Final Report (1993)

HDC Project BOF23

DWARF NARCISSUS VARIETIES BULB PRODUCTION

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Project Co-ordinator: David Almond
Project Commenced: April 1991
Project Completed: November 1993
Keywords: Narcissus, Daffodil, Bulbs

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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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APPLICATION

The main objective of the project was to generate advice for UK growers considering production of bulbs of the dwarf narcissus variety Tête-à-Tête. The secondary aim was to evaluate a range of dwarf varieties against Tête-à-Tête for bulb production and forced pot-plant use. Planting Tête-à-Tête bulbs at 5 to 10 t/ha and growing 'two-years-down' gave good yields, despite sensitivity to HWT damage (which could be prevented by a 30°C pre-warming treatment); there were no benefits of using crop covers. The characteristics of a range of dwarf varieties are described in the report. There is a good demand for quality bulbs of dwarf narcissus types, which would provide useful diversification for UK bulb growers.

SUMMARY

UK bulb growing depends heavily on a few standard daffodil varieties, whereas in The Netherlands narcissus bulb producers have moved away from traditional varieties, one major change being the large area of the dwarf variety Tête-à-Tête now grown. This variety is in demand for garden use, and for using as a naturally dwarf pot-plant. As little information was available on growing varieties like Tête-à-Tête in the UK (and particularly in eastern England), this project was set up (1) to obtain some basic cultural advice for growers for Tête-à-Tête bulb production and (2) to compare the performance of other dwarf varieties with Tête-à-Tête for bulb production in the field and for forced pot-plant production.

Bulb yields were examined in Tête-à-Tête grown with different pre-warming/hot-water treatment (HWT) regimes and planting densities, with one- or two-year-down growing. The variety was sensitive to HWT damage. When bulbs were stored at ambient temperatures before standard HWT (at 44.4°C), leaf tips were mottled and flowers distorted, but pre-warming bulbs (for 1 week at 30°C) before pre-soaking and high-temperature (46°C) HWT prevented damage and produced more and taller flowers the next spring; storage at 18°C for 2 weeks before standard HWT did not prevent HWT damage. In two-year-down crops, bulb yield was little affected by omitting pre-warming. For good bulb yields (6 to 7 t disposable yield /ha), planting bulbs at 5 to 10 t/ha and growing for two-years was recommended: there were no benefits in using higher planting densities (up to 20 t/ha) or one-year-down growing. Using small grades of planting material (< 8 or 8-10 cm) gave good weight increases.

The use of winter crop covers was examined, as varieties like Tête-à-Tête are less hardy than standard ones. Straw was most effective in increasing soil temperature, usually by 2 to 3°C at bulb depth, while polythene covers were less effective. However, there were no benefits on bulb yields of using covers, and in some cases bulb yields were reduced. The trial was done in three years, which covered a useful range of winter conditions.

Tête-à-Tête was also evaluated as a chipped crop. *Penicillium* was a problem during chip incubation and, in batches from different stocks, between 14 and 40 per cent of propagules rotted during incubation. Carrying out chipping in late-July, bulb yields were similar when

the chips were either incubated (planted after 12 weeks' storage at 20°C) or planted immediately after cutting (direct-planting). When chipping was delayed until mid-August, results from direct-planting were poor. A planting density of 5 t/ha (measured as the original weight of bulbs chipped) gave satisfactory yields. Using a straw winter crop cover did not benefit bulb yields, although leaving half of the straw cover in place after crop emergence suppressed weeds.

Plots of 28 dwarf and related varieties were evaluated in the field against three stocks of Tête-à-Tête. Besides Tête-à-Tête, the best bulb yields were found in *Narcissus canaliculatus*, February Gold, Little Beauty, Little Gem, Minnow, *N. obvallaris*, Sweetness, Topolino and W.P. Milner. The floral characteristics of all varieties are described in the report. In addition, Tête-à-Tête and 19 of the other cultivars were forced as pot-plants: several produced attractive pot-plants with long shelf-life and high numbers of flower stems. These trials highlighted the need to improve the quality of dwarf narcissus stocks: many of those tested had unacceptably high levels of bulb rot, virus, stem nematode or rogues.

Other cultural aspects of growing Tête-à-Tête are briefly reviewed in the report. Important aspects are careful handling of the bulbs, thorough drying, the use of suitable fungicides, and avoiding full rates of formaldehyde. Rates of multiplication when planting Tête-à-Tête as bulbs or chips are also discussed.

Growers considering bulb production of Tête-à-Tête or similar varieties will need to secure suitable stocks and be prepared to improve these by selection. Chipping should be considered as an option for bulking stocks more rapidly, but only once an adequate standard of plant health has been reached. Aside from these considerations, growing dwarf narcissus bulbs is largely a case of optimising normal cultural operations, eg planting densities and bulb handling and drying. Dutch statistics should be watched for indications of changing varietal trends. Good quality bulbs of dwarf narcissus varieties command a good price, and the opportunities for pot-plant production might also be considered.

DWARF NARCISSUS VARIETIES BULB PRODUCTION

EXPERIMENTAL SECTION

INTRODUCTION

Field-grown narcissus crops occupied 3930 ha in England and Wales in 1992/93 (MAFF Census), an area which has been reasonably static for the last 10 years (Table 1). It is likely that this represents an increase in crop tonnage over this period, as planting densities have increased. In addition, about 250 ha of narcissus are currently grown in Scotland. Although detailed statistics are not available, the UK industry depends heavily on a few standard varieties like Golden Harvest, Carlton and Dutch Master.

In The Netherlands, narcissus acreages have also been reasonably steady, at around 1600 to 1800 ha. Because narcissus are grown in The Netherlands as a one-year-down crop, with a greater percentage weight increase than applies to two-year-crops, Dutch output is much greater than these areas imply. The last few years, however, have seen a decrease in the Dutch narcissus area from a peak in 1988-1990 (Table 1) and, as detailed cultivar statistics are available, trends for the production of different types of narcissus can be seen. The area of trumpet narcissus has declined steadily over this period, and areas of large- and small-cup and of double cultivars has fallen more recently. On the other hand, the area of the cyclamineus types, among which one cultivar, Tête-à-Tête, dominates, has increased. The success of this variety has been due to its appeal for garden use and as a naturally dwarf forced pot-plant, coupled perhaps with changes in consumer tastes towards more delicate varieties; the variety also responds well to propagation by chipping.

The continued demand for Dutch bulbs of Tête-à-Tête suggested it would be worthwhile to investigate the potential for producing them commercially in the UK. Although a good bulb soil would be required for harvesting the relatively small bulbs, this seemed to be a useful diversification from the production of standard narcissus.

Preliminary trials on growing Tête-à-Tête for bulb production had been carried out at Rosewarne Experimental Horticulture Station (EHS) just prior to its closure in 1989. Tête-à-Tête, grown at a planting density of just under 10 t/ha, gave percentage weight increases between 161 and 182 in different treatments (ADAS, 1988a). Several cyclamineus varieties (and some other dwarf narcissus) were included in the variety trialling at Rosewarne EHS (NAAS, 1963, 1967), and these data were drawn together in the HDC report on Project BOF13 (Hanks, 1990, pp. 70-74). Bulb yields (percentage weight increase) for the different cultivars planted at relatively low densities (around 5 to 10 t/ha) ranged from 172 to 276 per cent for two-year-down growing and from 242 to 728 per cent for three-year-down growing. Cultivars Beryl, Garden Princess, Jack Snipe, Larkelly, Little Witch, March Sunshine and Orange Glory had the best weight increases.

There was little information on which to base cultural advice for growers. Furthermore, trials had not taken place under the conditions of eastern England. The present project was therefore set up, with the following objectives:

1. To investigate the effects of pre-warming and hot-water treatment (HWT), planting density and one- or two-year-down growing on bulb production;

2. To investigate the agronomics of growing bulbs from chips;

3. To investigate whether crop covers (straw, etc.) are beneficial in providing winter protection for the bulbs which are less hardy than standard varieties;

4. To compare stocks of Tête-à-Tête, and to investigate alternative cultivars for bulb production in the field and for pot-plant production.

MATERIALS AND METHODS

Plant material

Bulbs of *Narcissus* cultivars Tête-à-Tête and others were obtained from HRI stocks grown at Kirton or from commercial sources, indicated under individual experiments. The bulb grade used was 8-10 cm (circumference), unless otherwise stated. HRI stocks were lifted annually in July, dipped in aqueous thiabendazole, formalin and non-ionic wetter within two days of lifting, dried for 3 days at 35°C on a drying wall and then under fans at ambient temperatures, and (unless intended for forcing) given standard hot-water treatment (HWT) in mid-August (3 hours at 44.4°C with aqueous thiabendazole, formalin and non-ionic wetter), followed by drying under fans at ambient temperatures. Under Experiment 4, Kirton 'B' stock refers to a selected stock which had been vigorously rogued for a number of years. Commercial stocks were received in August/September and used as supplied, with storage at ambient temperatures until planting or the start of experimental treatments.

It should be noted that comments on individual varieties relate only to the individual samples of bulbs used in these experiments.

Experiment 1: effect of pre-warming, planting density and one- and two-year-down growing on bulb yields in different bulb grades of cultivar Tête-à-Tête

Bulbs of cv Tête-à-Tête (Kirton stock, grades <8, 8-10 and 12-14 cm) were used in this experiment in 1990-1992. Bulbs were hot-water treated on 28 August 1990, either (1) following storage at ambient temperatures, (2) following storage at 18°C for the previous 14 days, or (3) following storage at 30°C for the previous 7 days ('pre-warming'). For (1), bulbs were treated at 44.4°C for 3 hours, for (2) bulbs were treated at 44.4°C for 3 hours following dipping at ambient temperatures for 3 hours ('pre-soaking'), and for (3) bulbs were treated at 46°C for 3 hours ('high temperature HWT') following pre-soaking. HWT tanks contained aqueous thiabendazole, formaldehyde and non-ionic wetter (as 5 litre Storite Clear Liquid (260 g a.i./litre; MSD Agvet), 5 litre commercial formalin (38-40% a.i.) and 0.62 litre Agral (containing 900 g/litre alkyl phenol ethylene oxide; ICI)/1000 litre); pre-soak tanks contained formaldehyde and wetter only (as above).

Bulbs (from each HWT treatment and bulb grade) were planted in the field on 2 October 1990, in 1 m-long plots at densities of 5, 10, 15 or 20 t/ha. Plots from each

treatment combination were grown for one or two years before lifting (on 24 June 1991 or 18 June 1992).

Experiment 2: the effect of winter covers on bulb yield in cultivar Tête-à-Tête

This experiment was repeated in three successive years, 1989-1990 to 1991-1992.

In the first experiment, cv Tête-à-Tête bulbs (commercial stocks) were planted in the field in 4 m-long plots at a density of 5 t/ha on 14 September 1989. Each plot was surrounded by an unplanted area to give an overall area (for covering treatments) 5 m long and three ridges wide (10.7 m^2). On 7 November 1989 plots and their corresponding surrounding area were (1) covered with perforated clear polythene film (Agronet, 0.05 mm thick, 500 holes/m^2), (2) covered with non-perforated clear polythene film (0.04 mm thick), (3) covered with straw at a rate of 20 t/ha, (4) lightly raked and sown with winter wheat at a rate of 250 kg/ha, or (5) left non-covered as a control. Routine herbicides were applied one day before cover treatments were applied (with the exception of the plots due to be sown with wheat, where pre-emergence residual was omitted). Temperature probes were inserted in the ridge at bulb depth and half bulb depth in the centre of one plot of each treatment, and temperatures were logged at hourly intervals and converted to daily or weekly minima, averages and maxima. Plots were inspected at intervals for emergence of shoots from the soil, when the covers were removed (17 January 1990). The trial was lifted on 26 July 1990.

For the second trial the bulbs (Kirton stocks) were planted on 25 September 1990, covers were applied on 21 November 1990 and removed on 11 February 1991, and bulbs were lifted on 22 July 1991. Methods used were otherwise as before.

For the third trial, bulbs were from Kirton stocks and were equal weights of 8-10 and 10-12 cm grades (for three replicates) or of 10-12 and 12-14 cm grades (for the fourth replicate). Bulbs were planted on 18 September 1991, covers were applied 30 October 1991 and removed on 19 February 1992, and bulbs were lifted on 9 July 1992. Other methods were as before.

Experiment 3: the effect of straw cover and planting density on bulb yields in incubated and direct-planted chip crops of cultivar Tête-à-Tête

The 'full' experiment was set up as a two-year-down crop in 1991, and certain aspects were repeated in a one-year-down trial in 1992.

In the main experiment, a commercial stock of cv Tête-à-Tête bulbs, grade 10-12 cm, was chipped on 12-13 August 1991. Chips were either planted the next day ('direct planting'), or on 13 November 1991, after incubation. Planting was to 3.5 m-long plots at a density of 2.5, 5.0 or 7.5 t/ha (based on the original weight of bulbs chipped), and each plot was surrounded by an unplanted area to give an overall area (for covering treatments) 4.5 m long and three ridges wide (10.3 m^2). On 12 December 1991 plots and their surrounding areas were either left non-covered or were covered with straw (at 20 t/ha). Following regular inspection for crop emergence from the soil, following emergence on 17 February 1992, strawed plots either had all or half of the straw removed. Straw was reapplied to appropriate

plots in the following winter (17 November 1992) and fully or partially removed on 9 February 1993. During the covered period, soil temperatures at bulb depth were logged as described for experiment 2: soil temperatures were also logged under additional plots covered with straw at 10 or 40 t/ha. The trial was lifted on 8 July 1993.

For the subsidiary experiment, a commercial stock of cv Tête-à-Tête bulbs, 10 cm grade, was chipped on 29 July 1992. Chips were either planted directly after cutting and dipping (direct planting), or on 3 November 1992 after incubation. Planting was to 2.6 m-long plots at a density of 5.0 t/ha (based on weight of bulbs chipped), and each plot was surrounded by an unplanted area to give an overall area 3.6 m long and three ridges wide (8.2 m^2). Cover treatments were applied (as in the preceding experiment) on 17 November 1992 and removed (fully or partially) on 25 February 1993. Soil temperatures were logged in the plots as before. The trial was lifted on 7 July 1993.

