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AUTHENTICATION

We declare that this work was done under our 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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For accurate reporting, pesticides have generally been referred to by the name of the commercial product. No endorsement is intended of products mentioned, nor criticism of those not mentioned.

PRACTICAL SECTION

Objectives and background

Neck rot affects a significant number of narcissus stocks. Three pathogens - *Fusarium oxysporum* f.sp. *narcissi* (the basal rot fungus), *Penicillium* spp. and *Botrytis narcissicola* (the smoulder fungus) - have been implicated in the disorder. The aims of the project were:

- to identify which pathogens or combinations of pathogens are important in causing neck rot
- to identify crop husbandry practices that influence neck rot
- to investigate selected treatments with fungicides and disinfectants which could be useful in controlling the disorder around the time of bulb lifting

Summary of results

Field experiments on the causes and control of narcissus neck rot were carried out at Kirton, Lincs., from 1995 to 1998, using varieties Carlton and Dutch Master. In the first three years' experiments, despite inoculating damaged, defoliated shoots with highly concentrated spore and mycelial suspensions of *Fusarium oxysporum* f.sp. *narcissi*, *Botrytis narcissicola* and *Penicillium hirsutum*, only a very low incidence of neck and other bulb rots were found when the treated bulbs were subsequently stored and assessed. These experiments confirmed that *Fusarium* was the most effective pathogen of the three in inducing bulb rots. In some cases pre- or post-lifting fungicide treatments controlled bulb rots to some extent, but with such low incidences of rots, the effects were difficult to demonstrate conclusively, and they were not consistent enough to give firm recommendations.

For the final experiment in the series, in 1998, a number of technical changes were made in the procedures used, aimed at making disease development more effective. For example, pathogen inocula were applied at greater rates to the defoliated shoot bases, defoliation was carried out by removing foliage close to the bulb neck, and bulbs were not allowed to dry rapidly after harvesting. Treatments were applied in the second year of crops. Spray inocula of *Fusarium* spore suspensions were applied to crop foliage in April, May or June, or on all three dates, and mycelial inoculum (found to be more effective in some laboratory experiments) were also tested by application in June. Half of the experimental plots had flowers cropped as normal, and the other half were not cropped. Half of the plots received a regular fungicide spray programme (benomyl) from April to June, and the other half did not. In mid-June, foliage was removed by flailing (well above the soil surface) or 'top-bashing' (well into the soil, close to the bulb neck) and the cut stumps were sprayed with *Fusarium* spore inoculum or were left untreated. Bulbs were lifted one week after defoliation. One set of bulbs was bisected immediately, and the number and type of bulb rots was recorded. Half of each remaining plot was dipped, immediately after lifting, in thiabendazole plus formaldehyde, and the other half was untreated. Bulbs were then stored at 25°C and 80% relative humidity, and rots were assessed 4 and 8 weeks later.

There were some very clear conclusions from this experiment:

- almost all rots found in the assessment immediately after lifting were early-stage neck rots
- more advanced neck rot and some basal rot (mostly in Dutch Master) were found at the 4-week assessment

- many rots identified at 8 weeks were whole bulb rots
- a post-lifting dip in fungicide reduced the incidence of bulb rots by 80-90% when assessed 4 and 8 weeks later, compared with non-dipped bulbs
- more neck rot (and other rots generally) occurred in non-cropped than in cropped plots
- more neck rot (and other rots generally) occurred in plots which had received a regular fungicide spray programme than in those that had not
- flower cropping, combined with omitting a foliar fungicide spray programme, reduced the rot-enhancing effects of some other treatments (such as top-bashing and inoculation)
- more neck rot (and other rots generally) occurred in plots that had been severely top-bashed and inoculated
- applying a spray of pathogen spore suspension in April, May or June, or at all three dates, or of pathogen mycelium suspension (tested only in June), increased the amount of bulb rots, particularly when other factors predisposed the bulbs to rots (giving a regular fungicide spray programme and (or) not cropping)
- top-bashing and inoculating invariably produced much more of all types of bulb rots than any other treatment combinations; flailing and inoculation caused fewer rots, often less than if foliage was left intact until lifting

The findings support the hypothesis that pathogen entry via the shoot damaged by top-bashing (but not generally when damaged by milder flailing), leads to neck (and other) bulb rots. However, this occurs only when other conditions pre-dispose the bulbs to rots, i.e. giving an extended foliar fungicide spray programme and (or) not cropping flowers. Importantly for bulb growers, a prompt post-lifting bulb dip, a treatment long recommended for controlling bulb rots, was highly effective in reducing the subsequent development of neck rot. Pre- and post-lifting fungicide sprays, as used in the early experiments, were generally much less effective.

Action points for growers

To reduce neck and other bulb rots in daffodil bulbs, the following procedures are recommended:

- flower cropping (or de-heading)
- restriction of fungicide foliar sprays, especially towards the end of the growing season
- defoliation of crops by flailing, but not by top-bashing
- post-lifting dipping in fungicide
- rapid bulb drying

Practical and financial benefits from study

This project has generated a great deal of information about what does and does not increase levels of neck rot in two important commercial cultivars, Carlton and Dutch Master. Several crop husbandry practices have been identified that, alone or more often in combination, if avoided or modified will reduce neck (and other) rots. Evaluation of all the experimental data has allowed a number of recommendations to be proposed which should minimise the incidence of neck and other bulb rots.

The dramatic reduction of all types of storage rots after a post-lifting dip in thiabendazole reinforces the value of this protective treatment.

EXPERIMENTAL SECTION

Introduction

Neck rot of daffodils has been a periodical concern to UK bulb growers over the last 20 years. Although often over-shadowed by more serious and more obvious attacks of basal rot, losses due to neck rot continue to occur, and the disorder affects a wider range of varieties than basal rot. The background to neck rot was reviewed in an earlier levy-funded report (Project BOF 31; Linfield & Hanks, 1994).

Several fungi have been implicated as causes of neck rot in narcissus. In a survey conducted from 1980 to 1984, the two main organisms found were *Fusarium oxysporum* f.sp. *narcissi* (the cause of basal rot) and a *Penicillium* species, each of which caused a distinctive type of rot (Linfield, 1990). In later work funded by the HDC, several fungi were isolated from neck rot tissue, the three most common genera being *Penicillium*, *Fusarium* and *Botrytis* (Project BOF 28; Davies, 1994). In these samples, *Penicillium* was isolated on its own on only one occasion, and in no instance was *Botrytis* isolated alone. The pathogenicity of other isolated fungi was not tested. More recent research has confirmed that neck rot, or perhaps more accurately the 'neck rot complex', involves three main pathogens, *F. oxysporum* f.sp. *narcissi*, *Botrytis narcissicola* (the cause of smoulder) and *Penicillium* spp., and that all three rarely occur together (Carder, 1997a).

The survey conducted by Linfield (1990) suggested that an increase in neck rot occurred when 'top-bashing' (mechanical removal of the foliage to the extent that the top layer of the ridge soil is removed) was followed by a delay of several days before bulbs were lifted. This increase may well have resulted from damaged shoot tissues becoming infected by soil- or débris-borne fungi. Neck rot appears to have become more common in recent years despite the adoption by bulb growers of routine, and sometimes heavy, fungicide spray programmes. This increase is coincident with earlier lifting dates, usually before foliage has senesced naturally, and with the removal of 'green' foliage by mechanical means or acid sprays. There is certainly a need to determine the most effective crop management strategy to minimise neck rot. This may well include combinations of chemical controls and modified crop husbandry practices.

More recent research (Carder, 1997b) has demonstrated that three bulb pathogens, viz. *Fusarium oxysporum* f.sp. *narcissi*, *Penicillium hirsutum* and *Botrytis narcissicola,* can all cause neck rot in artificial inoculations but that *Fusarium* is the most virulent. This work has also shown that *Fusarium* is the pathogen most frequently isolated from neck rots. However, considerable uncertainty still exists over the relative importance of each of these pathogens as causal agents of neck rot either independently or with two or more acting together as a pathogen complex. Similarly, conflicting results on the effects on neck rot of bulb handling and crop husbandry factors and on the frequency of isolation of each of the three pathogens from commercial bulbs have been reported (Davies, 1994; Davis *et al.*, 1998).

Strategic work on the aetiology and epidemiology of neck rot is currently being funded by MAFF, to enable targets and control opportunities to be more clearly identified. The aims of the present HDC-funded project are to identify the important pathogens and to determine the efficacy of certain physical and chemical control measures. Since the MAFF and HDC projects are closely integrated, the present report includes the results of experiments not only seeking effective fungicide treatments to control neck rot, but also investigating the effects of applied pathogens. This final report on the project describes field experiments carried out over the 1995 to 1998 period. In the earlier years of this work, it proved difficult to induce significant levels of neck rot, even when pathogens were applied to damaged bulb tissue in the field. To encourage the development of disease, higher rates of inoculum were used in later experiments, severe leaf damage was caused by defoliation prior to the inoculation of pathogens, and bulbs were stored after lifting in conditions that did not lead to too rapid bulb drying. Using these means, and incorporating other treatments, much larger amounts of all bulb rots were produced in the 1998 experiment.

A series of laboratory-based bulb inoculation experiments was completed ahead of the main 1997 and 1998 field experiments, using forced bulbs which had flowered and begun to senesce. These bulbs were predicted to be in a similar physiological state to field grown bulbs just before lifting, and the results from this work also provided useful clues to developing appropriate treatments to use in the field experiments. When the bulb necks were severely damaged by cutting through the leaf bases and solid inocula (i.e., a mixture of fungal mycelium and spores growing on agar) or spore suspensions were applied immediately, faster and more extensive neck rots developed in response to the solid inoculum. Other studies with these bulbs demonstrated that neck rots could only be induced if bulb necks were wounded before inoculum application. The temperature at which these wounded bulbs were stored affected the rate at which neck rots progressed but did not alter the overall incidence of rots. Relative humidity (RH) did not appear to influence rate or total numbers of rots. Under standard conditions (25°C, 60% RH) neck rots occupied approximately two-thirds of the bulb volume after four weeks' storage. Successful infection was influenced markedly by inoculum concentration.

