3.2(7.9)	-3.2(7.9)
HWT	20.53	157	346	-2.9(4.9)	-2.9(4.7)
Cold dip	20.89	161	356	-3.3(3.3)	-3.3(3.1)
Spray	21.66	171	346	-3.0(4.6)	-3.0(4.3)
30°C pre-warm					
Control	21.48	169	340	-3.0(4.5)	-3.1(4.2)
HWT	22.55	182	360	-3.2(4.4)	-3.3(3.6)
Cold dip	20.04	151	327	-2.6(6.5)	-2.8(5.8)
Spray	22.34	179	353	-2.5(7.5)	-2.7(6.2)
SED (22 df)	1.098	13.7	15.8	0.60	0.59
Significance[a]					
storage	NS	NS	NS	NS	NS
chlorpyrifos	NS	NS	NS	NS	NS
interaction	NS	NS	*	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 16 Effect of storage and chlorpyrifos treatments on bulb yields and post-storage bulb assessments after two years in cv Golden Harvest (Experiment 2). Percentage unmarketable bulbs analysed as transformed values (logit (x+0.5)), with non-transformed percentages in parenthesis

Storage and chlorpyrifos treatment	Marketable yield (no. or weight of bulbs)			Unmarketable bulbs (% of total)	
	kg/plot	% weight increase	no./plot	Total	With maggots
Ambient storage					
Control	21.83	173	353	-1.9(12.9)	-2.0(11.2)
HWT	21.04	163	365	-2.2 (9.7)	-2.4 (8.6)
Cold dip	21.38	167	366	-1.9(13.2)	-2.0(11.8)
Spray	21.41	168	343	-1.6(17.4)	-1.9(13.4)
18°C storage					
Control	22.22	165	351	-1.8(14.2)	-1.9(13.1)
HWT	19.99	150	366	-2.0(12.0)	-2.3 (9.6)
Cold dip	20.49	156	385	-2.2(13.4)	-2.4(11.4)
Spray	22.01	175	317	-1.9(13.2)	-2.1(11.2)
30°C pre-warm					
Control	22.04	176	345	-2.3 (8.9)	-2.4 (7.6)
HWT	23.12	189	367	-2.3 (8.3)	-2.6 (6.6)
Cold dip	22.69	184	376	-2.3 (8.8)	-2.4 (7.6)
Spray	21.59	170	330	-1.5(19.9)	-1.7(16.7)
SED (22 df)	0.786	9.8	18.2	0.51	0.53
Significance[a]					
storage	**	**	NS	NS	NS
chlorpyrifos	NS	NS	**	NS	NS
interaction	NS	NS	NS	NS	NS

[a]NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 17 Effect of storage and chlorpyrifos treatments on bulb grade-out after one year in cv Carlton (Experiment 2)

Storage and chlorpyrifos treatment	Percentage of marketable weight in grades						
	<8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm	>18cm
Ambient storage							
Control	2	9	15	27	30	13	3
HWT	1	8	14	26	30	15	5
Cold dip	1	7	15	26	33	14	3
Spray	1	7	15	28	34	12	2
18°C storage							
Control	2	9	14	28	33	12	2
HWT	1	9	16	27	32	12	4
Cold dip	1	9	16	25	32	14	4
Spray	1	7	13	30	34	10	5
30°C pre-warm							
Control	1	8	17	25	34	13	3
HWT	1	6	13	22	34	18	7
Cold dip	2	8	14	23	34	16	4
Spray	1	8	15	25	30	14	5
Significance[a]							
storage	NS	NS	*	NS	NS	NS	NS
chlorpyrifos	NS	NS	NS	NS	NS	NS	NS
interaction	NS	**	NS	NS	NS	NS	NS

[a]Significance levels based on analysis of variance of weights per plot; NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

Table 18 Effect of storage and chlorpyrifos treatments on bulb grade-out after one year in cv Golden Harvest (Experiment 2)

Storage and chlorpyrifos treatment	Percentage of marketable weight in grades						
	<8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm	>18cm
Ambient storage							
Control	1	7	15	26	32	17	2
HWT	1	6	17	28	31	15	2
Cold dip	1	6	17	27	28	16	4
Spray	2	8	14	30	32	13	2
18°C storage							
Control	2	7	16	32	30	12	2
HWT	1	6	17	25	33	14	3
Cold dip	1	7	15	31	30	14	2
Spray	3	8	17	30	30	11	0
30°C pre-warm							
Control	1	8	17	28	31	14	2
HWT	1	6	18	26	30	16	4
Cold dip	1	5	14	25	30	19	6
Spray	1	6	17	24	32	17	3
Significance[a]							
storage	**	NS	**	NS	*	NS	NS
chlorpyrifos	***	*	NS	NS	NS	*	NS
interaction	**	NS	NS	NS	NS	NS	NS

[a]Significance levels based on analysis of variance of weights per plot; NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1% levels of probability.

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