Experiment 4: an examination of bulb production and forced pot-plant production for a range of dwarf narcissus cultivars and Tête-à-Tête stocks

A range of 28 dwarf and related cultivars was obtained, mainly from commercial sources, for evaluation against two Kirton and one commercial stocks of cv Tête-à-Tête. Details of cultivars, sources and bulb sizes are listed in Table 2. The full range of cultivars, together with bulb and chip crops of the Tête-à-Tête stocks, was evaluated for bulb production in a field trial. A more restricted range of suitable cultivars (18 plus Tête-à-Tête) was evaluated for pot-plant production in the glasshouse.

Bulb production trial Weighed, 100-bulb plots of each of the cultivars and Tête-à-Tête stocks were planted in the field in 4 m-long plots on 25 September 1992. Additional bulbs of two Tête-à-Tête stocks, one Kirton and one commercial, were chipped (in 100-bulb lots) on 6 August 1992, incubated, and planted in the field on 15 November 1992. The trial was lifted on 7 July 1993.

Forced pot-plant trial 100-bulb lots of 18 selected cultivars and of the three stocks of cv Tête-à-Tête were 'pre-cooled' at 9°C, planted in pots (5 bulbs per pot) and returned to the 9°C cold store until ready to move to a glasshouse.

General methods - field experiments

During storage bulbs were weighed into batches corresponding to field plots. Bulbs were planted in netting to aid recovery : prior to planting, each batch was placed in a length of tubular nylon netting (Netlon Oriented 1), using clips to distribute the bulbs evenly, the length of net used being twice the length of the field plot. Chips were planted in the same way, except that a narrower net (Netlon Diamond 2) was used. The trial area was ridged out and plots marked in advance, and at planting the net was laid double in the ridge bottom, and the ridges split back. Ridges were at 0.76 m centres, except in the 1989 experiment where 0.71 m centres were in use, and planting densities given in the text take this into account.

Husbandry followed good commercial practice (eg, see ADAS, 1985). Fertilisers were applied according to analysis and recommendations, phosphate, potash and magnesium in the

base before cultivation and nitrogen as a top-dressing pre-emergence in the first year. For trials involving crop covers, nitrogen was carefully applied by hand following cover removal. Weed control was by pre-emergence applications of paraquat + diquat and chlorpropham + linuron (or chloridazon + chlorburam for first-year chipped trials), post-emergence cyanazine (if needed), and post-flowering bentazone. For trials with crop covers, pre-emergence herbicides were applied immediately before covers were put in place; some hand weeding was usually needed after cover removal. Two-year-down crops were ridged-up between growing seasons. From emergence, crops received a regular and varied fungicide programme, usually with five sprays in the first year and three in the second.

At flowering, the number of flower stems per plot was recorded, along with the stem (scape) length of 20 central blooms per plot. Abnormalities, such as HWT damage to leaves or flowers, were noted. Dates of first, 50 per cent and full flowering were recorded. Percentage foliage senescence was recorded about weekly. In the 'variety trial' (experiment 4), the number of florets per stem, and the diameter of the first floret, were also recorded, and all varieties were photographed. In the case of experiments or treatments using 'chipped' bulbs (see below), field records were limited to leaf counts in the first year and percentage ground cover and flower counts in the second year.

For harvesting bulbs the foliage was flailed off (if necessary), bulbs were lifted, dried under fans at ambient temperatures, cleaned by hand and graded. The weight and number of sound bulbs in each grade was recorded, along with any additional number of rotted bulbs. Percentage increases in bulb weight were calculated as the excess of lifted weight over planted weight, multiplied by 100, divided by planted weight.

Experiments 1 to 3 were of a randomised block design. In experiment 1 the three bulb grades used corresponded to the replicate blocks, and data were adjusted using bulb grade as a covariate. There were three blocks for experiment 1 and four for experiments 2 and 3. In experiment 4 field plots were fully randomized, with plots of Tête-à-Tête stocks replicated three times and plots of other cultivars included as unreplicated observations. The pot-plant trial of experiment 4 was set out as a randomised block design with five replicate blocks (corresponding to glasshouse benches) and four pots of each cultivar or stock in each block. Data were subjected to the analysis of variance as appropriate.

General methods - bulb chipping

For experiment 3 bulbs were chipped using a prototype chipping machine which produced eight segments ('chips') per bulb. Bulbs were inspected during cutting, removing and replacing any affected by, for example, basal rot or narcissus fly. Chips were dipped after cutting in aqueous benomyl plus captan (as 2 g Benlate Fungicide (50% a.i.; Du Pont) and 10 g PP Captan 83 (83% a.i.; ICI) per litre) for 15 minutes at ambient temperatures, and allowed to drain. For direct-planting chips were netted and planted straightaway. For incubated chips, each weighed plot was mixed with twice its volume of previously moistened vermiculite (11:1 vermiculite: water ratio by volume), placed in a tray (58 x 42 x 10 cm, internal dimensions) enclosed in a thin (125 gauge) polythene bag, and stored in the dark at 20°C for 3 months. After incubation, bulbil production was recorded on the chips, and the propagules netted and planted.

For experiment 4 methods were similar except that the small batches were chipped manually.

General methods - bulb forcing

Bulbs were placed in a cool store at 9°C on 29 September 1992, except for cv Trena which was not received until 15 October 1992 when it was immediately cool stored. On 26 October 1992, bulbs were dipped for 30 minutes at ambient temperatures in aqueous captan, benomyl and formaldehyde (as 100 g PP Captan 83 (83% w/w; ICI), 10 g Benlate (50% w/w; Du Pont) and 50 ml commercial formalin (38-40% a.i.) per 10 litres), dried under fans at ambient temperatures overnight, planted in 14 cm-diameter half-pots of unamended medium grade sphagnum peat, five bulbs per pot, watered well, and replaced at 9°C. There were 20 pots per cultivar. The cool store was changed to 5°C on 8 December 1992 and cultivars were moved individually to a store at 1°C as required to slow excessive shoot growth (February Gold on 17 December 1992, Hawera on 28 December 1992, Jetfire and February Silver on 4 January 1993, and Tête-à-Tête, Sweetness and Jack Snipe on 11 January 1993).

All varieties were moved to a glasshouse on 20 January 1993, except for Trena which was not housed until 2 February 1993. Glasshouse conditions were: minimum maintained day and night temperature, 16°C; ventilation temperature, 18°C; natural light. Pots were kept well watered according to need. The marketable date (when half the shoots in a pot had produced a swollen but un-split bud) was recorded. At full flower of individual inflorescences, date, stem length, first floret diameter and floret number were recorded. Stem lengths and dates were recorded again at the individual senescence of each inflorescence. The number of bulbs per pot with disease or pest symptoms or other disorders was recorded.

RESULTS

Experiment 1: the effect of pre-warming, planting density and one- and two-year-down growing on bulb yield in different bulb grades of cultivar Tête-à-Tête

In the spring following HWT, bulbs which had been pre-warmed (30°C storage) produced flowers and leaves free from HWT damage, whereas treatments involving ambient storage or 18°C treatment gave plants with mottled leaf tips and distorted flowers (split coronas and 'starry' perianth segments). Pre-warmed plots produced more and taller inflorescences than other treatments, with 18°C-treated plots significantly poorer in both respects (Table 3).

In the second spring, flowers and leaves of all remaining plots were free of HWT damage. Inflorescence numbers were again generally lower in plots which had received 18°C treatment (Table 3). Increasing planting density had the expected effect of producing taller stems. There were no differences between treatments in flowering or senescence dates in either year.

Bulb yields (by weight and number) are given in Table 4. Planting density and growing years interacted strongly on bulb yields. Percentage weight increase fell from 56 per cent at 5 t/ha to 9 per cent at 20 t/ha for one-year-down growing, but from 125 to 4 per cent for

two-year-down growing. At the two lower densities, percentage yield increases for two-year growing greatly exceeded those for one-year growing, while at higher densities, increases were similar for each growing system. Translated into disposable yields (surplus of lifted over planted weight), growing for one, two-year cycle at 5 or 10 t/ha, or growing for two, one-year cycles at the same density, would give similar yields of about 6 to 7 t/ha. The percentage of harvested bulb weight in the larger (>8 cm) grades increased slightly (from 43 to 55%) as planting density was reduced from 20 to 5 t/ha, and was somewhat higher for one-year growing (54%) than for two-year growing (43%). Pre-warming and HWT regime had only minor effects on yields. Higher planting densities and two-year-down growing produced more but smaller bulbs. Most bulbs harvested were of good quality, very few rotted bulbs being observed.

For the data given, the effects of bulb size have been ignored. Bulb size had little effect on the variates measured, although percentage bulb weight increases were greater from small (<8 cm) bulbs (54% on average) than from larger ones (40% for 8-10 cm bulbs, 32% for 12-14 cm bulbs).

Experiment 2: the effect of winter covers on bulb yields in cultivar Tête-à-Tête

1989-1990 trial Bulb weights harvested (Table 5) were greater in non-covered plots than in any covering treatment, and there were no significant differences in weights between the four covering treatments. Total bulb numbers were unaffected by treatment, but for the larger grades (>8 cm) more were produced in the non-covered plots. The growth of the wheat crop was relatively poor, accounting for the intermediate yields between non-covered and other covers in this treatment. Although flowering performance was not recorded as part of this experiment, it was observed that there were more inflorescences in covered plots (239 to 255) than in non-covered plots (230). Straw-covered plots reached 50 per cent flowering a week earlier than other plots.

Typical daily temperature records are shown in Figures 1-3. All covering materials reduced temperature fluctuations compared with non-covered plots, straw being most effective and the sown cereal least effective: the two types of polythene gave similar, intermediate protection. In the coldest periods, average temperatures at bulb depth were 2 to 3°C warmer in straw-covered plots than in non-covered plots. Differences in soil temperatures between bulb depth and half-bulb depth were small.

1990-1991 trial Cover treatments did not have a statistically significant effect on bulb yields (weights or numbers) in this trial (Table 6). The plots covered with perforated polythene produced a greater yield of larger bulbs.

There were no significant differences in the number of inflorescences per plot, although in some cover treatments (particularly straw) stems were longer (Table 6). Flowering was about a week earlier under unperforated polythene, compared with other treatments. There were no differences in senescence dates.

Weekly soil temperatures for the trial at bulb depth are shown in Figures 4-6. Straw was the most effective material in reducing temperature fluctuations and especially in raising minimum temperatures (by 3 to 4°C in extreme conditions). Growth of the sown cereal crop

was poor, giving temperature records similar to non-covered plots. Polythene covers were about half as effective as straw in reducing minimum temperatures. Figure 7 is an example of soil temperature at half bulb depth, showing this was similar to the temperatures recorded by the deeper probes.

1991-1992 trial In this year of the trial covering treatments had major effects on bulb weights harvested (Table 6). Weights were greatest in non-covered plots and in plots sown with wheat (which again failed to grow well); yields were lowest when a straw cover was used, and intermediate when polythene covers were used. Bulb numbers were not significantly affected by treatments.

As in the previous year there were no significant effects of treatment on flower numbers. Stem length was increased in straw and polythene cover treatments (Table 6). Straw- and polythene-covered plots reached median flowering a week ahead of other plots. There were no differences in senescence dates.

For the data tabulated, effects of bulb size have been ignored: bulb size did not interact significantly with covering treatments.

Soil temperature records confirmed the effectiveness of straw in maintaining soil temperatures (Figures 8-10). In the cold periods which occurred in early-December, a straw cover was most effective in preventing the soil from freezing.

Experiment 3: the effect of straw cover and planting density on bulb yields in incubated and direct-planted chip crops of cultivar Tête-à-Tête

Main experiment (1991-1993) Satisfactory bulbil production was recorded on the incubated chips, with means of 1.03 bulbils per chip, 11.1 mm bulbil length and 18 per cent propagules rotted. Incubated chips grew well, whereas emergence from direct-planted chips was poor (Table 7). There was a suggestion (the effect just failed to achieve statistical significance) that plant emergence (in incubated chips) was greater when a straw cover was used, particularly if it was not left in place after emergence.

Bulb yields from incubated chips were much greater than those from direct-planted ones. For incubated chips, non-covered plots yielded on average 162 bulbs per plot (weight, 0.51 kg), while covered plots yielded 207 bulbs per plot (weight, 0.65 kg), although the effect of covering treatment failed to reach statistical significance. Covering treatments were also without statistically significant effects for direct-planted chips. The results suggested a planting density of around 5 t chipped bulb/ha would be suitable.

Weekly average soil temperatures under different thicknesses of straw are shown in Figure 11. The standard rate of straw (20 t/ha) is probably ample to prevent freezing.

Subsidiary experiment (1992-1993) Bulbil production during incubation was again satisfactory, with means of 1.00 bulbils per chip, 9.9 mm bulbil length and 14 per cent propagules rotted. Emergence from incubated chips was greater than from direct-planted chips, while there was no evidence for improved plant growth as a result of using a straw cover (Table 8). At bulb lifting, plots where half the straw had been left in place were

weed-free (except for a few volunteer cereals), whereas almost total weed cover had developed (despite herbicide treatments) in non-covered plots or where the straw had been removed. There was no significant effect in this trial of chipping method (incubation or direct-planting) on bulb yields (numerical or weight), while the suggestions of greater bulb weights from non-covered plots just failed to achieve statistical significance.

Weekly average, minimum and maximum soil temperatures (Figure 12) confirmed earlier results.

Experiment 4: an examination of bulb production and forced pot-plant production for a range of dwarf narcissus cultivars and Tête-à-Tête stocks

Bulb production trial

Details of flowering characteristics of field-grown bulbs of the 29 varieties are given in Table 9, and bulb production is summarised in Table 10. Additional performance information on chipped stocks of Tête-à-Tête is given in Table 11. Note, when considering bulb yields, that the plots were grown only for a single year.

Tête-à-Tête The 'standard' cyclamineus narcissus cultivar, with yellow perianth and slightly darker trumpet, and up to three florets per stem. Two Kirton and one commercial stocks were included in this trial. The variety emerged about 20 January, all stocks reaching flowering in mid-March. The larger bulbs from the commercial stocks produced an average of 2.4 stems per bulb, the small ones from the Kirton stocks an average of 1.6 stems per bulb. Mean stem lengths at flowering for the three stocks varied from 153 to 161 mm, with 1.1 to 1.2 florets per stem and mean first floret diameters of 46 to 51 mm. Percentage bulb weight increase was 77 per cent for the commercial stock, and 123 and 160 per cent for the two Kirton stocks; at lifting, there were 7, 10 and 8 per cent of bulbs with rots for the three stocks, respectively.