Materials and methods

Inoculum production

Methods of inoculum production were modified as the project developed.

1995 and 1996 experiments

Spore suspensions of *Fusarium oxysporum* f.sp. *narcissi* (strains GCRI-X and LVB Na2), *Penicillium hirsutum* (strains IMI 212083, IMI 29205 and IMI 91943) and *Botrytis narcissicola* (strains MUCL 2120, MUCL 18861, MUCL 21380 and Kirton-A) were prepared by growing *Fusarium* cultures on Potato Sucrose Agar and *Botrytis* and *Penicillium* isolates on Potato Dextrose Agar (PDA) for 14 days at 20°C. Spores were washed from the plates with sterile distilled water containing 0.001% polyoxyethylene sorbitan monolaurate (Tween 20), and the number of spores per ml was estimated on a Fuchs Rosenthal haemocytometer.

1997 and 1998 experiments

Spore suspensions of *F. oxysporum* f.sp. *narcissi* (strains GCRI-X and LVB Na2) were prepared by growing the two isolates as liquid shake cultures in Czapek–Dox medium for 7 days at 20°C on an orbital shaker. Spores were harvested by filtration through muslin to remove mycelium which was retained for production of 'solid' inoculum. A top-drive macerator was used to disrupt the fungal hyphae which were dispersed in distilled water._Spore concentrations were determined as before. Spore suspensions of *P. hirsutum* (strains IMI 212083, IMI 29205 and IMI 91943) were produced from PDA plate cultures grown for 14 days at 20°C (used in 1997 only). Plates were washed with sterile distilled water and spore concentrations determined as before.

For the supplementary treatments of the 1998 experiment, spore suspensions of *Fusarium* were used as described above. Spore inoculum of two *Penicillium* isolates (DM320 and DM309, originally isolated from neck rots in Dutch Master) and two *Botrytis narcissicola* isolates (C455 and C462, from neck rots in Carlton) was prepared from PDA plate washings to give 0.6×10^6 spores/ml.

Plant material

1995 experiment

Standard plots of *Narcissus* cultivar Carlton were available at HRI Kirton at the start of this project, and were used in a preliminary experiment in 1995. Bulbs of HRI stocks, grade 12-14 cm (circumference, slotted riddle), had been planted in 2.5 m long plots of 25 bulbs each, surrounded by guard plots, on 19 September 1993.

1996 – 1998 experiments

Bulbs of *Narcissus* cultivars Carlton and Dutch Master, 12-14 cm grade, were purchased locally and planted in 1995 and 1996 for experiments in the following years.

In 1995 bulbs were planted as weighed, 10 kg lots in 7.5 m long plots (equivalent to a planting density of 17.5 t/ha) on 19 September. For each cultivar there were 60 plots (20 plots in each of three randomised blocks) for treatment and lifting in 1996 (one-year-down plots), and 60 plots for treatment and lifting in 1997 (two-year-down plots). Additional 'guard areas' were planted at the end of plots and in the ridges between plots; guards for the ends of plots were planted in netting (Netlon 'Oriented 1') to distinguish them from the bulbs in the plots themselves.

In 1996 bulbs for a further experiment were planted on 17 September. For each cultivar there were 120 plots (40 plots in each of three randomised blocks). These were all grown for two years and experimental treatments were applied in 1998. Other planting details were as in 1995.

Crop husbandry

In all cases the basic crop husbandry followed the standard commercial practices for the area. Before planting, bulbs received standard hot-water treatment (4 hours at 44.4°C) in thiabendazole, formaldehyde and non-ionic wetter, all at recommended rates. Fertilisers were applied according to analysis and MAFF recommendations (nitrogen as a top dressing pre-emergence, potash in the base pre-planting). Weed control was by dormant season diquat + paraquat, pre-emergence cyanazine and post-emergence chlorpropham + linuron, all used according to standard recommendations. No routine fungicide sprays were applied in the field, other than the experimental treatments specified below. Flowers were not cropped, except in the specified treatments of the 1998 experiment.

Experimental fungicide sprays were applied to individual plots, using either a precision sprayer or a knapsack sprayer (at a standard pressure), as specified in the text. Medium spray quality nozzles were used for fungicide and related applications, and coarse spray quality nozzles for pathogen applications.

Bulbs were harvested by elevation to the surface with a single-row bulb lifter, then picking bulbs by hand into standard bulb trays (lined with paper) or net bags. Prior to lifting, bulbs were mechanically defoliated according to treatment: 'flailing' refers to removal of the foliage usually to just above the soil surface, while 'top-bashing' refers to foliage removal by flailing into the ridge top so that some soil was displaced and a greater amount of foliage removed than with 'flailing'.

Experimental treatments

1995 experiment

Crop foliage was flailed-off to leave about 2 cm above the soil surface, on 28 June 1995, when foliage was becoming senescent (pale green and flaccid). On the same day plots were inoculated with suspensions of *Fusarium oxysporum* f.sp. *narcissi*, *Botrytis narcissicola* and *Penicillium hirsutum*, alone or in combination, or were left untreated (as controls). Inoculation was made using a hand-operated sprayer to drench the stumps of the cut foliage. Some plots were sprayed at double rates.

Twenty-four hours after inoculation plots were either left unsprayed (as controls) or were sprayed with one of the following fungicides:

- thiabendazole (as 5 litres Storite Clear Liquid (260 g a.i./litre; MSD Agvet) per 1000 litres)
- prochloraz (as 2 kg Fisons Octave (46% a.i. w/w; Levington Horticulture) per 1000 litres)
- captan (as 5 kg PP Captan 80 WG (80% a.i. w/w; Zeneca Crop Protection) per 1000 litres)

Sprays were carried out using a precision sprayer, applying 100 ml spray per plot as a directed spray to the cut foliage or foliage base.

There were 23 treatment combinations, as shown in the following table, each applied to three plots in a completely randomised layout:

Ref.	Pathogen	Fungicide
1	None	None
2	None	Thiabendazole
3	None	Prochloraz
4	None	Captan
5	*Penicillium*	None
5a	*Penicillium* (double rate)	None
6	*Penicillium*	Thiabendazole
7	*Penicillium*	Prochloraz
8	*Penicillium*	Captan
9	*Botrytis*	None
9a	*Botrytis* (double rate)	None
10	*Botrytis*	Thiabendazole
11	*Botrytis*	Prochloraz
12	*Botrytis*	Captan
13	*Fusarium*	None
13a	*Fusarium* (double rate)	None
14	*Fusarium*	Thiabendazole
15	*Fusarium*	Prochloraz
16	*Fusarium*	Captan
17	*Penicillium* + *Botrytis*	None
18	*Penicillium* + *Fusarium*	None
19	*Botrytis* + *Fusarium*	None
20	*Botrytis* + *Fusarium* + *Penicillium*	None

The bulbs were lifted on 12 July 1995 and stored in trays at 18°C. Bulb rots were assessed on 11-12 September 1995. About 60 bulbs were harvested from each plot, after the separation of offsets (Table 1).

1996 experiment

The one-year-down plots planted in 1995 were used for the experiment in 1996. There were 20 treatments with three replicates each.
One group of fungicide treatments was applied as foliar sprays on 13 June 1996:

- thiabendazole to treatments 13 and 16 (as 5 litres Storite Clear Liquid in 1000 litres/ha)
- prochloraz to treatments 14 and 17 (as 2 kg Fisons Octave in 1000 litres/ha)
- peroxyacetic acid (PAA) to treatment 15 (as 8 litres Jet 5 (5% a.i., Hortichem) in 1000 litres/ha)

6 days later (19 June) all treatments, except treatment 1, had the foliage and top 2-5 cm of soil removed by top-bashing. However, as this left rather variable amounts of exposed shoot tissue for accurate spray applications, the top 2 cm of soil was then raked from the ridges manually

and shoots were then cut off just above the soil surface using a 'strimmer'. At this stage senescence was still incomplete and some green colour remained in the foliage, especially in Dutch Master. Treatments 13, 14 and 15 (see above) received a second spray of thiabendazole, prochloraz or PAA, respectively, using the same concentrations as before, but applying 400 ml of spray per plot in a band over the cut shoots.

Pathogens were also applied on 19 June, using the following amounts per plot:

- 1 litre of distilled water to treatment 2
- 1 litre of *Fusarium* inoculum containing 2.5×10^6 spores/ml to treatment 3
- 1 litre of *Botrytis* inoculum containing 1.6×10^6 spores/ml to treatment 4
- 1 litre of *Penicillium* inoculum containing 4.6×10^6 spores/ml to treatment 5
- 1 litre of a mixture containing 1.25×10^6 *Fusarium* spores/ml and 8.0×10^5 *Botrytis* spores/ml to treatment 6
- 1 litre of a mixture containing 1.25×10^6 *Fusarium* spores/ml and 2.3×10^6 *Penicillium* spores/ml to treatment 7
- 1 litre of a mixture containing 8.0×10^5 *Botrytis* spores/ml and 2.3×10^6 *Penicillium* spores/ml to treatment 8
- 1 litre of a mixture of containing 8.4×10^5 *Fusarium* spores/ml, 1.5×10^6 *Penicillium* spores/ml and 5.3×10^5 *Botrytis* spores/ml to treatments 9 to 12 and 16 to 20

One day later, on 20 June, the mixture of the three fungi (as above) was applied at the rate of 1 litre per plot to treatments 13, 14 and 15.