Virus-tested (VT) stocks of Tête-à-Tête were not available for evaluation for this project. However, some relevant data will be available from the HDC project on narcissus variety assessment (BOF17), where both an 'ordinary' stock (ex-Kirton) and a 'VT' stock of Tête-à-Tête were included. Further data comparing ordinary and VT stocks will be available in due course from the HDC project on re-infection and evaluation of VT bulbs (BOF2a).

The variation in vigour between stocks was further shown by chipped plots of two stocks (commercial and Kirton) which were included in the present trial. During chip incubation, chips from the commercial stock produced an average of 0.51 bulbils per chip with mean bulbil length of 8.7 mm, whereas the Kirton stock gave more and larger bulbils (0.63 per chip, 9.1 mm length); 40 per cent of the chips of the former rotted, but only 12 per cent of the latter. Plots of chips of the commercial stock gave plant counts and bulb yields (both numerical and by weight) less than half those of chips from the Kirton stocks, although in lifted bulbs the percentage of rotted bulbs found was similar in each (11 to 12 per cent).

Beryl A primrose-yellow cyclamineus narcissus with an orange trumpet. Shoots emerged early in trial (early-January), but flowered about 2 weeks after Tête-à-Tête. Taller and with larger florets than Tête-à-Tête; one floret per stem. Only moderate bulb weight increase (60%).

Narcissus canaliculatus White perianth, golden yellow trumpet tazetta-type narcissus with two to three small, scented florets per stem. Late to emerge (late-February) and flower (mid-April). Dwarfer than Tête-à-Tête. Good rate of bulb increase (103%).

February Gold Cyclamineus narcissus with bright yellow perianth and golden trumpet, one floret per stem. Emerged earlier than Tête-à-Tête but flowered about the same date. Larger plant than Tête-à-Tête, taller and with larger florets. Moderate bulb weight increase (79%), but sample had 5 per cent of lifted bulbs with rots.

February Silver White perianth, pale yellow trumpet cyclamineus type similar to February Gold, but florets larger. Only moderate rate of bulb increase (41%), but 7 per cent of lifted bulbs with rots.

Garden Princess Deep yellow cyclamineus narcissus, otherwise similar flower characteristic to February Gold and February Silver. Only moderate bulb increase (46%).

Hawera Yellow triandrus type narcissus with two to three small florets per stem. Late-flowering (mid-April), taller than Tête-à-Tête, and poor weight increase (32%).

Itzim Cyclamineus narcissus with bright yellow perianth segments and orange trumpet. Recent introduction (registered 1982). Similar height to Tête-à-Tête, florets larger, one per stem, emerging and flowering about 2 weeks later. Very poor bulb weight increase (4%), but 8 per cent of lifted bulbs rotted in sample.

Jack Snipe Cyclamineus narcissus with white perianth and yellow trumpet. One floret per stem, taller, later and larger-flowered than Tête-à-Tête. Sample had 18 per cent rotted bulbs when lifted, hence negative bulb weight increase.

Jenny Cyclamineus narcissus with white perianth and pale yellow trumpet (fading to white). Late to emerge (early-February). Other floral characteristics similar to Jack Snipe. Sample had 31 per cent rotted bulbs when lifted, and negative bulb weight increase.

Jetfire Cyclamineus narcissus with bright yellow perianth and yellow-orange trumpet. Early to emerge, but flowering with Tête-à-Tête. One floret per stem, taller and larger-flowered than Tête-à-Tête. Bulb weight increase figures dubious because of large proportion of rogue bulbs in sample.

Jumblie Cyclamineus narcissus with yellow perianth and orange trumpet, about two florets per stem. Earlier to emerge than Tête-à-Tête, but flowering the same time. Similar stem length and floret size and number to Tête-à-Tête. Very poor bulb weight increase in sample (11%), but lifted bulbs had 13 per cent with rots.

Larkwhistle Yellow cyclamineus narcissus with one floret per stem. Same flowering period as Tête-à-Tête, but emerging earlier and with longer stems and larger florets. Very poor rate of bulb increase in sample (8%), but lifted bulbs had 18 per cent with rots.

Little Beauty Dwarf Division 1 daffodil with white perianth and yellow trumpet. Similar growing and flowering periods to Tête-à-Tête, only slightly taller and with slightly larger flowers. Reasonable bulb weight increase (87%).

Little Gem Dwarf, yellow Division 1 daffodil. Late to emerge (mid-February), but similar flowering period to Tête-à-Tête. Stem length and flower diameter similar to Tête-à-Tête. Moderate bulb weight increase (75%).

Little Witch Bright yellow cyclamineus narcissus, one floret per stem. Flowered 2 weeks after Tête-à-Tête. Taller than Tête-à-Tête, with larger florets. Only moderate bulb weight increase (52%), but 5% rotted bulbs at lifting.

Midget Very dwarf yellow daffodil, a form of *Narcissus nanus*. Late to emerge (mid-February), but flowering at same time as Tête-à-Tête. Much shorter than Tête-à-Tête, flower diameter similar. Poor rate of bulb increase (35%), but sample had 7 per cent of bulbs with rots at lifting.

Minnow Dwarf tazetta narcissus with two to three florets per stem, perianth creamy yellow with golden cup. Flowering about 2 weeks after Tête-à-Tête, shorter than Tête-à-Tête and with smaller florets. Moderate rate of bulb increase (72%) despite 11 per cent rotting in sample at lifting.

Narcissus obvallaris Dwarf yellow daffodil, late emerging (early-February) and flowering at similar time to Tête-à-Tête. Taller than Tête-à-Tête, florets of similar diameter. Good rate of bulb increase (131%).

Peeping Tom Yellow cyclamineus narcissus with one floret per stem. Emerging early (early-January), flowering at similar time to Tête-à-Tête. Taller than Tête-à-Tête, and much larger diameter florets. Only moderate bulb increase (50%).

Quince Cyclamineus narcissus with pale yellow perianth and deeper yellow cup, two to three florets per stem. Similar flowering characteristics to Tête-à-Tête, but somewhat shorter. Very poor rate of bulb increase (8%), but sample had 16 per cent of lifted bulbs rotted.

Rip van Winkle Dwarf, yellow double daffodil. Emerging after Tête-à-Tête, and flowering at about same time with shorter stems and larger florets. Moderate rate of bulb increase (62%), 3 per cent of lifted bulbs with rots.

Rippling Waters Creamy-white triandrus narcissus, about two florets per stem. Late to emerge (early-February), late flowering (mid-April). Shorter than Tête-à-Tête, florets larger. Moderate rate of bulb increase (59%), despite 11 per cent rotted bulbs in lifted sample.

Satellite Cyclamineus narcissus with bright yellow perianth and golden cup, one floret per stem. Very early to emerge (mid-December), flowering with Tête-à-Tête. Much longer stems, and larger florets, than Tête-à-Tête. Moderate rate of bulb increase (61%) despite 10 per cent of lifting bulbs with rots.

Sweetness Jonquilla narcissus with golden perianth and cup. Emerging in early-January and flowering two to three weeks after Tête-à-Tête. Tall, with larger florets than Tête-à-Tête. Quite good rate of bulb increase (108%) with little rotting (1%) in lifted sample.

Topolino Dwarf Division 1 daffodil with creamy white perianth and pale yellow trumpet. Emerging and flowering about same time as Tête-à-Tête, with longer stems and larger florets. Moderate rate of bulb increase (69%), with only low rate of rotting in lifted bulbs (1%).

Trena Cyclamineus narcissus with white perianth and yellow trumpet, one floret per stem. Flowering about two weeks after Tête-à-Tête, with taller stems and larger florets. Only moderate rate of bulb increase (53%), but lifted sample had 8 per cent of bulbs with rots.

W.P. Milner Pale yellow (white in descriptions) dwarf Division 1 daffodil, trumpet darker. Late emerging (early-February), flowering two to three weeks after Tête-à-Tête, with taller stems and larger florets. Moderate rate of bulb increase (70%), with 4 per cent rotting in lifted sample.

Winged Victory Cyclamineus narcissus with white perianth and yellow trumpet, one floret per stem. Flowering two to three weeks after Tête-à-Tête, with taller stems and much larger florets. Sample had 40 per cent rotted bulbs when lifted, hence bulb increase was negative.

Forced pot-plant trial

Flowering performance of the 19 cultivars tested (including three stocks of Tête-à-Tête) are shown in Table 12. The percentage of bulbs showing obvious disease symptoms or other disorders is shown in Table 13.

Tête-à-Tête Bulbs from the Kirton stocks produced two stems each, with the larger bulbs from the commercial stock giving three or four stems each; irrespective of bulb size, this cultivar gave only 1.1 to 1.2 florets per stem. Floret diameter was about 40 mm; stem length at flowering was about 210 mm, with considerable post-flowering stem extension (stem lengths of about 300 mm at senescence). Tête-à-Tête produced marketable pots within a few days of housing, and 'shelf-life' (from marketable stage to senescence) was 10 to 12 days. All three stocks gave a proportion of plants with obvious virus symptoms on the foliage: for the Kirton stocks the percentage affected was 4 or 18 per cent (despite the roguing carried out on stock 'B'), but for the commercial stock it was higher at 25 per cent.

Narcissus canaliculatus Produced dwarfer plants than Tête-à-Tête, with up to three florets per stem and a shelf-life of about 14 days. Glasshouse production period of about 10 days. Twenty-four per cent of the bulbs, however, produced blind shoots.

February Gold and February Silver Larger plants than Tête-à-Tête; similar production time in glasshouse, slightly longer shelf-life (13 to 15 days). About 6 stems per pot of five bulbs. The stock of February Silver had about 9 per cent of bulbs with obvious virus symptoms.

Hawera Similar height to Tête-à-Tête, but producing an average of 2.5 florets per stem and an average of 19 stems per pot over an extended period (22 day shelf-life). Three week

glasshouse period to marketable stage. Despite the high number of infloresences, 9 per cent of bulbs produced stems with necrotic buds.

Jack Snipe Taller than Tête-à-Tête, with an average of 11 stems per pot of five bulbs, and a longer shelf-life (16.5 days). The stock had 9 per cent of plants with obvious virus symptoms and 3 per cent with 'spikkels' characteristic of stem nematode infection.

Jenny Taller than Tête-à-Tête, slightly longer shelf-life (14 days). Average number of stems per pot of five bulbs was only 4, but 39 per cent of bulbs in the stock rotted. Three per cent of bulbs produced blind shoots, probably due to less advanced bulb rot.

Jetfire Similar stem length to Tête-à-Tête, although less post-flowering extension and therefore more compact at end of shelf-life. Produced an average of 15 stems per pot of five bulbs. Glasshouse production period similar to Tête-à-Tête, but longer shelf-life (15 days). However, over half the bulbs appeared to be rogues, and the stock exhibited 3 per cent with virus symptoms and 6 per cent with stem nematode.

Little Beauty and Little Gem Dwarfer than Tête-à-Tête, similar production period and shelf-life, but only five to six stems per pot. Three per cent of Little Beauty bulbs showed virus symptoms and four per cent of Little Gem produced blind shoots.

Midget Much dwarfer than Tête-à-Tête and usually producing only one stem per bulb, but similar floret diameter, production period and shelf-life. Three per cent of bulbs had virus symptoms, and five per cent yielded blind shoots.

Minnow Dwarfer than Tête-à-Tête at end of shelf-life, with averages of 2.2 florets per stem and 6.4 stems per pot of five bulbs. Similar production period and shelf-life. Ten per cent of bulbs gave blind shoots.

Narcissus obvallaris Slightly taller than Tête-à-Tête, with slightly longer shelf-life (13 days) despite single floret per stem and, on average, only 3.3 stems per pot. Thirty per cent of bulbs in sample gave blind shoots.

Rip van Winkle Slightly taller than Tête-à-Tête at flowering, but with little post-flowering stem extension. Similar production period, but longer, 16 day shelf-life. Only one viable stem per bulb, but 36 per cent of bulbs produced stems with dead buds.

Rippling Waters Taller than Tête-à-Tête, with up to two florets per stem. About 10 days in glasshouse to reach marketable stage, thereafter a longer shelf-life than Tête-à-Tête (15.5 days). Mean of 4.7 viable stems per pot, but 16 per cent of bulbs gave blind shoots.

Sweetness The tallest cultivar in the trial. Glasshouse production period about a week, but long shelf-life (19 days). Average of 4.2 stems per pot of five bulbs, but 10 per cent of bulbs gave blind shoots and 12 per cent rotted.

Topolino Dwarfer than Tête-à-Tête, similar production period and shelf-life, but only 4.9 stems per pot on average. Three per cent of bulbs gave blind shoots.

Trena Tall cultivar but producing an average of 8.3 stems per pot. Similar glasshouse production period to Tête-à-Tête, with longer shelf-life (15 days). Three per cent of bulbs with obvious virus symptoms.

W.P. Milner Taller than Tête-à-Tête, with similar production period and longer shelf-life (16 days). Produced 6 stems per pot on average.

DISCUSSION

Experiment 1 provided some useful recommendations on the agronomy of Tête-à-Tête bulb production. The variety is sensitive to HWT damage, with flower and foliage symptoms. Damage could be prevented by pre-warming at 30°C but not by storing at 18°C before HWT. Especially in two-year-down crops, however, bulb yield was little affected by omitting 30°C pre-warming. For good bulb production, with a 6 to 7 t/ha disposable yield and about half the lift in grades over 8 cm, planting at 5 to 10 t/ha and growing for two years is recommended. Trials at Rosewarne (ADAS, 1988a) showed a small yield advantage (after one year growing) using 30°C pre-warming (178% weight increase) compared with ambient storage before HWT (162% increase); growing in netting did not significantly reduce yields.

'Cyclataz' varieties, such as Tête-à-Tête, are less hardy than standard narcissus varieties because of their tazetta parentage. While this may not be a problem in the mild south-west of England, or even in the more continental climate of The Netherlands because crop covers (such as straw) are routinely used, it might be detrimental in eastern England in cold winters. In The Netherlands, sensitive varieties like Tête-à-Tête are recommended to have a thicker straw cover, and this may be left in place to reduce weeds and lower soil temperatures (van der Zwet *et al.*, 1990). In Experiment 2, winter crop covers were assessed for their effects on bulb yield. In both 1989/90 and 1991/92, non-covered plots gave greater bulb yields than covered plots, especially in the case of straw, which was the most effective covering material included. In the intervening year, 1990/91, straw (and other covers) did not reduce bulb yield. The experiment therefore showed no advantage of winter covers in these three years, which covered a range of winter temperature conditions (Table 14): in 1989/90 the January-February period was very mild, whereas in 1990/91 February was very cold, and in 1991/92 temperatures over the November to February period were similar to the 20-year averages. In mild winters there appeared to be a harmful effect of using a straw cover on bulb yield, possibly related to increased flower survival as covered plots produced more flowers than non-covered plots in these years.

Bulbs of Tête-à-Tête and other dwarf narcissus can be chipped successfully, although the incidence of disease (especially *Penicillium*) may be a problem. Methods are given, for example, in Hanks (1987, 1989) and van der Zwet *et al.* (1990). In Experiment 3, 14 to 18 per cent of incubated propagules rotted, while in the commercial stock chipped for Experiment 4, the figure reached 40 per cent. As an alternative to incubation, chips may be direct-planted after cutting, although direct-planting should be carried out early in the season. In the second chip trial, results from incubating and from direct-planting were similar when chips were cut in late-July, whereas mid-August (as used in the first trial) appeared to be too late, as soil temperatures soon become too low for bulbil production. A planting density around 5 t chipped bulbs/ha appears appropriate. Beneficial effects of a winter covering of

straw seemed doubtful, apart from weed suppression, which may be useful as chip crops are relatively sensitive to herbicide damage (ADAS, 1988b).

Bulb yields of Tête-à-Tête obtained in these trials were highly variable, perhaps as might be expected considering the range of stocks and bulb grades used and the variable (and sometimes very high) amount of disease encountered. In a well selected stock, however, a percentage weight increase of 150 might be reasonably expected over a two year growing cycle. Under normal field growing, narcissus bulbs increase in numbers by less than two-fold per annum, probably about 1.6-fold per annum, equivalent to 16 years to go from one bulb to a thousand bulbs (Rees, 1969). These weight and numerical increases have to be considered against rates from chipped crops. Dutch experience with chipping suggested an average of a nine-fold increase in bulb numbers for each chipping cycle of three years (from chipping to regaining bulbs of a marketable size), with a corresponding nine-fold weight increase (Vreeburg and van der Weijden, 1987). Although in the present trial chipped crops were not grown on for three years, three years from chipping to flowering or marketable size seems reasonable from other chipping experience at HRI Kirton, so that numerical and weight multiplication rates should be equivalent over a three year period (the numerical increase occurs at chipping while the weight increase builds up slowly). In the one- and two-year chipping experiments with Tête-à-Tête in the present project, numerical multiplication rates were lower, say four- or five-fold, but this is not unexpected with the levels of disease found. On a healthy stock, but still being conservative about multiplication rates, the figure of three- or four-fold per annum (nine- to twelve-fold over a three year cycle) suggested by Hanks and Rees (1979), and equivalent to between 6.5 and 5 years from one bulb to one thousand, is probably reasonable.

The stock and variety trial (Experiment 4) highlighted the need for stock improvement among dwarf narcissus varieties. Some stocks of Tête-à-Tête exhibited a high incidence of *Penicillium* infections, while samples of many of the other cultivars had unacceptably high levels of rotting, virus, bud necrosis, blindness or rogues, and at least six showed symptoms of stem nematode infestation.

The field trial of alternative cultivars showed few which produced percentage bulb increases within the range of those of the three Tête-à-Tête stocks (77 to 160%): those that did were *Narcissus canaliculatus*, February Gold, Little Beauty, *N. obvallaris*, and Sweetness, and several others approached these increases (Little Gem, Minnow, Topolino and W. P. Milner). A wide range of types was included in the trial, with varieties which would suit different purposes. Quince and Jumblie, siblings to Tête-à-Tête, both had poor rates of bulb increase in the samples used. Other cyclamineus types were generally taller and larger plants than Tête-à-Tête, flowering at the same time or somewhat later; only Itzim was comparable in height, although somewhat later flowering and larger in form. Among the dwarf Division 1 trumpet varieties included, Little Beauty had a similar flowering date to Tête-à-Tête and was only slightly larger: Little Gem and Topolino were larger, and W.P. Milner was also later flowering. Midget (Division 10) and Minnow (Division 8) were both much shorter than Tête-à-Tête, as was the scented *N. canaliculatus* which was late-flowering. The triandrus types Hawera and Rippling Waters were later to flower, the latter being shorter than Tête-à-Tête. *N. obvallaris* (Division 10) and Sweetness (Division 7) were taller than Tête-à-Tête, and Sweetness was later. Rip van Winkle (Division 4) was shorter and with larger florets.

Several of these varieties produced attractive pot-plants: important characteristics would be dwarfness, large number of flowers, and long shelf-life.

Disease and pest control aspects of growing Tête-à-Tête were not specifically dealt with in this project, but information is available in the Dutch literature. Miniatures like Tête-à-Tête are known to be susceptible to 'skin diseases' (Bergman *et al.*, 1978, p. 151-153), *Botrytis* and *Penicillium* (van der Weijden, 1989). When dealing with Tête-à-Tête, and probably other dwarf narcissus bulbs, handling procedures should be optimised: for example, physical damage should be minimised, drying should be in trays and with high air flows, offsets must be removed at least a week before HWT, late-HWT should be avoided, and formaldehyde in dips should be avoided because of crop sensitivity (Vreeburg, 1984; Anon., 1987; van der Weijden, 1989). Formaldehyde, which may slow the healing of wounds and encourage *Penicillium*, should, according to Dutch recommendations, be used with miniature narcissus in the HWT tank only at half-rate and only if basal rot is a problem in a stock (van der Zwet *et al.*, 1990); at Kirton, the full rate of formaldehyde has routinely been used without obvious ill effects, although this aspect has not been critically examined. Recent Dutch recommendations for fungicides in HWT tanks for dwarf varieties are captan or maneb/zineb (at higher rates than used for standard varieties) plus an MBC fungicide such as benomyl (van der Zwet *et al.*, 1990). Extensive recommendations have been published for using Tête-à-Tête as a forced pot-plant (Vreeburg & Korsuize, 1991; Vreeburg & Schipper, 1990; van der Weijden & Vreeburg, 1988): one important point is that bulbs should be dipped in a mixture of fungicides twice, once before storage and again at planting. Normal pest control would be required, bearing in mind the above provisos about the use of formaldehyde, but it should be noted that Tête-à-Tête bulbs may be preferred by large narcissus fly (Conijn & Koster, 1990; Collier, personal communication), meriting extra precautions.

ACKNOWLEDGEMENTS

The author thanks the staff of HRI-Kirton, especially Mr G P Clark, Mrs L J Withers and Mr R Asher, for skilfully carrying out these experiments; Miss S Hammond (HRI-Littlehampton) for statistical services; and Ing P.J.M. Vreeburg (Bulb Research Centre, Lisse, The Netherlands) for advice on suitable cultivars.

Work prior to April 1991 was funded by the Ministry of Agriculture, Fisheries and Food.

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Table 1 Areas (ha) of field-grown narcissus in England & Wales and in The Netherlands

	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93*
England and Wales Narcissus (total)	3616	4013	3721	4042	N/A	3826	3961	3972	3702	3930
The Netherlands Narcissus (total)	1542	1605	1620	1644	1680	1803	1799	1652	1533	1343
(of which) Yellow trumpets	476	453	423	398	385	407	406	374	348	288
Bicolour trumpets	20	18	17	18	21	24	27	30	31	28
White trumpets	14	14	15	15	15	17	16	16	18	17
Large-cups	689	737	752	772	752	760	756	664	592	473
Small-cups	44	40	39	36	36	39	39	35	31	27
Doubles	112	126	133	145	161	183	196	195	170	153
Triandrus	19	23	21	22	22	22	19	16	15	16
Cyclamineus	80	99	116	134	163	192	198	186	195	207
(of which Tête-à-Tête)	33	45	62	82	114	141	150	138	145	157
Jonquilla	19	17	15	16	15	18	20	21	23	23
Tazetta	40	43	43	47	54	59	63	62	58	57
Poeticus	4	4	4	4	4	4	5	6	5	6
Species, etc	5	7	3	3	3	3	4	6	6	6
Split-corona	8	11	13	20	28	34	35	30	30	27

Source: MAFF and PVS/BKD statistics. No figures available for England and Wales for 1987. Latest years figures may be provisional

Table 2 Experiment 4: details of cultivars used

Cultivar*	RHS class	Year introduced or registered	Bulb source	Bulb grade (cm)	100-bulb weight (kg)	Cultivars included in forcing trial
Beryl	6W-YYO	Pre-1907	Commercial	10-12	2.65	
N. canaliculatus	10W-Y	-	Commercial	8-10	2.00	+
February Gold	6Y-Y	Pre-1923	Kirton	12-14	2.42	+
February Silver	6W-W	Pre-1949	Commercial	12-14	3.16	+
Garden Princess	6Y-Y	Pre-1938	Commercial	14-16	6.86	
Hawera	5Y-Y	Pre-1928	Commercial	8-10	1.85	+
Itzim	6Y-R	1982	Commercial	10-12	3.28	
Jack Snipe	6W-Y	Pre-1951	Commercial	10-12	3.34	+
Jenny	6W-W	Pre-1943	Commercial	10-12	1.46	+
Jetfire	6Y-O	1966	Commercial	14-16	5.87	+
Jumblie	12Y-O	Pre-1952	Commercial	8-10	1.76	
Larkwhistle	6Y-Y	1960	Commercial	14-16	6.96	
Little Beauty	1W-Y	Pre-1953	Commercial	8-10	0.97	+
Little Gem	1Y-Y	1938	Commercial	8-10	1.63	+
Little Witch	6Y-Y	Pre-1921	Commercial	12-14	2.67	
Midget	10Y-Y	1984	Commercial	8-10	1.33	+
Minnow	8Y-Y	1962	Commercial	10-12	1.76	+
N. obvallaris	10Y-Y	-	Commercial	8-10	1.22	+
Peeping Tom	6Y-Y	pre-1948	Commercial	14-16	5.96	
Quince	12Y-Y	Pre-1953	Commercial	12-14	2.89	
Rip van Winkle	4Y-Y	Pre-1885	Commercial	8-10	1.73	+
Rippling Waters	5W-W	Pre-1932	Commercial	10-12	1.91	+
Satellite	6Y-O	1952	Commercial	12-14	4.33	
Sweetness	7Y-Y	Pre-1939	Commercial	10-12	1.94	+
Tête-à-Tête A	12Y-Y	Pre-1949	Kirton A	9-11	1.20	+
Tête-à-Tête B	12Y-Y	Pre-1949	Kirton B	9-11	1.42	+
Tête-à-Tête C	12Y-Y	Pre-1949	Commercial	10-12	2.47	+
Topolino	1Y-Y	1965	Commercial	8-10	2.07	+
Trena	6W-Y	1971	Commercial	12-14	3.80	+
W.P. Milner	1W-W	Pre-1869	Commercial	8-10	1.70	+
Winged Victory	6W-Y	1961	Commercial	14-16	7.26	

*Classification and names checked against the International Daffodil Checklist and subsequent supplements (Kington, 1989) and the Abridged List of Daffodil Names (Throckmorton, 1989).

Table 3 Experiment 1 (1989-91): effect of HWT regime, planting density and one- and two-year-down growing on flower production in cv Tête-à-Tête

Planting density (t/ha)	Storage and HWT regime	Growing years	1991 results		1992 results	
			Stems (no./plot)	Stem length(mm)	Stems (no./plot)	Stem length(mm)
5	Ambient	1	21.7	127	-	-
		2	26.0	131	82.3	158
	18°C	1	25.0	121	-	-
		2	17.0	111	67.7	152
	30°C	1	31.7	137	-	-
		2	34.0	127	85.7	162
10	Ambient	1	53.0	149	-	-
		2	52.0	141	144.7	195
	18°C	1	40.7	138	-	-
		2	43.3	136	144.7	179
	30°C	1	73.3	144	-	-
		2	69.3	142	128.7	176
15	Ambient	1	88.3	155	-	-
		2	79.3	134	198.7	226
	18°C	1	52.7	133	-	-
		2	54.0	125	166.3	193
	30°C	1	96.3	153	-	-
		2	88.3	150	211.7	181
20	Ambient	1	92.7	145	-	-
		2	96.3	148	245.0	208
	18°C	1	85.7	152	-	-
		2	71.0	149	199.0	200
	30°C	1	121.3	159	-	-
		2	109.1	153	223.3	208
SED			8.44 (46 df)	9.2 (46 df)	16.47 (22 df)	17.3 (22 df)
Significance of						
Density			***	***	***	***
Regime			***	***	*	NS
Years			NS	NS	-	-

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 4 Experiment 1 (1989-91): effect of HWT regime, planting density and one- and two-year-down growing on bulb yield in cv Tête-à-Tête.