All fungicide and spore suspension sprays in the field were applied with a precision sprayer.

The trials area was irrigated with 6 mm water on 21 June and again on 24 June, to assist survival of the applied pathogens and as an aid to disease development.

On 26-27 June 1996 all bulbs were lifted. On the same day as lifting, bulbs received dip or spray treatments as follows:

- formaldehyde dip (5 litre commercial formalin (containing 38-40% a.i.)/1000 litre) for treatment 10
- thiabendazole and formaldehyde dip (5 litre Storite Clear Liquid plus 5 litres commercial formalin/1000 litres) for treatment 11
- prochloraz and formaldehyde dip (2 kg Fisons Octave plus 5 litres commercial formalin/1000 litres) for treatment 12
- thiabendazole spray (1 litre Storite Clear Liquid in 5 litre spray per tonne bulbs) for treatment 18
- prochloraz spray (400 g Fisons Octave in 5 litres spray per tonne bulbs) for treatment 19
- PAA spray (40 ml Jet 5 in 5 litres spray per tonne bulbs) for treatment 20

All dips were at ambient temperatures for 15 minutes, with added non-ionic wetter (310 ml/1000 litres). Sprays were applied over a roller table, using hydraulic spray nozzles mounted inside a spray hood.

The following is a summary of the 20 treatments:

Ref.	Pathogen inoculation (19 June, except 13,14 and 15 which were 20 June)	Fungicide treatment		
		Pre top-bash (13 June)	Post top-bash (19 June)	Post-lifting (26-27 June)
1	None (not top-bashed)	-	-	-
2	None (water spray)	-	-	-
3	*Fusarium* (F)	-	-	-
4	*Botrytis* (B)	-	-	-
5	*Penicillium* (P)	-	-	-
6	F + B	-	-	-
7	F + P	-	-	-
8	B + P	-	-	-
9	F + B + P	-	-	-
10	F + B + P	-	-	Formaldehyde dip
11	F + B + P	-	-	Thiabendazole dip
12	F + B + P	-	-	Prochloraz dip
13	F + B + P	Thiabendazole spray	Thiabendazole spray	-
14	F + B + P	Prochloraz spray	Prochloraz spray	-
15	F + B + P	PAA spray	PAA spray	-
16	F + B + P	Thiabendazole spray	-	-
17	F + B + P	Prochloraz spray	-	-
18	F + B + P	-	-	Thiabendazole spray
19	F + B + P	-	-	Prochloraz spray
20	F + B + P	-	-	PAA spray

After lifting and treatment all bulbs were placed in trays, surface-dried at ambient temperatures by fans, and stored at 18°C. Samples of 50 bulbs per plot were assessed for rots on 4 September 1996, and the remainder on 16 October 1996.

1997 experiments

The two-year-down plots planted in 1995 were used for the experiment in 1997. Treatments consisted of various combinations of pathogen inoculations and fungicide sprays, given before or after different defoliation treatments. A distinct series of treatments was applied to each cultivar, for each of which there were 20 treatments with three replicates each.

<u>Carlton</u> The aim of the experiment was to discover whether natural levels of neck rot in the crop could be either controlled by applying a fungicide before or after defoliation, or augmented by

pathogen inoculation prior to defoliation. Five fungicide/inoculation treatments were applied across four defoliation treatments. The fungicide/inoculum treatments were:

- untreated (control)
- sprayed with thiabendazole fungicide one week before defoliation
- sprayed with thiabendazole fungicide one day after defoliation
- inoculated with *Fusarium* and *Penicillium* spore suspension one week before defoliation
- inoculated with *Fusarium* mycelial macerate one week before defoliation

The defoliation treatments were:

- untreated, i.e. foliage not removed (control)
- flailed off
- flailed off then covered with polythene film
- burnt off

<u>Dutch Master</u> The aim of the treatments was to discover whether neck rot could be produced by pathogen inoculation before or after defoliation, and if a fungicide treatment at about the same time would control the applied pathogen. Five fungicide/inoculum treatments were applied across four defoliation treatments. The fungicide/inoculum treatments were:

- untreated (control)
- inoculated with *Fusarium* and *Penicillium* spore suspension one week before defoliation
- inoculated with *Fusarium* and *Penicillium* spore suspension immediately after defoliation
- sprayed with thiabendazole fungicide one week before defoliation and inoculated with *Fusarium* and *Penicillium* spore suspension later on the same day
- inoculated with *Fusarium* and *Penicillium* spore suspension immediately after defoliation and sprayed with thiabendazole fungicide the next day

The four defoliation treatments were the same as used in the experiment with cv Carlton.

All defoliation treatments were carried out on 18-19 June 1997. Defoliation by flailing involved removing shoots at soil level. After flailing off, plots were either left uncovered or were covered with clear polythene film (125 µm thick) until lifting ('flailed/covered'). The intention behind the covering of shoots with polythene film was to maintain higher levels of moisture around these shoots, hopefully encouraging infection, compared with those left uncovered. However, an exceptional 90 mm of rain fell over the period between film application and bulb lifting, so the uncovered shoots and surrounding soil may well have been exposed to higher moisture levels than those under the film. Burning off foliage was done using a propane burner, removing foliage to soil level.

The thiabendazole fungicide product used was Storite Clear Liquid. Applied as a conventional overall foliar spray before defoliation, the fungicide rate was equivalent to 5 litres Storite Clear Liquid in 1000 litres per ha. When applied after defoliation, the rate was again 5 litres Storite in 1000 litres, but it was applied as a directed spray at the stumps of the shoots, using 400 ml spray per plot.

Spore suspensions contained 8.3 x 10^5 *Fusarium* spores/ml plus 1 x 10^6 *Penicillium* spores/ml. Mycelial suspensions contained 0.3 mg/ml dry weight *Fusarium* only. For spore and mycelial suspensions, 1 litre was used per plot as a directed spray at the leaf bases pre-defoliation, or at the shoot stumps post-defoliation. All sprays were applied using a precision sprayer.

All plots were lifted on 7 July 1997, 2½ weeks after defoliation. The trays of bulbs were placed in a controlled-temperature store with a low rate of air movement, to allow slow surface-drying. The store temperature was 18°C until 4 August, then 25°C. In the store the trays from each replicate block were stacked on one pallet, with plots arranged in the stacks according to a pre-determined randomised layout. 'Guard' trays were placed on the top of each stack to equalise conditions further.

Samples of bulbs were assessed for rots immediately after lifting (7 July) and then on 1 August, 27 August, 17 September and (Dutch Master only) 8 October 1997. On each date about equal numbers of bulbs were assessed.

1998 experiment

Bulbs planted in 1996 were used for the 1998 experiment. For each cultivar there were two flower cropping treatments (flowers cropped or not), two fungicide treatments (fungicide spray programme or not), and ten defoliation/inoculation treatments, a total of 40 treatment combinations in the field.

In the cropped plots, flowers were harvested at a commercial picking stage ('upright pencil') in early March 1998.

For plots receiving a fungicide spray programme, benomyl and non-ionic wetter were applied six times in 1998, on 8 April, 29 April, 8 May, 27 May, 5 June and 12 June. The spray consisted of 1.1 kg Benlate Fungicide (50% a.i. w/w; DuPont) plus 300 ml wetter (Activator 90) applied in 500 litres per ha on 8 April and in 1000 litres per ha on the subsequent dates. Applications were made using a knap-sack sprayer. With some plots receiving a fungicide spray programme, and others not, there were considerable differences between plots in the rate of foliage senescence; percentage die-down was estimated for each plot on 30 April 1998.

The defoliation/inoculation treatments were as follows:
- Not inoculated
- Inoculated with spore suspension on 22 April
- Inoculated with spore suspension on 15 May
- Inoculated with spore suspension on 16 June
- Inoculated with spore suspension on 22 April, 15 May and 16 June
- Inoculated with mycelium suspension on 16 June
- Leaves flailed off on 17 June and inoculated with spore suspension
- Leaves flailed off on 17 June, not inoculated
- Leaves top-bashed on 17 June and inoculated with spore suspension
- Leaves top-bashed on 17 June, not inoculated

Defoliation consisted of either flailing-off leaves about 5 cm above the soil surface, or top-bashing to remove foliage and the top 10 to 12 cm of the ridge, close to the neck of the bulb.

Spore and mycelium suspensions were applied as sprays directed into the neck of all bulbs in a plot, using a knap-sack sprayer. Applications were made within 15 minutes of defoliation. Each plot received 4 litres of suspension, directed as precisely as possible into the neck regions of the bulbs. This was enough to drench the base of the plants in the 5 minutes taken to apply it. The spore and mycelial suspensions contained 0.4×10^6 spores/ml or 0.2 mg/ml dry weight of mycelium. Stock suspensions were made up to the required dilutions using tap-water, but this was allowed to stand over-night before use, to allow the dispersion of chlorine.

All of the remaining foliage was removed by flailing and then the bulbs were lifted over the period 22-25 June 1998. Fifty bulbs were removed at random from each plot for the assessment of rots immediately after lifting. The remaining bulbs in each plot were divided into two roughly equal batches; one batch was dipped in thiabendazole, formaldehyde and non-ionic wetter (concentrations as for previous experiments) for 15 minutes at ambient temperatures immediately after lifting, and the other batch was left untreated.

All bags of bulbs were placed in trays and stacked in a store at 25°C and 80% RH. Fifty bulbs from each treatment (dipped or not dipped) of each plot was assessed for rots 4 and 8 weeks after lifting.

Some extra non-replicated combinations of defoliation treatments and pathogen inoculations were applied to some small (2.5m long) plots of Carlton (planted 1996). Spore suspensions of *Fusarium*, *Penicillium* and *Botrytis* were applied to 'flailed', 'top-bashed' or untreated foliage in exactly the same way as *Fusarium* in the main experiment. Defoliation of these small plots was done by cutting the foliage to the top of the ridge with shears ('flailing') or digging away the ridge soil and foliage with a spade to expose the bulb necks ('top-bashing'). These bulbs were lifted manually then stored (not dipped) and assessed on the same dates and in the same way as the rest of the experimental material. Data from the storage assessments of these bulbs were not subjected to statistical analysis.

Bulb rot assessments

At lifting, some bulbs were observed which were already 'mummified' (i.e., completely rotted and desiccated). In the 1997 and 1998 experiments these bulbs were separated, counted and discarded at lifting.

Bulb rots were assessed after various periods in storage (see individual experiments for duration and conditions of storage). Bulbs were bisected length-wise, and the occurrence and type of bulb rots (whether neck rot, basal rot or whole-bulb rot, and the colour and extent of rot) were recorded. The term 'whole-bulb rot' was used where a rot had progressed so far that its basal or neck origin could not be determined on examination. At some assessments the whole-bulb rots had progressed even further to become 'mummified'. The appearance of most rots found were characteristic of the dark brown rot due to *Fusarium oxysporum* f.sp. *narcissi*. Some neck rots, especially at the first assessment just after lifting, were gingery in appearance. This type of rot was never observed to occupy more than 10% of the bulb volume even at later assessments. Isolations were made from typical infections to identify the causal organisms.

Statistical analysis

Data were subjected to the analysis of variance, using angle-transformed values. Data were analysed using a factorial structure to assess the significance of specific treatments and groups of treatments. Both the 'raw' (non-transformed) and angle-transformed data are given in the Tables. The description of significant or non-significant effects is based on the results of the analyses on the transformed data. For variables where many zero values occur, the results should be interpreted cautiously.

Results

1995 experiment

Table 1 shows the percentage of bulbs in different rot categories. The most obvious result was that a high proportion of bulbs in all treatments (between 13 and 30%) showed a whole-bulb rot. In contrast, few bulbs (typically 1 or 2%) showed clearly distinguishable basal or neck rots. A small number of bulbs (0-3%) were mummified. The very low numbers of bulbs with distinguishable basal or neck rot did not allow meaningful statistical analysis of these figures. In all cases the chocolate brown rots were typical of *Fusarium oxysporum* f.sp. *narcissi*, as confirmed by re-isolation of the pathogen. Ginger neck rots were only rarely found, and were associated with either *F. oxysporum* f.sp. *narcissi* or *Penicillium* spp. The colour of rots could not therefore be relied on as a means of pathogen identification.

Treatment effects were further studied by combining all rot types (whole-bulb, basal and neck rots), and deducting the background figure (15%, the percentage of affected bulbs in the untreated control, see Table 1) from the other treatments' totals. Highest levels of all bulb rots occurred when all three pathogens had been applied together (treatment 20, 19% over background level) and in some treatments where *Fusarium* alone had been applied (treatments 13, 13a and 16, 12-16% over background level). The application of prochloraz or thiabendazole (but not of captan) appeared to give some control of the effect of applied *Fusarium*. Overall, the application of fungicide sprays to the defoliated crops 24 hours after inoculation and before lifting had only a slight moderating effect on the rots induced by the applied pathogens, and gave no control of background levels of rots. The application of *Penicillium* alone resulted in a 5 to 6% increase over background levels of all rots (reduced to just 2% when thiabendazole was applied) but *Botrytis* alone did not increase rots.

For statistical analysis, the data were subjected to angular transformation (Table 2). There appeared to be no statistically significant effects of treatments on individual rot categories, but the finding that the greatest overall numbers of bulbs with rots were found where all three pathogens had been applied was confirmed.

1996 experiment

The first bulb assessment (after 10 weeks) showed little neck rot, and so the remaining bulbs were assessed after 16 weeks. The percentage of bulbs in the different rot categories (combined totals for 10 and 16 weeks) is shown in Tables 3 (Carlton) and 5 (Dutch Master). The angular-transformed figures used for statistical analysis are given in Tables 4 and 6. The treatments in this experiment fall into two groups: first, those involving different pathogen inoculations but no fungicide application (treatments 2 to 9), which are generally compared with the untreated control plots (treatment 1); and, secondly, treatments involving inoculation with all three pathogens and various fungicide or disinfectant applications (treatments 10 to 20), generally compared with treatment 9 (which received all three pathogens but no chemical treatment). Results for the two varieties will be considered separately.

Carlton Although only a few bulbs were mummified at the first assessment date, nearly one-third were mummified by the second assessment date. The only obvious treatment effect was a reduced number of mummified bulbs (18%) in plots which had received a post-lifting dip with prochloraz, although this effect was not statistically significant. The percentage of mummified bulbs in other treatments varied from 22 to 31%, with the untreated control at 27%.

Amongst the inoculation treatments (treatments 1 to 9) there were no important effects on the numbers of bulbs with basal and neck rots. The numbers of bulbs with basal rot varied from 1 to 3% (control, 2%), with neck rot from 3 to 6% (control, 3%), with whole-bulb rot from 3 to 5% (control, 5%); combining all rot types, the numbers affected varied from 8 to 13% in the different treatments (control, 10%). Statistical analysis, however, showed that there was a slight tendency towards more basal rots (and overall numbers of bulbs with rots) where *Fusarium* had been applied, and that this was slightly increased when combined with *Botrytis* inoculation.

Among the chemical treatments (treatments 10 to 20), most also showed no significant differences from the appropriate control. However, the prochloraz dip treatment produced more whole-bulb rots and fewer bulbs with neck rot. Statistically, plots treated with a double peroxyacetic acid spray pre-lifting had a reduced number of bulbs with basal rot. Amongst the remaining fungicide treatments, the number of bulbs with basal rot varied from 0 to 2% (compared with 1% in the control), with neck rot from 3 to 7% (control, 4%), with whole-bulb rots from 3 to 6% (control, 5%), and, summing all rot types, from 8 to 14% (control, 10%).

Dutch Master There were fewer rotted bulbs in this variety, and fewer statistically significant effects were seen. The percentage of mummified bulbs varied from 2 to 7%, untreated controls (treatment 1) being 5% and the inoculum control (treatment 9) being 2%. The percentage of bulbs with all rot types combined varied from 1 to 7%, untreated controls being 4% and the inoculated control 3%. Statistically, there was a small increase in overall bulb rots when *Fusarium* and *Botrytis* were applied (singly or together), and a reduction in neck rots (and total rots) when two pre-lifting prochloraz sprays were given.

1997 experiment

Carlton The percentage of mummified bulbs found at lifting was very low, between 0 and 3% (Table 7). Analysis of variance on angle-transformed data showed that there were no significant effects of experimental treatments (either spraying/inoculation treatments or pre-lifting defoliation treatments) on the number of such bulbs.

The percentage of bulbs with neck rot at each of the four assessment dates is given in Table 8, and the percentage of bulbs with basal rot or whole-bulb rot (the latter found only at the last assessment date) in Table 9. Percentages were low in all cases. Increasing the storage temperature from 18 to 25°C after the second assessment led to slightly higher percentages of almost all rots when compared with the 1996 assessments.

The percentage of bulbs with neck rot increased from sample 1 to sample 3, but never exceeded 7% in any treatment, and in sample 4 the highest percentage found was 1%. No basal rot was found in the first sample, and the greatest occurrence was in sample 3 where the highest treatment mean was 7%. In sample 4, the various treatments had between 1 and 8% whole-bulb rots. Analysis of variance showed that none of these percentages was significantly affected by the experimental treatments.

The total number of bulbs with various types of rot were also summed across all sample dates and subjected to statistical analysis; this also failed to show informative significant effects.

Dutch Master The percentage of mummified bulbs found on lifting was very low, not reaching 1% in any treatment (Table 10). There were no significant effects of treatment on these numbers.

The percentage of bulbs with neck rot at each of the five assessment dates are shown in Table 11, and the percentage of bulbs with basal rot or whole-bulb rot (the latter found only at the last two assessment dates) in Table 12.

Most bulbs with neck rot were found in samples 1 and 2, where the maximum percentage was still only 4.5, and percentages fell in subsequent samples with virtually no neck rot being found by the last sample. Few significant effects were found. In sample 2, the effect of fungicide/inoculation treatments was statistically significant, with the greatest percentage of neck rot being found in untreated plots and in plots inoculated late, and the lowest in plots inoculated early. In sample 4, there were significant effects of defoliation treatments, with most neck rot in control (non-defoliated) plots and in plots which had been top-bashed and left uncovered, and least in plots which had been burnt-over or top-bashed and covered. There was also a significant interaction between the two experimental factors, with most neck rot occurring in plots which had been inoculated (either late or early), not sprayed, top-bashed and not covered with polythene.

The number of bulbs with neck rot increased to a maximum in sample 3, where the percentage in different treatments varied from 1.5 to 5.9, and then decreased in later samples. Statistical analysis showed that there were no significant effects of experimental treatments on the percentage of bulbs showing basal rot.

Bulbs with whole-bulb rot were found only at the last two sample dates, with up to 5% of bulbs affected. Statistical analysis again showed that there were no significant effects of experimental treatments on these numbers.

The total number of bulbs with various types of rot were also summed across all sample dates and subjected to statistical analysis; this also failed to show informative significant effects.

1998 experiment

Carlton The mean estimated percentage foliage die-down (on 30 April 1998) was 22% for plots receiving the fungicide spray programme and 64% for plots which received no fungicide. By the time of defoliation and lifting, foliage on the non-sprayed plots had virtually died down. A greater incidence of smoulder was seen in the Carlton plants than in Dutch Master.

The percentage of mummified bulbs found at lifting was very low, between 0 and 2%. There was no relationship between these numbers and any specific treatments.