Planting density (t/ha)	Storage and HWT regime	Growing years	Per cent weight increase	Disposable yield (t/ha)	% lifted weight in grades >8 cm	Bulbs lifted (no./plot)	% lifted bulbs in grades >8 cm	Additional rotted bulbs at harvest
5	Ambient	1	40	2.02	57	50	32	1
		2	131	6.54	55	72	31	0
	18°C	1	61	3.03	69	46	40	1
		2	96	4.78	45	65	24	0
	30°C	1	66	3.29	55	55	30	0
		2	149	7.46	51	85	28	0
10	Ambient	1	43	4.25	50	101	28	1
		2	67	6.71	44	127	24	0
	18°C	1	29	2.89	56	93	29	4
		2	76	7.61	53	119	31	0
	30°C	1	36	3.64	52	98	26	4
		2	65	6.51	49	126	27	0
15	Ambient	1	16	2.37	52	132	27	1
		2	23	3.42	38	156	21	0
	18°C	1	13	1.93	55	116	30	7
		2	10	1.45	34	147	15	0
	30°C	1	24	3.64	54	135	29	3
		2	28	4.23	44	160	21	0
20	Ambient	1	11	2.28	52	178	26	3
		2	12	2.30	33	197	17	0
	18°C	1	8	1.58	50	167	26	6
		2	-3	-0.53	39	167	20	0
	30°C	1	7	1.36	48	173	25	6
		2	4	0.86	36	186	18	0
SED (46 df)			16.9	1.388	7.3	15.8	5.0	-
Significance of								
Density			***	***	***	***	***	-
Regime			NS	NS	NS	NS	NS	-
Years			***	***	***	***	***	-

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 5 Experiment 2 (1989-1990): effect of covering materials on bulb yields in cv Tête-à-Tête. Values in parenthesis are log-transformed data used for statistical analyses

Cover	Total bulb yield			Yield in grades >8cm		Rotted bulbs
	% weight increase	Weight (kg/plot)	Number (no./plot)	Weight (kg/plot)	Number (no./plot)	Number (no./plot)
None	26	1.77	250(2.40)	0.63	42(1.62)	4
Polythene (perforated)	12	1.56	257(2.41)	0.42	30(1.48)	5
Polythene (unperforated)	13	1.58	251(2.40)	0.41	30(1.47)	5
Straw	9	1.53	250(2.40)	0.42	30(1.46)	4
Wheat	16	1.63	254(2.40)	0.51	36(1.55)	5
SED (12 df)	5.2	0.072	(0.018)	0.051	(0.050)	-
Significance	*	*	NS	**	*	-

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 6 Experiment 2 (1990-1991 and 1991-1992 trials): effect of covering materials on flower production and bulb yields in cv Tête-à-Tête. Values in parenthesis are log-transformed data used for statistical analyses.

Cover	Stems per plot	Stem length (mm)	Total bulb yield			Yield in grades >10cm		Rotted bulbs (no./plot)
			% weight increase	weight (kg/plot)	Number (no./plot)	Weight (kg/plot)	Number (no./plot)	
1990-1991 trial								
None	153(2.18)	186	88	2.86	146(2.16)	1.65	42(1.63)	1
Polythene (perforated)	155(2.19)	207	106	3.14	116(2.04)	2.27	46(1.66)	2
Polythene (unperforated)	160(2.20)	201	92	2.92	147(2.15)	1.69	40(1.59)	6
Straw	156(2.19)	220	86	2.82	154(2.18)	1.39	35(1.54)	3
Wheat	155(2.19)	187	72	2.61	158(2.19)	1.53	42(1.62)	2
SED (12 df)	(0.020)	10.0	11.7	0.177	(0.081)	0.307	(0.032)	-
Significance	NS	*	NS	NS	NS	NS	*	-
1991-1992 trial								
None	187(2.27)	139	52	2.30	78(1.89)	1.84	42(1.62)	0
Polythene (perforated)	201(2.30)	160	43	2.17	90(1.95)	1.60	39(1.59)	0
Polythene (unperforated)	216(2.33)	171	42	2.16	91(1.95)	1.51	37(1.57)	0
Straw	221(2.34)	179	28	1.95	88(1.94)	1.32	36(1.55)	1
Wheat	190(2.27)	144	51	2.30	96(1.98)	1.61	40(1.59)	0
SED (8 df)	(0.032)	6.4	4.2	0.063	(0.023)	0.106	(0.035)	-
Significance	NS	***	**	**	*	*	NS	-

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 7 Experiment 3 (1991-1993): effect of straw covers and planting density on plant growth and bulb yield in direct-planted and incubated chipped crops of cv Tête-à-Tête. Separate statistical analyses were carried out for incubated and direct-planted treatments.

Production method	Planting density (t/ha)	Cover	1992 leaf count (no./plot)	1993 plant density score +	1993 flower count (no./plot)	Bulb yield per plot	
						Number	Weight (kg)
		Straw (removed)	349	4.0	19	137	0.49
		Straw (left)	180	3.3	19	108	0.37
	5.0	None	330	4.0	32	183	0.62
		Straw (removed)	454	4.0	35	208	0.69
		Straw (left)	463	4.7	36	203	0.62
	7.5	None	379	4.3	30	208	0.59
		Straw (removed)	578	5.0	36	298	0.90
		Straw (left)	384	4.3	51	285	0.82
SED (16 df)			114.8	0.83	12.8	63.9	0.237
Significance of							
Density			*	*	*	**	*
Cover			NS	NS	NS	NS	NS
Direct-planted	2.5	None	34	1.7	3	25	0.05
		Straw (removed)	6	1.0	1	11	0.02
		Straw (left)	15	1.0	2	24	0.05
	5.0	None	37	2.0	2	45	0.10
		Straw (removed)	63	1.7	1	43	0.08
		Straw (left)	55	1.7	5	55	0.11
	7.5	None	77	2.0	4	55	0.10
		Straw (removed)	68	2.3	2	75	0.14
		Straw (left)	57	1.3	3	64	0.09
SED (16 df)			32.4	0.56	2.3	26.6	0.055
Significance of							
Density			*	NS	NS	*	NS
Cover			NS	NS	NS	NS	NS

+scored from 0 to 5, representing no plants, few plants, 10, 50, 75 and 100% cover, respectively.

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 8 Experiment 3 (1992-1993): effect of straw covers on plant growth and bulb yield in direct-planted and incubated chipped crops of cv Tête-à-Tête

Production method	Cover	1993 leaf count (no.plot)	Bulb yield (per plot) Number	Weight (kg)
Incubated	None	484	210	0.35
	Straw (removed)	315	172	0.26
	Straw (left)	451	195	0.31
Direct-planted	None	333	262	0.47
	Straw (removed)	155	202	0.28
	Straw (left)	222	175	0.21
SED (15 df)		109.6	42.0	0.086
Significance of				
Method		*	NS	NS
Cover		NS	NS	NS

NS, not significant; *, ** and ***, significant at the 5, 1 and 0.1 per cent levels of probability, respectively; - indicates not applicable.

Table 9 Experiment 4 (1992/93): flowering performance of bulbs of Tête-à-Tête and other varieties in field trial

Cultivar	Dates (day no. of 1993)				Stems	Mean	Florets	Mean
	First emergence	First flower	50% flowers	Full flower	per 100 bulbs	stem length (mm)	/stem	floret diam (mm)
Beryl	6	82	84	92	156	246	1.0	73
N. canaliculatus	54	92	105	108	76	135	2.7	33
February Gold	6	71	73	74	118	284	1.0	81
February Silver	19	71	74	78	96	267	1.0	95
Garden Princess	19	76	78	82	196	281	1.0	88
Hawera	19	108	110	113	204	200	2.4	45
Itzim	33	82	84	92	160	150	1.0	73
Jack Snipe	26	82	84	92	191	230	1.0	74
Jenny	40	82	84	92	100	252	1.0	88
Jetfire	6	71	74	78	218	211	1.0	70
Jumblie	6	71	74	78	208	165	1.9	57
Larkwhistle	6	76	78	82	223	291	1.0	90
Little Beauty	19	71	74	82	89	170	1.0	56
Little Gem	47	74	78	82	117	160	1.0	46
Little Witch	26	82	90	92	116	229	1.0	77
Midget	47	74	76	78	120	83	1.0	44
Minnow	26	82	90	92	118	128	2.3	30
N. obvallaris	40	76	78	82	74	216	1.0	53
Peeping Tom	6	68	74	78	238	389	1.0	95
Quince	19	71	78	82	400	125	2.6	50
Rip van Winkle	33	74	78	82	129	157	1.0	71
Rippling Waters	40	98	103	106	104	157	1.9	72
Satellite	-16	74	76	78	184	312	1.0	80
Sweetness	6	82	92	97	77	307	1.0	65
Tête-à-Tête A	21	69	74	78	153	158	1.1	46
Tête-à-Tête B	19	68	74	78	169	155	1.0	47
Tête-à-Tête C	21	71	74	78	243	161	1.2	51
Topolino	26	68	74	78	103	206	1.0	66
Trena	26	82	84	92	176	186	1.0	87
W.P. Milner	40	82	92	97	110	203	1.0	66
Winged Victory	26	84	92	97	60	205	1.0	101

Table 10 Experiment 4 (1992/93): bulb yields of Tête-à-Tête and other varieties in field trial

Cultivar	Bulbs lifted (weight, kg)	% weight increase	Bulbs lifted (number)	% bulbs with rots
Beryl	4.2	58.9	243	2.4
N. canaliculatus	4.1	103.3	384	1.3
February Gold	4.3	78.9	163	4.7
February Silver	4.5	40.8	145	6.5
Garden Princess	10.0	46.3	242	0.0
Hawera	2.5	32.4	248	0.0
Itzim	1.7	4.3	132	7.7
Jack Snipe	2.5	-26.6	247	17.9
Jenny	1.4	-6.5	102	30.6
Jetfire	7.9	33.7	230	0.4
Jumblie	2.0	11.4	187	13.4
Larkwhistle	7.5	8.1	180	17.8
Little Beauty	1.8	87.1	216	0.5
Little Gem	2.8	75.1	313	0.6
Little Witch	4.1	52.2	200	4.8
Midget	1.8	35.3	262	7.1
Minnow	3.0	71.6	268	11.3
N. obvallaris	2.8	131.1	298	0.3
Peeping Tom	8.8	49.7	188	1.1
Quince	3.1	8.1	296	16.1
Rip van Winkle	2.8	61.8	181	3.2
Rippling Waters	3.0	59.1	145	11.0
Satellite	7.0	61.4	196	9.7
Sweetness	4.0	108.0	174	1.1
Tête-à-Tête A	3.1	160.3	167	8.3
Tête-à-Tête B	3.2	122.8	209	10.1
Tête-à-Tête C	4.4	76.6	245	6.5
Topolino	3.5	68.5	287	1.4
Trena	5.8	52.7	166	7.8
W.P. Milner	2.9	69.7	187	3.6
Winged Victory	2.6	-59.0	87	40.0

Table 11 Experiment 4 (1992/93): Performance of two Tête-à-Tête stocks as chipped bulbs in field trial

Stock	Incubation results			
	No. bulbils per chip	Mean length (mm)	% Chips rotted	
Commercial	0.51	8.68	40.33	
Kirton	0.63	9.07	12.00	
	Field results (per plot)			
	Leaf number	Mkt. bulb number	Mkt. bulb weight (kg)	Rotted bulb no.
Commercial	308.00	118.00	0.24	16.00
Kirton	785.33	367.67	0.62	42.67

Table 12 Experiment 4 (1992/93): Performance of Tête-à-Tête and other cultivars as forced pot-plants

Cultivar or stock	No. stems /pot	Stem length (mm) Flowering	Stem length (mm) Senescence	No. florets /stem	Floret diam (mm)	Dates (day no.)* Marketable	Dates (day no.)* Flowering	Dates (day no.)* Senescence	Shelf life(d)
Tête-à-Tête A	9.4	208	303	1.1	39	24	29	34	9.9
Tête-à-Tête B	10.0	206	297	1.2	40	24	29	34	10.1
Tête-à-Tête C	17.5	206	290	1.2	41	24	31	35	11.6
N. canaliculatus	3.8	177	262	2.8	24	31	40	45	13.8
February Gold	6.8	323	385	1.0	79	25	30	38	13.2
February Silver	5.1	226	357	1.0	82	25	30	40	14.6
Hawera	19.2	234	300	2.5	38	37	51	59	21.7
Jack Snipe	11.3	307	380	1.0	62	25	35	42	16.5
Jenny	4.3	282	350	1.0	69	27	35	41	13.7
Jetfire	15.2	217	275	1.0	60	25	33	40	14.9
Little Beauty	5.1	162	240	1.0	53	25	30	36	11.0
Little Gem	6.1	158	235	1.0	46	25	30	37	12.1
Midget	5.5	110	170	1.0	42	26	30	38	12.0
Minnow	6.4	233	298	2.2	25	29	35	40	11.0
N. obvallaris	3.3	239	328	1.0	51	26	32	39	13.2
Rip van Winkle	5.0	255	269	1.0	50	25	37	41	15.7
Rippling Waters	4.7	332	395	1.8	65	31	40	46	15.5
Sweetness	4.2	356	449	1.0	52	28	38	47	18.6
Topolino	4.9	197	277	1.0	64	23	28	34	10.1
Trena	8.3	313	377	1.0	77	35	45	50	15.1
W.P. Milner	6.0	271	319	1.0	56	25	35	41	15.6

*Note that bulbs were moved to the glasshouse on day 20, except for cv Trena which was moved on day 33.