A summary of key results for Carlton is given in Figures 1 and 2 (results for Dutch Master were similar). Figure 1 illustrates the difference in overall bulb rots between dipped and non-dipped bulbs, and Figure 2 shows the effects of cropping and applying a fungicide spray programme for non-dipped bubs.

In rot assessments carried out immediately after lifting, the only rots found were neck rots, generally only in a few percent of bulbs (Table 13). In all cases the proportion of the bulb found to be rotted was less than 10% and in many instances it was difficult to distinguish between necrosis caused by fungal infection and that resulting from natural die-back of neck tissues. Some 20% of the necroses observed were gingery in colour. There were more neck rots in cropped, non-sprayed plots (overall mean, 4%) than others (overall mean, 2%). This higher mean was strongly influenced by a high incidence of neck rot (13%) in these plots inoculated in April.

In non-dipped bulbs assessed 4 weeks later, the incidence of neck rots had increased, and there was also a low incidence of basal rot (Table 14). Gingery rots now represented less than 3% of the total found.

Neck rot occurred:
- least in non-inoculated plots (overall mean 1%) regardless of other treatments
- more in non-cropped plots (overall mean, 6%) than in cropped plots (overall mean, 4%)
- more in sprayed plots (overall mean, 6%) than in non-sprayed plots (overall mean, 3%)
- most in top-bashed, inoculated plots, except where cropped and non-sprayed, (overall mean, 18%)

Basal rot also occurred most in top-bashed, inoculated plots, whether cropped or non-cropped, sprayed or non-sprayed (overall mean, 5%, compared with a mean of 1% in all other treatments).

Analysis of the overall percentage of bulbs with rots (of either type) confirmed these findings. More rots were found in (in descending order):
- all top-bashed inoculated plots (overall mean, 19%)
- plots inoculated in June (spore or mycelial inoculum) or at all three dates, in both sprayed and non-sprayed, non-cropped plots (overall mean, 11%)
- flailed inoculated plots (only where non-cropped) (overall mean, 8%)
- all other treatment combinations resulted in overall levels of rots of 1 to 8%, with lowest

values in the non-inoculated plots

In dipped bulbs assessed 4 weeks after lifting, the incidence of neck and basal rot was much lower, and was only found in certain treatments (Table 15). Neck rot was largely confined to top-bashed inoculated plots (with the exception of cropped, non-sprayed plots), where it occurred at 5-11% (0-2% in all other treatments). Basal rot occurred at 4-6% in plots which were sprayed with fungicide, top-bashed and inoculated (0-1% in nearly all other treatments).

Analysis of the overall percentage of rots confirmed these findings. Most rots occurred in sprayed, top-bashed, inoculated plots (whether cropped or not) (12-17%), with 6% rots in equivalent plots which were non-cropped and non-sprayed, and 0-1% rots in nearly all other cases.

Penicillium spores were visible as dusty green masses on the outer surfaces of many of the dipped bulbs. This was probably a consequence of the slow post-dip drying at ambient temperature and the subsequent storage at high humidity. This observation applied to bulbs of both cultivars and at both late assessment dates.

In non-dipped bulbs assessed 8 weeks after lifting, many rots had progressed to rot the whole bulb (Table 16). Only low levels of neck rot were found in any treatments (0 to 4%), and these were not consistently associated with any particular treatment combinations. No gingery rots were seen at this assessment.

Basal rot levels were also low in almost all treatments (0 to 3%) except in cropped, sprayed, top-bashed inoculated plots where it reached 7%.

Whole-bulb rots occurred:

- more in non-cropped plots (overall mean 8%) than in cropped (overall mean 5%)
- more in sprayed plots (overall mean 8%) than in non-sprayed (overall mean 4%)
- most in top-bashed inoculated plots (28-30% where sprayed, 12-13% where not sprayed), where inoculated in May, June (spores or mycelium) or at all three dates (mean, 6%), or where flailed and inoculated (mean, 7%) (mean of 2% or less in other treatments)

Analysis of overall percentage of rots confirmed these results:

- sprayed, top-bashed inoculated plots had 35-38% rots
- non-sprayed, top-bashed inoculated plots had 13-15% rots
- most inoculated plots had 3-19% rots
- all non-inoculated plots had 1-5% rots

In dipped bulbs assessed 8 weeks after lifting, the percentage of bulb rots remained low, similar to the assessments at 4 weeks. Little neck rot was found, and the highest treatment mean was only 2%. Basal rot occurred in top-bashed inoculated plots which had been non-cropped but sprayed at 7%, and in those which had been cropped but not sprayed at 3%. In most other treatments percentage with basal rot was 1 or less. Whole-bulb rots occurred mainly in top-bashed inoculated plots (except where these had been cropped but not sprayed) (5-7%, compared with 0-3% in other treatments).

Analysis of overall rots confirmed the effect of top-bashed, inoculated treatments: in non-cropped, sprayed plots of this treatment there were 15% rots, and in other treatment combinations, 5 to 9% rots. There were 7% rots in the triple-inoculated plots which had been cropped but not sprayed. In all other treatment combinations the percentage of rots was 0 to 3%.

The results of the extra non-replicated treatments on Carlton bulbs demonstrated that there was no increase in neck (or other) rots as a consequence of applying *Botrytis* inoculum, only a slight increase (4% overall) when *Penicillium* was applied, but a much larger (11%) increase when *Fusarium* was present. This ranking order of disease induction was observed regardless of the defoliation treatment applied. This result confirms the findings of the 1995 and 1996 experiments that *Fusarium oxysporum* f.sp. *narcissi* is a more important and aggressive bulb rot pathogen than *Botrytis narcissicola* or *Penicillium* spp.

<u>Dutch Master</u> Unlike the results for Carlton, little smoulder was seen in Dutch Master, and the differences in percentage foliar die-down between sprayed and non-sprayed plots in April were insignificant. At the time of defoliation and lifting, senescence was much more advanced in plants that had not been sprayed with fungicide.

The percentage of mummified bulbs found at lifting was very low (0-2%), as it was in Carlton, and lower or higher values were not associated with particular treatments.

In <u>rot assessments carried out immediately after lifting</u>, there were no statistically significant effects of any of the treatments (Table 18). Most of the rots found were neck rots, the percentage of which varied from 0 to 8 in different treatments. As for Carlton, the proportion of the bulb found to be rotted was less than 10%, and again it was difficult to distinguish between necrosis caused by fungal infection and that resulting from natural die-back of neck tissues. Some 60% of these necroses observed were gingery in colour. There were a very few instances of basal rot.

In <u>non-dipped bulbs assessed 4 weeks later</u>, the number of bulbs with neck rot, and especially the number with basal rot, had increased (Table 19). Overall, there was more neck rot in non-cropped plots (overall mean, 3%) than in cropped plots (overall mean, 2%). Most neck rot occurred in top-bashed, inoculated plots (9-12% rots), except where these had been cropped and not sprayed (3% rots); in all other treatments the means for neck rot were 0-7%. Gingery rots now represented less than 20% of the total found.

Basal rot occurred:

- more in non-cropped (8% overall) than cropped plots (5%)
- more in sprayed (7% overall) than non-sprayed plots (5%)
- generally more in sprayed plots which had been inoculated in June (with spores or mycelium) or on all three dates (9-12% overall), and in top-bashed and inoculated plots (whether sprayed or not) (8-17%), than in other combinations

Analysis of the overall percentage of bulbs with rots (all types) confirmed these findings. Most rots occurred in top-bashed and inoculated plots (20-29%, but only 11% in cropped, non-sprayed plots), and in some inoculated plots, mainly in non-cropped, sprayed plots inoculated in June (15-17% rots).

In dipped bulbs assessed 4 weeks after lifting there had been, in contrast, little increase in neck or basal rots (Table 20). The main findings were that neck rot occurred most in sprayed plots which had been top-bashed and inoculated (4-7%); there were few neck rots in other treatments (0-2%). There were few significant effects on the percentage of bulbs with basal rot, which did not exceed 2% in any treatment. See the comments above (under Carlton) about the occurrence of *Penicillium* spores on these dipped bulbs.

The results for non-dipped bulbs assessed 8 weeks after lifting are given in Table 21. Many rots had progressed to the whole-bulb rot stage. Only 12% of recorded neck rots were gingery. The results showed:

- Neck rot occurred mostly in plots which had been sprayed, top-bashed and inoculated (5-9%), and also in plots inoculated with spores on all three dates, with the exception of the non-cropped, non-sprayed plots, (3-5%)
- Basal rot occurred most in non-cropped, sprayed plots which had been inoculated on all three dates (12%) or top-bashed and inoculated (14%); basal rot occurred at 0-6% in all other treatments.
- Whole-bulb rot occurred at a consistent high rate in top-bashed, inoculated plots (8-19%). Relatively high rates of whole-bulb rot occurred sporadically, and without a clear pattern, in various other treatment combinations.

The analysis of combined rots showed that:

- there were more rots in non-cropped (overall, 15%) than cropped plots (10%)
- there were more rots in sprayed (15%) than non-sprayed plots (10%)
- the treatments with the highest rots involved inoculation at all three dates and top-bashing followed by inoculation; both these treatments gave a high percentage of rotting irrespective of cropping and spray treatments (12-35%). Some other treatment combinations produced high rates of rots, but without a clear pattern.

In dipped bulbs assessed 8 weeks after lifting, levels of all rots remained low (Table 22). Neck rot occurred mainly in top-bashed, inoculated plots, except when non-cropped and non-sprayed, (3-6%), but was rare in other treatments. Basal rot followed a similar trend to neck rot, although incidence was very low. Whole-bulb rots were rare (0-1% in most treatments) but occurred at 6% in plots which were cropped, sprayed, top-bashed and inoculated. The overall analysis of rots confirmed the overriding effect of top-bashing and inoculation, which gave 5-10% rots compared with 0-2% in other treatment combinations

Discussion

At the start of the project the hypothesis to be tested was that neck rot resulted from infection of damaged shoot tissue by pathogens at the time foliage was removed by flailing or top-bashing prior to lifting; applying a fungicide around this time should, therefore, reduce the incidence of neck rot.