Table 13. Experiment 4 (1992/93): pest, disease and disorder symptoms in plants in the forced pot-plant trial

	Percentage of bulbs with symptoms					
Cultivar or stock	Virus	Bulb rot	Dead buds	Blind shoots	Stem nematode	Rogue
Tête-à-Tête A	4	0	0	0	0	0
Tête-à-Tête B	18	2	0	0	0	0
Tête-à-Tête C	25	0	0	0	1	0
N. canaliculatus	2	0	0	24	0	0
February Gold	1	0	0	0	0	0
February Silver	9	2	0	2	0	0
Hawera	0	0	9	0	1	0
Jack Snipe	9	0	0	0	3	1
Jenny	1	39	0	3	0	0
Jetfire	3	1	0	0	6	60
Little Beauty	3	2	0	2	0	0
Little Gem	0	0	0	4	0	0
Midget	3	0	0	5	0	1
Minnow	0	0	2	10	0	0
N. obvallaris	2	2	0	30	0	0
Rip van Winkle	0	0	36	1	0	0
Rippling Waters	0	0	0	16	0	0
Sweetness	0	0	12	10	0	0
Topolino	1	0	0	3	1	0
Trena	3	0	0	0	1	0
W.P. Milner	2	0	0	1	0	0

Table 14 Mean monthly winter screen temperatures (°C) for the years of Experiment 2

Month	1989/90	1990/91	1991/92	20-year mean (as at 1990/91)
November	6.2	6.6	6.2	6.2
December	5.0	4.5	4.0	4.6
January	6.2	3.1	3.0	3.2
February	7.2	1.4	5.2	3.8

Fig.1 Experiment 2 (1989-1990)
Daily average soil temperatures at bulb depth

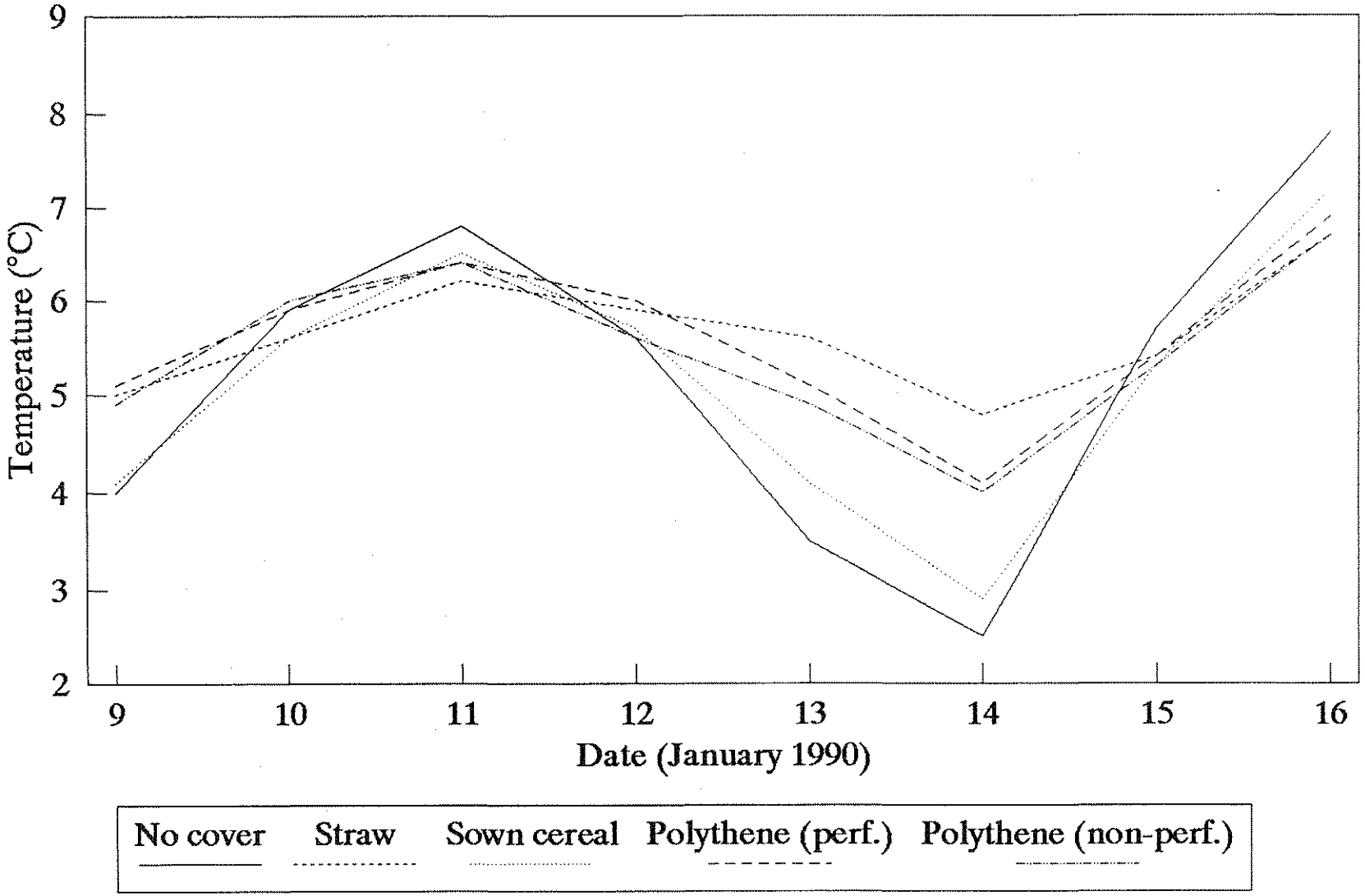


Fig.2 Experiment 2 (1989-1990)
Daily minimum soil temperatures at bulb depth

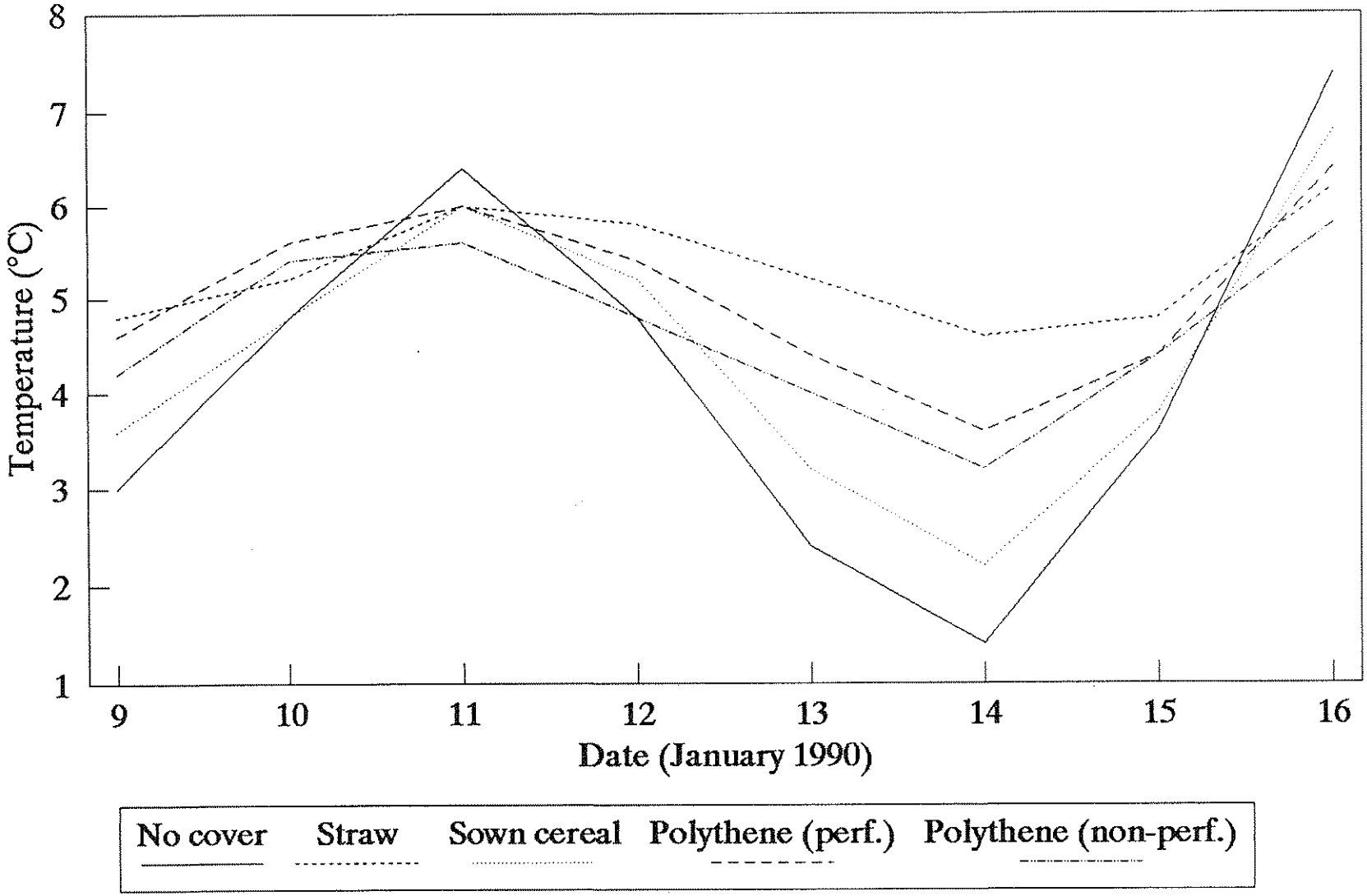


Fig.3 Experiment 2 (1989-1990)
Daily maximum soil temperatures at bulb depth

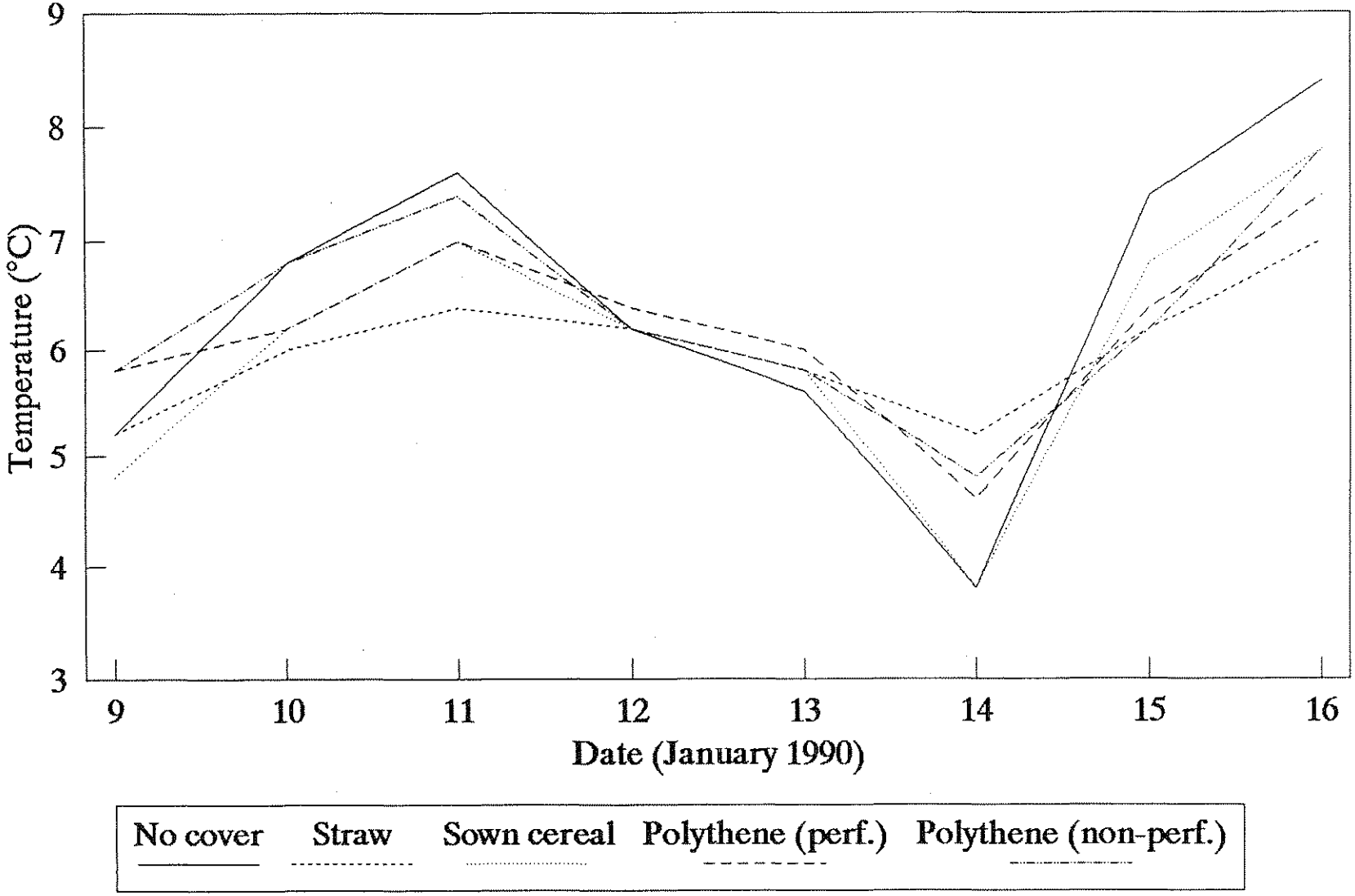
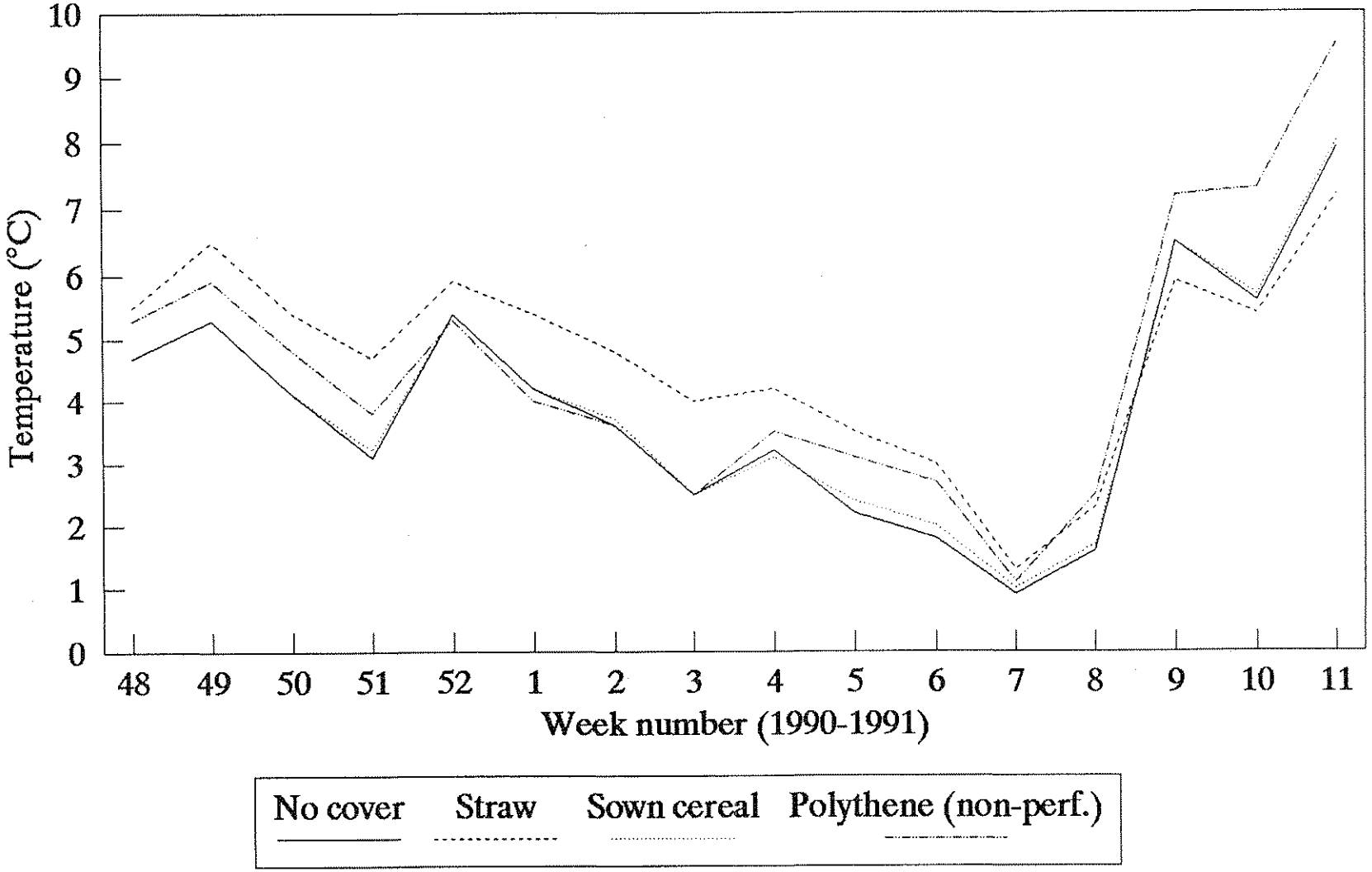
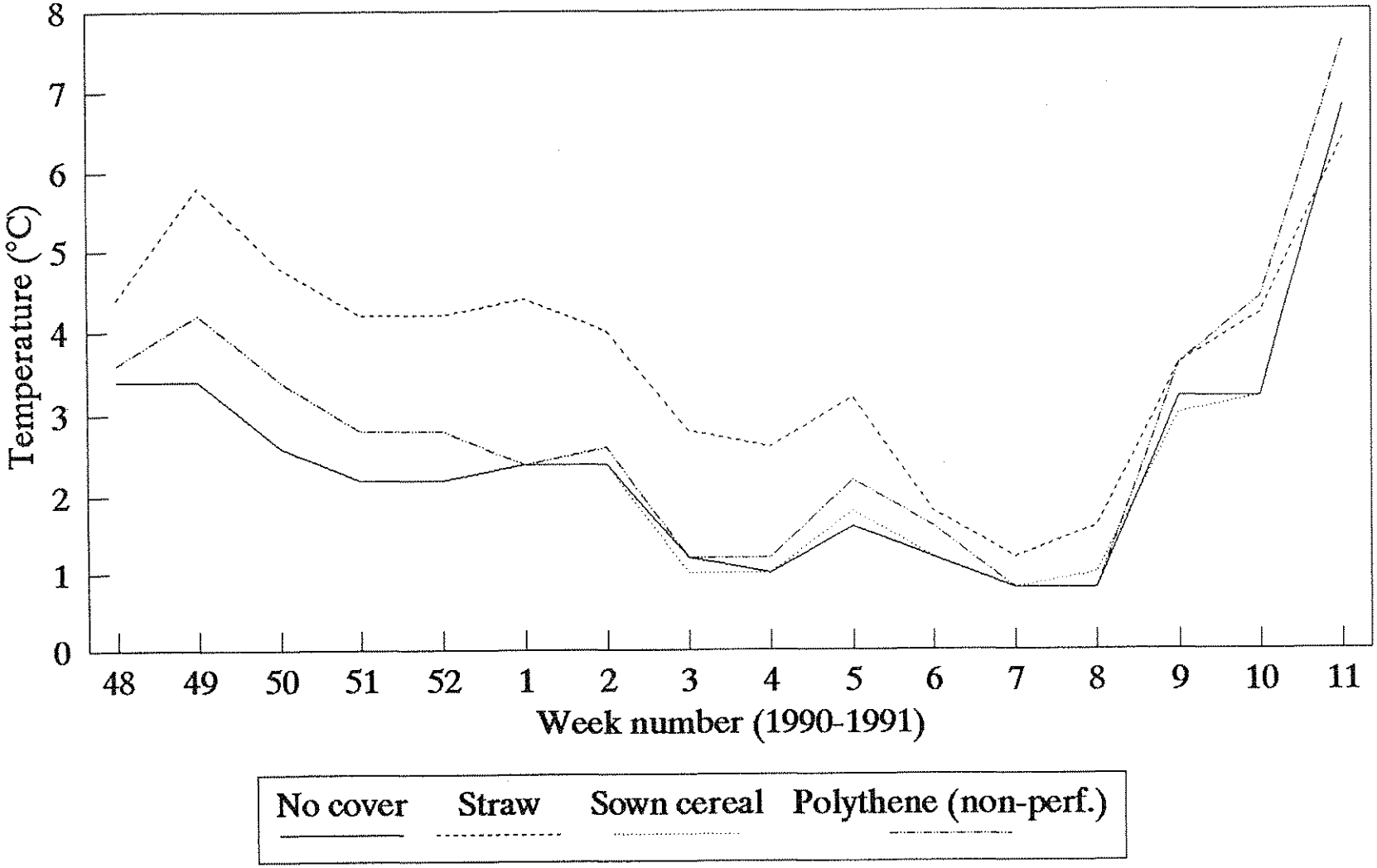