In the first experiment (1995) the foliage was removed from all plots by flailing-off to just above soil level and the stumps were inoculated with spore suspensions of *Fusarium*, *Botrytis* and *Penicillium*, singly and together. Fungicide sprays were applied over the stumps 24 hours later, and two weeks later (allowing time for disease development) the bulbs were lifted and dried and stored at 18°C for nine weeks, when bulb rots were assessed. None of the pathogen inoculation treatments caused significant increases in the number of identifiable neck rots, even in the cases of the double rate applications or combined pathogen applications. Treatment effects were difficult to determine because, under these conditions, there was a high background incidence of bulb rots (15% in untreated controls) and most bulb rots had progressed to a whole-bulb rot, so that neck (and basal) rots could not be clearly distinguished. Some trends were, however, evident, in particular that the incidence of rots was highest when all three pathogens had been applied together. The high background level of bulb rots may have been due to the fact that the usual fungicide spray programme had been deliberately omitted from the crop, as part of the experimental protocol designed to encourage the development of neck rot.

In the second experiment (1996) treatments involved causing greater damage to the foliage bases (by top-bashing then 'strimming') and (for most treatments) inoculation with all three pathogens, in an attempt to induce more neck rot than had previously been found. Inoculations were made just after defoliation, or on the next day, and a number of fungicide treatments were used before or after defoliation or as post-lifting dips or sprays. Bulbs were lifted one week after defoliation, dried at ambient temperatures initially and then in an 18°C store. Bulb rots were assessed 10 and 16 weeks after lifting. Despite using such treatments, which exposed damaged shoot tissues to substantial pathogenic inoculum, this experiment confirmed the finding of the previous one, that significant amounts of neck rot could not be induced by these means, but that applying *Fusarium* increased the overall number of bulb rots, an effect enhanced when *Botrytis* was applied in combination with *Fusarium*. Although cv Dutch Master developed fewer rots than Carlton, the effect of *Fusarium* (alone or combined with *Botrytis*) in increasing rots overall was repeated. In both this experiment and the previous one, there were some small effects of some fungicide treatments in reducing the incidence of bulb rots, but these effects were not consistent or large enough to warrant their recommendation for controlling bulb rots. Several factors may have been responsible for the low levels of neck rots found in 1995 and 1996. In both of these experiments the intervals between lifting and the rot assessments (19 weeks in 1995 and 10 and 16 weeks in 1996) were long enough to have allowed many neck and basal rots to progress to whole bulb rots or even to 'mummified' bulbs.

Another possible explanation for the low incidence of neck rot seen in both of these experiments is that the bulb necks dried out too quickly for neck rot to develop, perhaps in the field or after bulb lifting. A third possibility is that infection leading to neck rot occurred before defoliation and lifting. Further clues to factors that may moderate neck rots were provided by the results of the laboratory tests on forced bulbs (see Introduction).

The influence on neck rot in field bulbs of some of these factors was examined in the 1997 experiments. Here a different series of treatments was applied to each cultivar. Treatments tested on the Carlton crop were designed to discover whether naturally occurring levels of neck rot could be controlled by a fungicide either before or after defoliation, or could be augmented by pathogen inoculation before defoliation. The aim of the Dutch Master treatments was to see if neck rot could be produced by pathogen inoculation before or after defoliation, and whether fungicide applied around the same time would control it. In this experiment defoliation of both cultivars was effected by flailing or burning (with a propane burner) to soil level and, in an attempt to maintain moist conditions around the cut shoots subsequently, some of the flailed plots were covered with polythene film (in fact, heavy rainfall subsequently resulted in the non-covered plots being wetter than the covered ones). Bulbs were lifted 2½ weeks after defoliation, and were allowed to dry slowly at 18°C for one month (to maintain a moist bulb neck) and thereafter at 25°C (to encourage the development of *Fusarium*); bulb rots were assessed at shorter intervals than in previous experiments.

Despite modifications in the experimental treatments and procedures, to encourage neck rot, statistical analyses of the 1997 field experiment data showed that there were hardly any significant effects of foliar, fungicide or pathogen treatments on any types of bulb rots found. Inoculations showed no consistent effects on increasing levels of disease over and above the levels observed in non-inoculated bulbs, even using a mycelial inoculum.

The possibility that infections leading to neck rots developed before defoliation and lifting was tested by the application of inoculum one week before defoliation. No increase in disease was observed, and so earlier and serial inoculations were planned for the 1998 experiment. No one defoliation treatment consistently differed from any other in terms of symptom expression. Levels of all rots, especially neck rots, were very low (average of 0 to 2% for either variety on any assessment date) indicating perhaps that natural and applied levels of inoculum entering the bulb necks in the field were below the threshold required for successful rot establishment. Foliage treatments would become irrelevant under such circumstances.

The quantities of pathogens reaching the bulb necks in field treatments cannot be determined accurately because of the unknown influence of the layer of ridge soil around the leaf bases on downward pathogen movement, the variable distance from cut leaf surface to bulb neck, and the limited amount of directional control over the inoculum spray applied. It is possible, however, that with 1 litre of inoculum being dispersed amongst approximately 400 bulbs, very little (or possibly none) of the average 2.5 ml applied per bulb actually reached the junctions between leaf bases and bulbs. It was decided to use higher concentrations and volumes of inoculum in the 1998 experiment, and to direct the inoculum more precisely into the neck area of the bulbs.

The ineffectiveness of the thiabendazole sprays, either pre- or post-defoliation, in controlling storage rots indicated that the fungicide either did not reach the source of infection early enough to prevent rot establishment and development, or was present at too low a concentration to control pathogen growth. To test these hypotheses it was decided to apply earlier and serial foliar sprays of fungicide in the 1998 experiment, and to treat some bulbs with a post-lifting thiabendazole dip.

In the 1997 experiment the greatest amount of neck rot was observed 51 days (cv Carlton) or 25 days (cv Dutch Master) after lifting. Basal rots were also most frequently found on these dates for the respective cultivars. After 72 days' storage, most rots encountered were whole-bulb rots that could have resulted from either type of rot initially. These percentages are summarised in the table below:

Percentage of neck or basal rots in bulbs of Carlton and Dutch Master over a period of 72 days in storage.

Cultivar	Type of rot	Date 1 (0 days)	Date 2 (25 days)	Date 3 (51 days)	Date 4 (72 days)
Carlton	Neck	1.00	1.12	1.93	0.42
Carlton	Base	0	1.21	4.52	1.35
Dutch Master	Neck	1.76	2.38	1.15	0.47
Dutch Master	Base	0.95	3.36	1.13	0.24

In this experiment the bulb storage temperatures were increased from 18 to 25°C after the second rot assessment, which had shown low overall levels of rots, to ensure that conditions were more favourable for fungal growth and hence rot development. Whilst it is difficult to make comparisons between experimental data from two different years, it is possible that the overall higher levels of almost all rots recorded in 1997 compared with 1996 may have been due in part to this increased store temperature, even though the increases for Dutch Master were greater than for Carlton, as shown in the following table:

Cultivar & year	% neck rot	% basal rot	% all rots (neck, basal and whole-bulb)
Carlton 1996	4.5	1.3	10.3
Carlton 1997	4.3	7.1	16.2
Dutch Master 1996	1.9	0.8	3.5
Dutch Master 1997	5.8	5.7	16.3

As mentioned previously, a number of technical changes, aimed at making the procedures more effective, were introduced in the 1998 experiment, and some alternative factors were examined. Early-season and serial applications of pathogens were included. The effects of flower cropping, and of using an extended fungicide spray programme, were tested. Defoliation treatments included conventional flailing as well as deep top-bashing, well into the ridge so that damage was caused close to the neck of the bulb. After lifting, half of all bulbs to be stored were dipped in fungicide. Bulb storage was carried out at 25°C, to encourage the growth of *Fusarium*, but at high humidity, to prevent rapid drying of the bulb neck. Rot assessments were carried out immediately after lifting and then again at 4 and 8 weeks to ensure that neck and basal rots could be clearly distinguished and recorded before they progressed to become whole-bulb rots.

While the number of experimental factors in the 1998 experiment made statistical interpretation of the results complex, there were several very clear conclusions which, unless qualified, apply to both cultivars:

- most rots found in the assessment immediately after lifting were neck rots and these were slightly more frequent in Dutch Master than in Carlton
- almost twice as much neck rot was seen in Carlton at the 4-week assessment
- basal rots were rarely observed until the later two assessments and in both of these the overall mean levels were between three and six times greater in Dutch Master
- whole rots were only seen at the final assessment and their overall mean numbers were almost identical for both cultivars
- total numbers of all types of rots at 8 weeks were greater in Dutch Master (12% overall

mean) than Carlton (9%)

- a post-lifting dip in fungicide greatly reduced the incidence of bulb rots when assessed 4 and 8 weeks later, compared with non-dipped bulbs; there was a reduction of between 80 and 90% overall, depending on cultivar
- more neck rot (and other rots generally) occurred in non-cropped than in cropped plots
- more neck rot (and other rots generally) occurred in plots which had received a regular fungicide spray programme than in those that had not
- cropping, combined with not giving a fungicide spray programme, reduced the rot-enhancing effects of some other treatments (such as top-bashing and inoculation)
- more neck rot (and other rots generally) occurred in plots that had been severely top-bashed and inoculated
- applying a spray of pathogen spore suspension in April, May or June, or at all three dates, or of pathogen mycelium suspension (tested only in June), increased the amount of bulb rots, particularly when other factors predisposed the bulbs to rots (giving a regular fungicide spray programme and (or) not cropping)
- top-bashing and inoculating invariably produced many more of all types of bulb rots than any other combination of treatments; flailing and inoculating caused far fewer rots and usually less than when foliage was left intact until lifting

Some of these findings were unexpected although possible explanations for most can be proposed:

- Neck rots were more numerous in Carlton and basal rots more prevalent in Dutch Master, reflecting perhaps differential susceptibilities for these two types of rot between the two cultivars
- The post-lifting fungicide dip controlled all types of rot in both cultivars to such an extent that in many treatment combinations no rots at all were found. Why this dip was less effective in the 1996 experiment is unclear
- The reduced incidence of rots in most treatments applied to flower-cropped plots was unexpected as we had thought that the cut or broken scape would increase accessibility of the neck region to pathogens. It is possible that early removal of this part of the plant encouraged the formation of barriers to infection at a time when there was little active pathogen inoculum present in the field
- The extended foliar fungicide spray applications had a similarly unexpected negative effect on reducing numbers of rots. We believe that this may have resulted from the well-known delay to foliar senescence that late season applications of fungicides can produce in daffodil crops. Abscission layers may be incomplete or totally absent in sprayed plants which may provide easier access to neck pathogens. That this treatment, in many instances, also increased levels of basal rot as well is perhaps even more surprising. The explanation here may be a consequence of similar delays to natural root senescence that in turn could lead to increased infection at this end of the bulbs
- The way in which foliage is removed just before lifting has a big impact on the number of rots that develop later in storage. Top-bashing low into the ridge exacerbates all types of rots and also reduces the efficacy of post-lifting fungicide dips. Far fewer rots developed after defoliation by flailing in place of top-bashing. Indeed in many treatment combinations the bulbs from flailed plots developed less rots than those where the foliage had been left intact until immediately before lifting. This effect may have been due to the removal by flailing of some neck tissues that were already infected thus reducing the

amount of fungus in or around the bulb necks at lifting.

Data for all four years' experiments support the hypothesis that *Fusarium oxysporum* f.sp. *narcissi* is the most frequent and serious cause of neck rot and that damaged neck tissues provide the most likely means of pathogen entry. The location and quantity of fungal inoculum in the field is important, especially though not exclusively, at lifting. Pre-lifting, and to a great extent post-lifting, fungicide sprays were ineffective at controlling rots and in some circumstances actually increased them. Some combinations of crop husbandry practices (e.g. flailing, rapid drying) were found to be beneficial but some were detrimental (e.g. top-bashing, storage at 25°C in place of 18°C).

To reduce neck and other bulb rots in daffodil bulbs, the following procedures are recommended:

- flower cropping (or de-heading)
- restriction of the fungicide spray programme, especially towards the end of the growing season
- defoliation of crops by flailing, but not by top-bashing
- post-lifting dipping in fungicide
- rapid bulb drying

Further research

Further experiments are needed to confirm and refine some of these recommendations and to examine other factors that may influence both neck and basal rots. The following points need attention:

- the extent of restriction of the fungicide spray programme required (and whether in the first or second years of the crop) and the implications for the control of foliar diseases (such as smoulder and white mould)
- alternatives to post-lifting thiabendazole dips (other fungicides as dips or use of sprays instead of dips) and an investigation of the most cost effective concentrations to be used
- an investigation of the movement of inoculum from infected to healthy bulbs both in the field and during storage
- the impact on rots of the different storage techniques and conditions used throughout the industry including the relative importance of temperature and humidity (clearly 80% humidity or higher is not to be recommended for dipped bulbs which have not been dried rapidly)
- a study of methods to enhance the rate of senescence in crops to be lifted before the natural process has had time to proceed to completion

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Key to inoculum and defoliation treatments in Figures 1 and 2

- 1 no inoculum
- 2 inoculum (April)
- 3 inoculum (May)
- 4 inoculum (June)
- 5 inoculum (3x)
- 6 mycelium (June)
- 7 flail + inoculum
- 8 flail only
- 9 top-bash + inoculum
- 10 top-bash only

Figure 1. Cropped, sprayed plots (dipped or non-dipped bulbs)

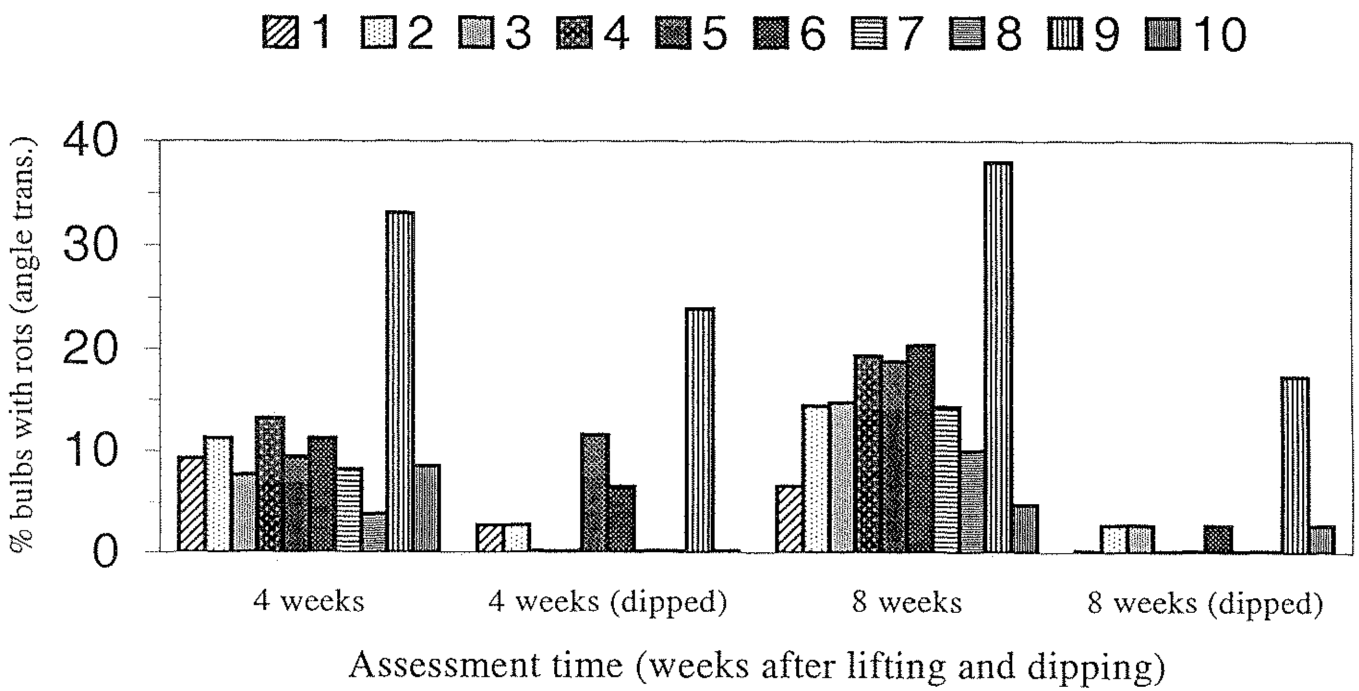
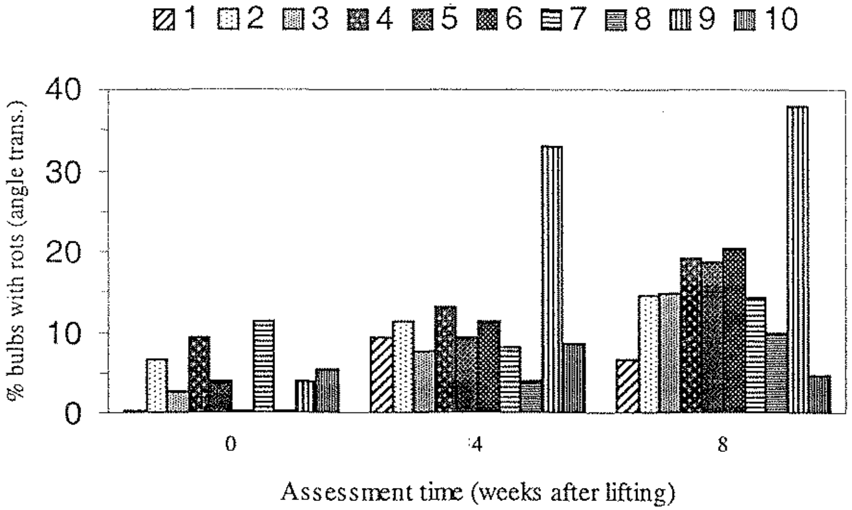
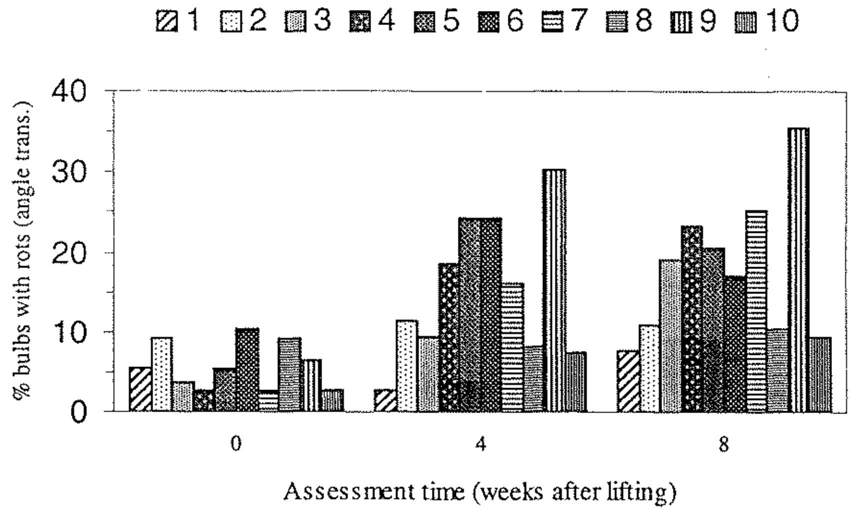