Fig.4 Experiment 2 (1990-1991)
Weekly average soil temperatures at bulb depth



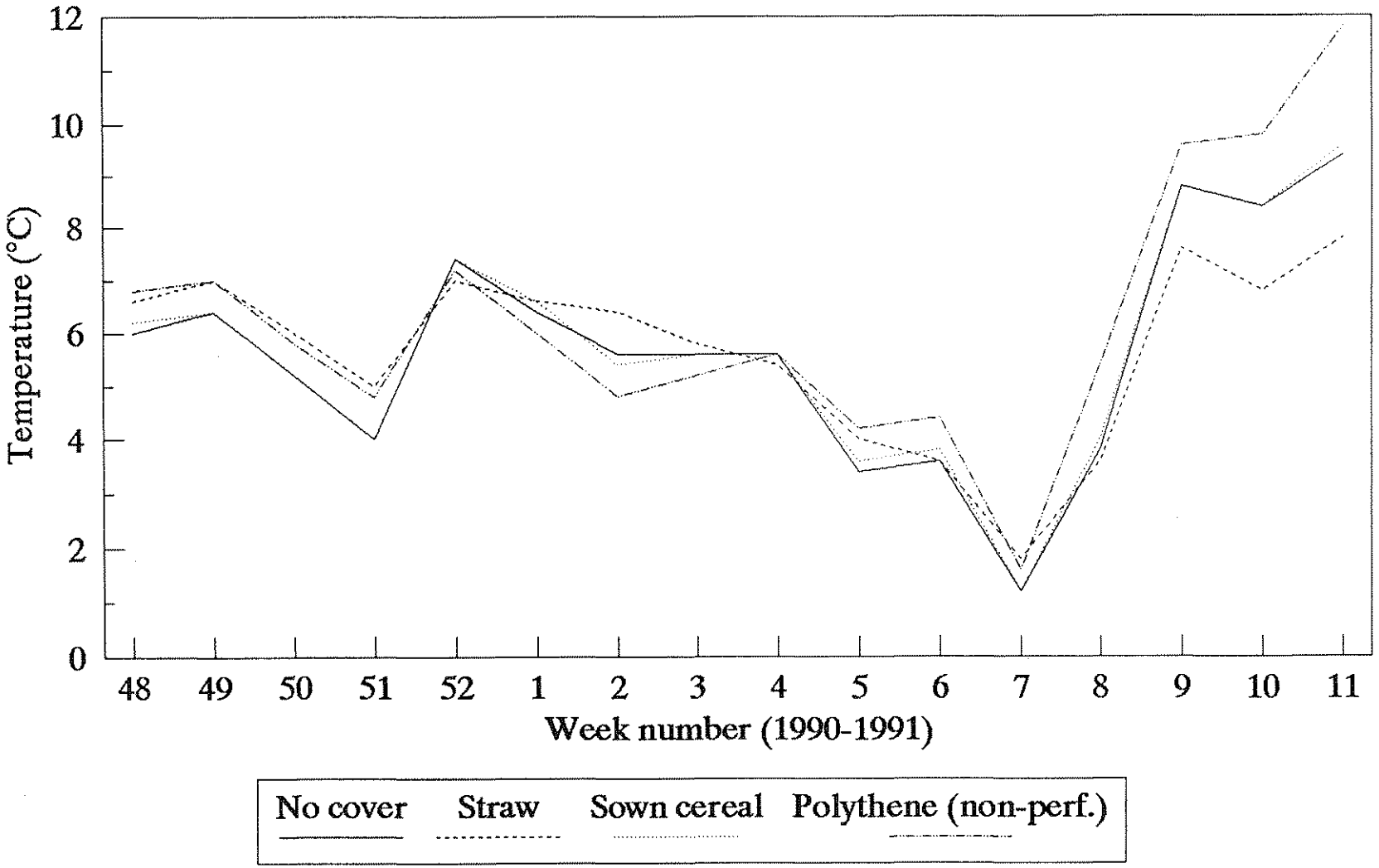
No readings available for perforated polythene

Fig.5 Experiment 2 (1990-1991)
Weekly minimum soil temperatures at bulb depth



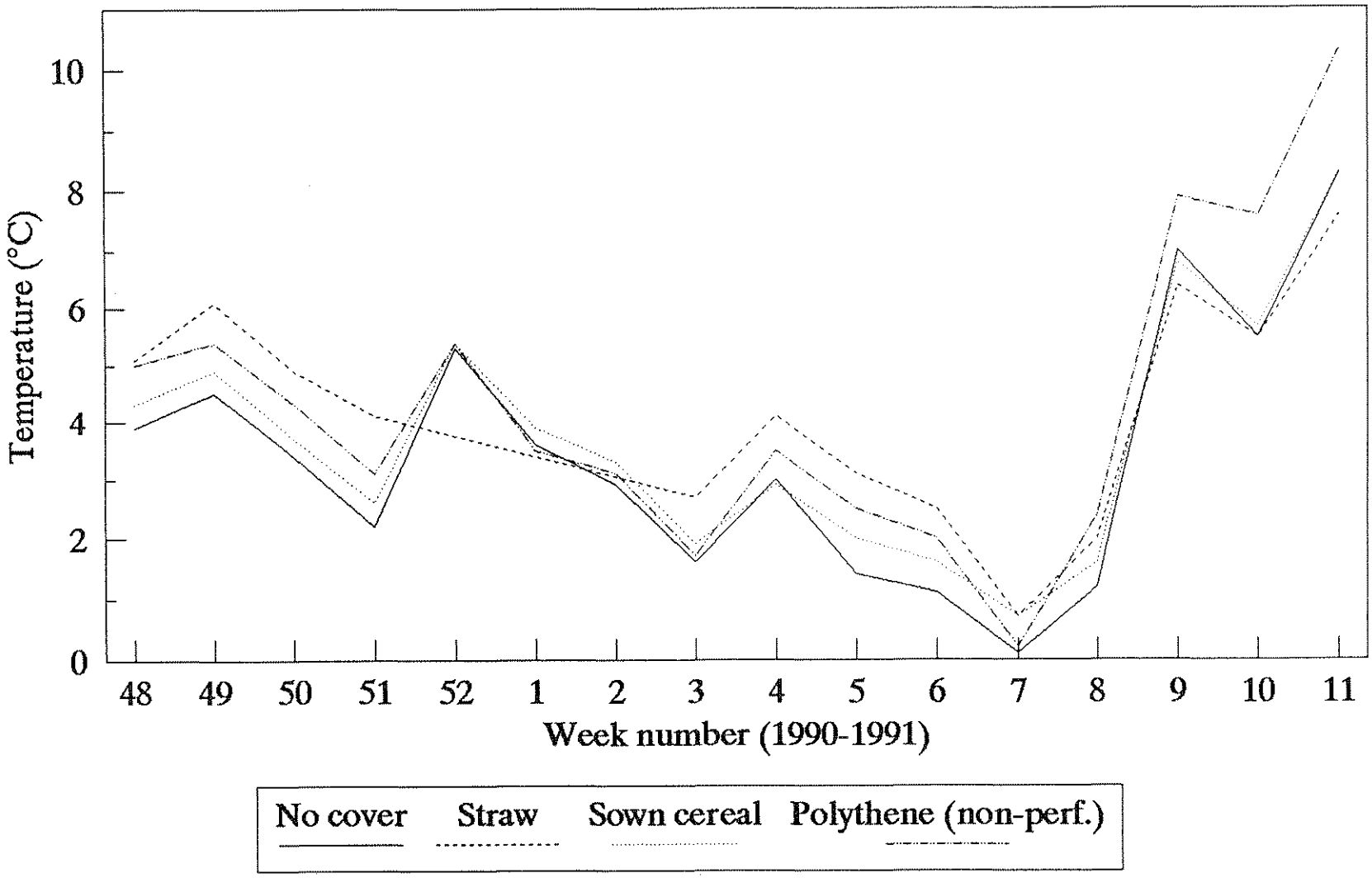
No readings available for perforated polythene

Fig. 6 Experiment 2 (1990-1991)
Weekly maximum soil temperatures at bulb depth



No readings available for perforated polythene

Fig.7 Experiment 2 (1990-1991)
Weekly average soil temperatures at ½ bulb depth



No readings available for perforated polythene

Fig.8 Experiment 2 (1991-1992)
Weekly average soil temperatures at bulb depth

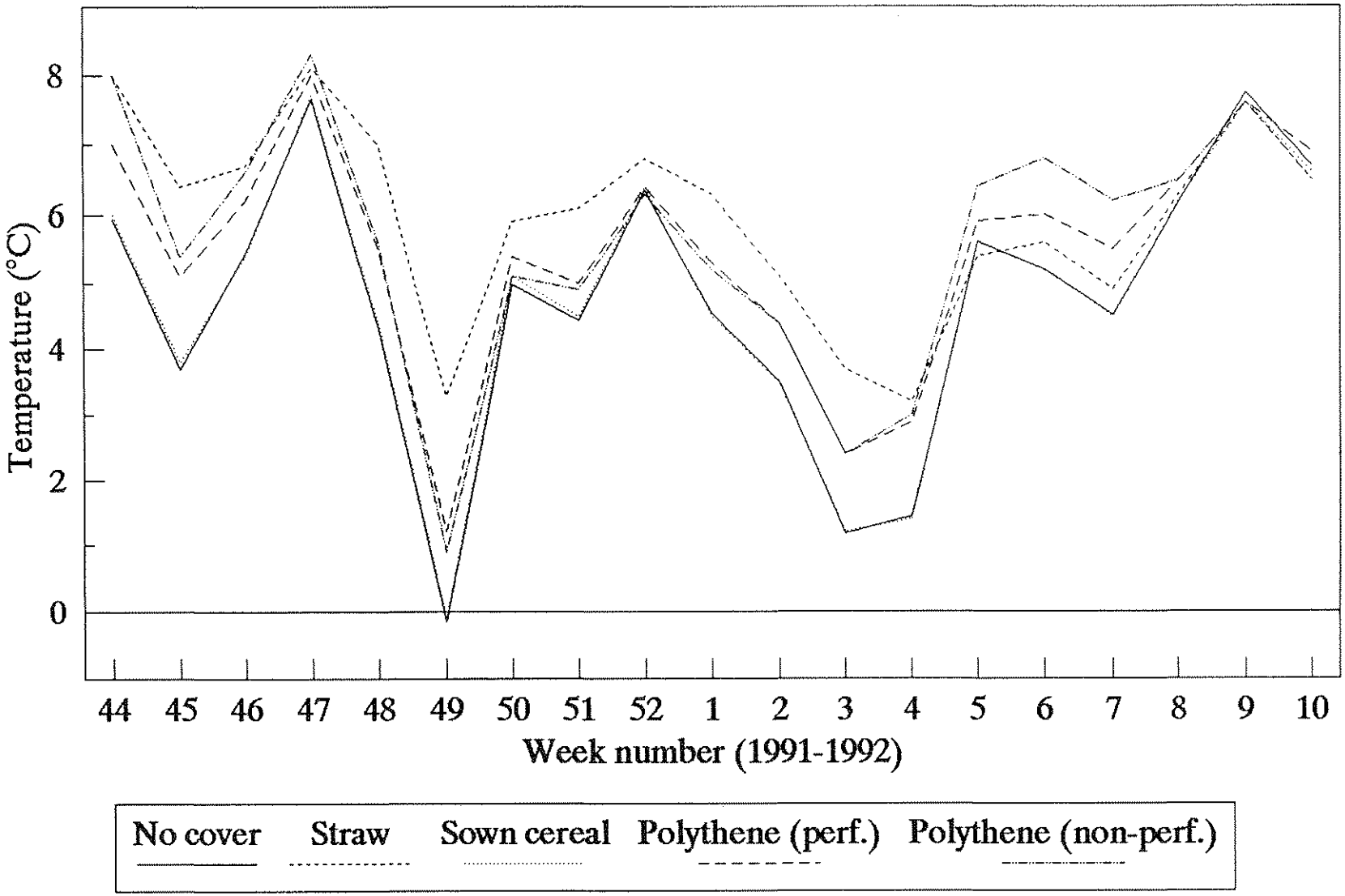


Fig.9 Experiment 2 (1991-1992)
Weekly minimum soil temperatures at bulb depth

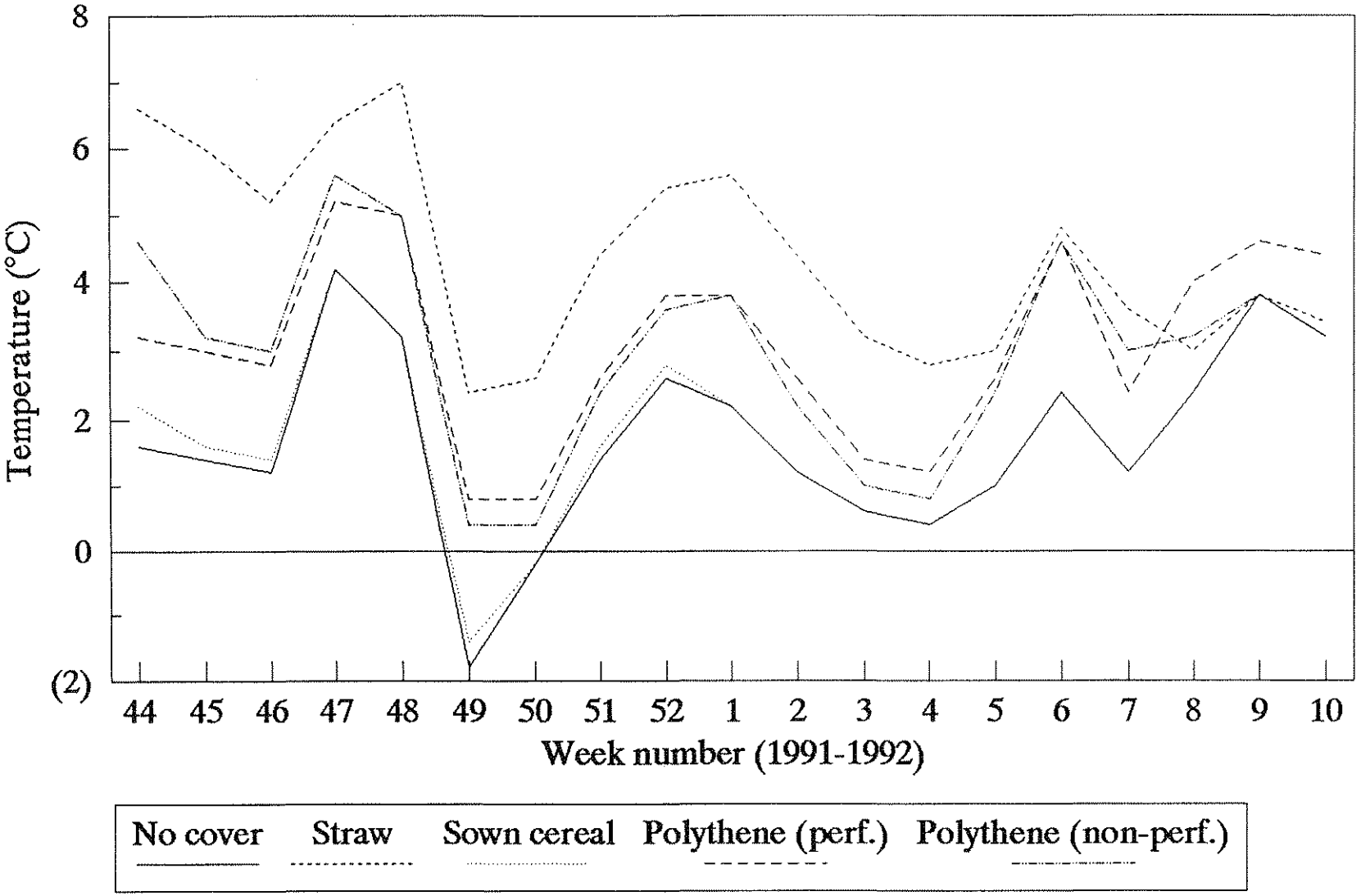


Fig.10 Experiment 2 (1991-1992)
Weekly maximum soil temperatures at bulb depth

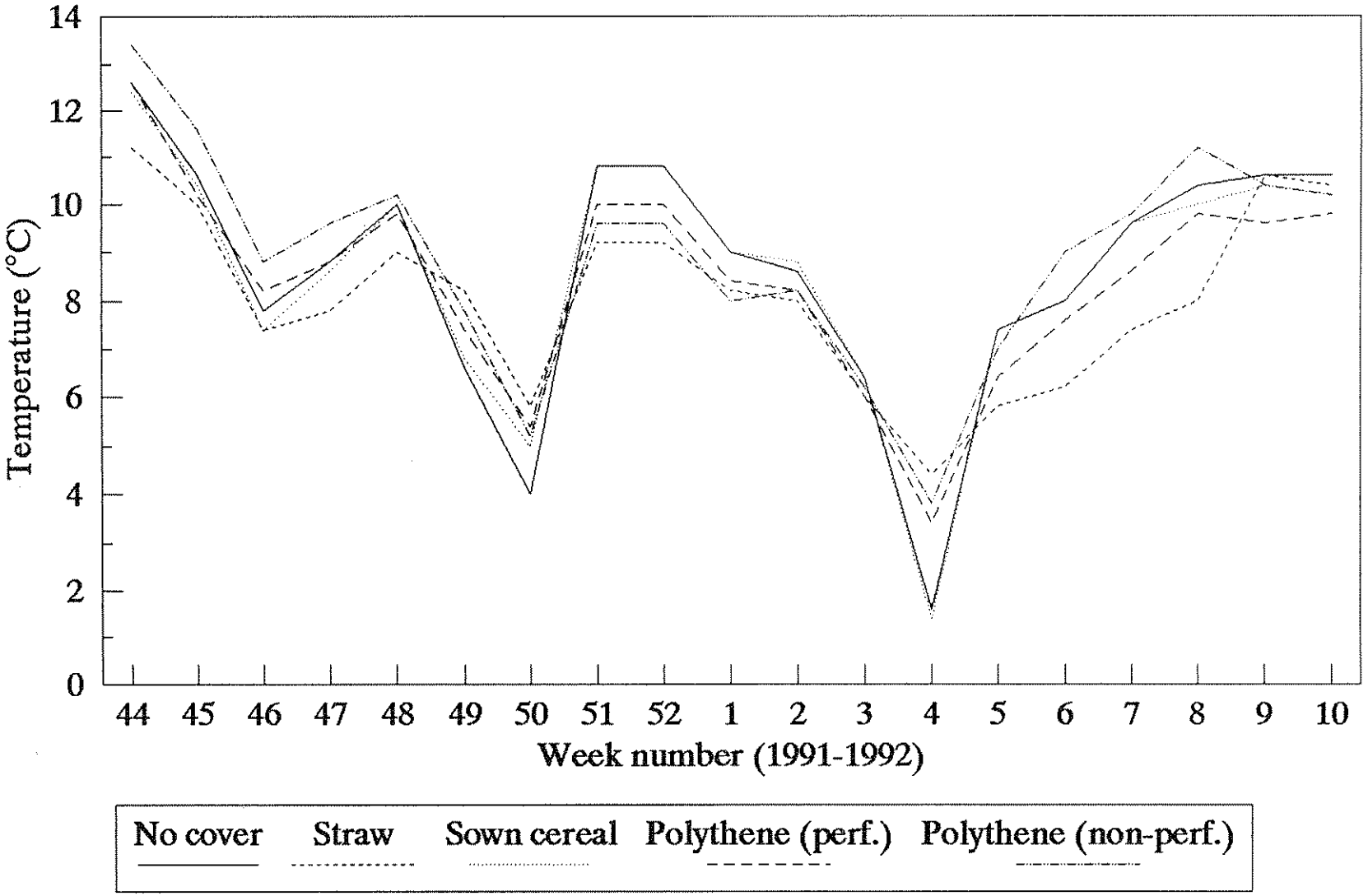


Fig.11 Experiment 3 (1991-1992)
Weekly average soil temperatures at bulb depth

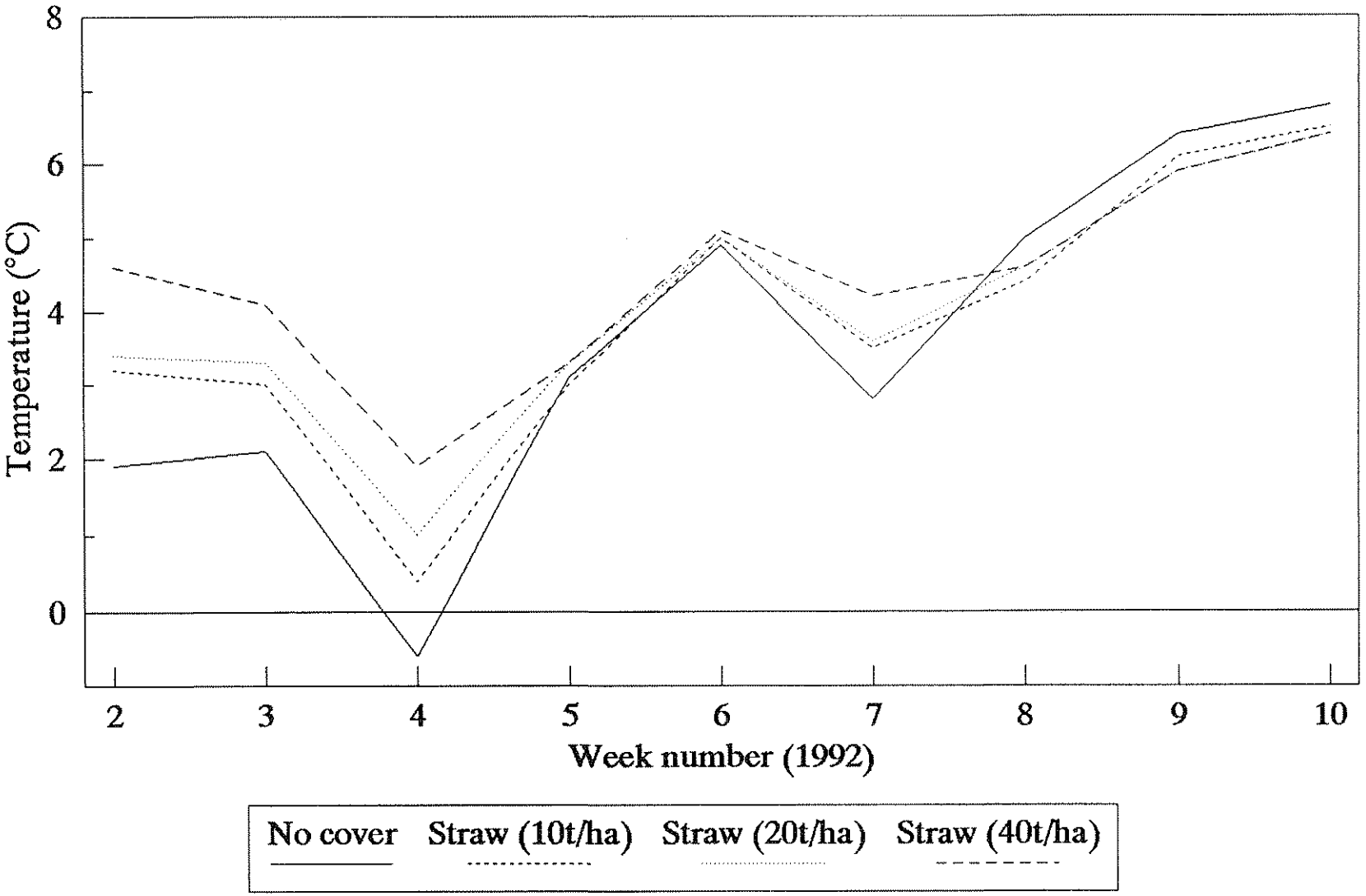


Fig.12 Experiment 3 (1992-1993)
Weekly soil temperatures at bulb depth