Figure 2

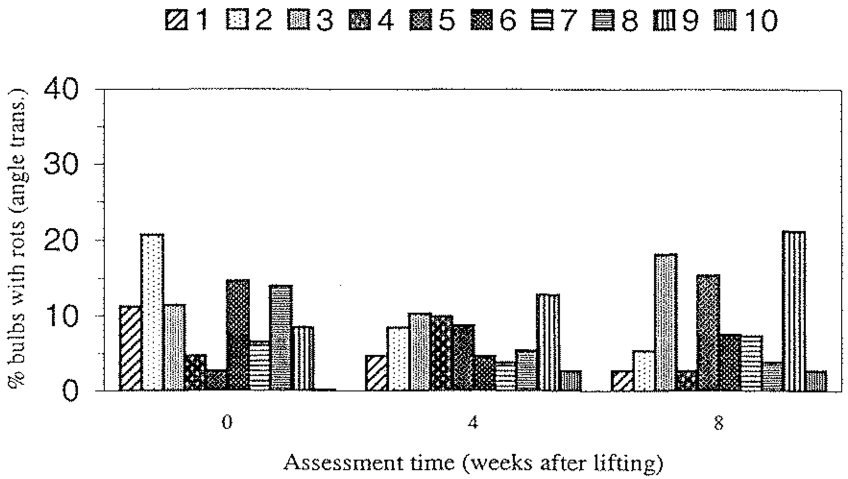
Cropped, sprayed plots (non-dipped bulbs)



Non-cropped, sprayed plots (non-dipped bulbs)



Cropped, non-sprayed plots (non-dipped bulbs)



Non-cropped, non-sprayed plots (non-dipped bulbs)

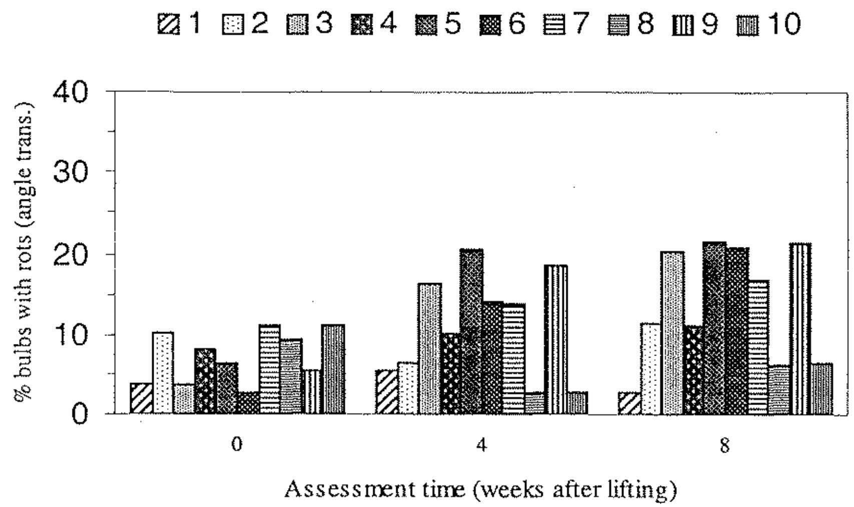


Table 1 Storage assessment of bulb rots in narcissus bulbs cv Carlton following inoculum and fungicide application after defoliation (1995 experiment). Non-transformed data (See Table 2 for angle-transformed data and results of analysis of variance)

Treatment			Mean percentage of bulbs[a]								Mean no.
Ref	Pathogen	Fungicide	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	'Ginger' neck rot	All rots	All rots (adj.)[b]	bulbs per plot
1.	None	None	84	2	13	1	1	1	15	0	58
2.	None	TBZ	82	2	14	1	1	0	17	2	58
3.	None	Prochloraz	78	2	19	1	1	0	21	6	53
4.	None	Captan	73	1	20	1	4	1	26	11	55
5.	*Penicillium* (P)	None	80	1	16	1	2	0	19	4	63
5a.	(double rate)	None	75	3	21	1	1	0	23	8	61
6.	*Penicillium* (P)	TBZ	83	0	17	1	0	0	17	3	61
7.	*Penicillium* (P)	Prochloraz	77	1	21	0	1	1	22	8	56
8.	*Penicillium* (P)	Captan	76	1	22	0	2	0	23	9	60
9.	*Botrytis* (B)	None	84	0	14	1	2	0	17	2	61
9a.	(double rate)	None	79	2	15	2	0	2	19	4	55
10.	*Botrytis*	TBZ	81	2	15	1	1	0	16	2	55
11.	*Botrytis*	Prochloraz	83	1	14	1	1	0	16	1	58
12.	*Botrytis*	Captan	84	1	15	0	1	0	15	1	55
13.	*Fusarium* (F)	None	69	1	28	1	1	0	30	15	58
13a.	(double rate)	None	72	1	24	3	1	0	27	12	59
14.	*Fusarium*	TBZ	73	3	24	1	0	0	24	9	57
15.	*Fusarium*	Prochloraz	78	1	20	0	2	0	22	7	56
16.	*Fusarium*	Captan	69	0	28	1	2	0	31	16	56
17.	*P + B*	None	77	3	18	1	1	0	19	5	59
18.	*P + F*	None	75	0	24	1	1	0	25	10	56
19.	*B + F*	None	74	1	22	2	1	0	25	10	61
20.	*B + F + P*	None	65	1	30	1	4	0	34	19	56

[a] in these Tables totals and their components may differ due to rounding errors
[b] adjusted value is 'corrected for background', ie amount of rots in untreated control deducted

Table 2 Storage assessment of bulb rots in narcissus bulbs cv Carlton following inoculum and fungicide application after defoliation (1995 experiment). Angle transformed data as used in analysis of variance (aov)

Treatment			Mean percentage of bulbs (angle transformed)						
Ref	Pathogen	Fungicide	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	'Ginger' neck rot	All rots
1.	None	None	66.8	4.3	20.8	2.5	2.6	2.5	22.2
2.	None	TBZ	65.5	7.6	21.2	3.6	5.1	0	23.0
3.	None	Prochloraz	61.7	4.5	25.6	2.6	5.2	0	27.0
4.	None	Captan	59.0	5.2	26.4	2.6	11.4	2.5	30.2
5.	*Penicillium* (P)	None	63.6	5.0	23.6	2.3	8.3	0	25.6
5a.	(double rate)	None	59.8	8.3	27.2	3.4	3.8	0	28.6
6.	*Penicillium*	TBZ	65.9	0	23.7	2.4	0	0	24.1
7.	*Penicillium*	Prochloraz	61.2	3.5	27.2	0	2.7	2.5	28.0
8.	*Penicillium*	Captan	60.8	2.4	27.7	0	5.9	0	28.8
9.	*Botrytis* (B)	None	66.0	0	21.8	4.9	5.9	0	24.0
9a.	(double rate)	None	63.2	4.7	22.5	7.5	0.2	5.8	25.9
10.	*Botrytis*	TBZ	64.6	7.3	22.1	5.2	2.6	0	23.6
11.	*Botrytis*	Prochloraz	66.2	5.1	21.4	2.4	5.2	0	22.9
12.	*Botrytis*	Captan	66.0	3.9	22.5	0	2.5	0	22.9
13.	*Fusarium* (F)	None	56.0	3.5	32.2	3.6	2.5	0	33.3
13a.	(double rate)	None	58.0	2.9	29.4	8.9	3.7	0	31.7
14.	*Fusarium*	TBZ	58.6	10.5	28.9	2.4	0	0	29.2
15.	*Fusarium*	Prochloraz	62.2	2.5	26.1	0	7.7	0	27.4
16.	*Fusarium*	Captan	56.2	0	32.1	2.4	6.8	0	33.8
17.	*P + B*	None	61.7	8.7	24.6	2.5	3.5	0	26.0
18.	*P + F*	None	60.1	0	29.2	2.4	2.4	0	29.9
19.	*B + F*	None	59.6	3.6	27.7	6.9	2.4	0	29.6
20.	*B + F + P*	None	54.0	2.7	33.1	2.6	10.4	0	35.6
	SED (44 df)		4.22	4.06	4.15	3.47	3.52	1.62	4.00
	Significance (1-factor aov)[a]		ns	ns	ns	ns	ns	ns	*

[a]In these tables, ns = not significant, and *, ** and ***, significant at the 5, 1 and 0.1 % levels of probability, respectively

Table 3 Storage assessment of bulb rots in narcissus bulbs cv Carlton following defoliation and inoculum and fungicide application (1996 experiment). Non-transformed data (see Table 4 for angle transformed data and results of analysis of variance)

Treatment				Mean percentage of bulbs						Mean no. bulbs per plot
Ref	Pathogen	Fungicide (pre-lifting)	Fungicide (post-lifting)	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	All rots	
1.	None (not defoliated)	None	None	63	27	5	2	3	10	202
2.	None	Water only	None	69	24	4	1	3	8	209
3.	*Fusarium* (F)	None	None	60	26	5	2	6	13	193
4.	*Botrytis* (B)	None	None	65	25	3	1	5	10	195
5.	*Penicillium* (P)	None	None	66	26	5	1	3	8	195
6.	*F + B*	None	None	63	28	3	1	4	8	220
7.	*F + P*	None	None	59	28	5	3	4	12	208
8.	*B + P*	None	None	61	29	5	1	4	10	187
9.	*F + B + P*	None	None	64	26	5	1	4	10	196
10.	*F + B + P*	None	For dip	61	28	6	1	5	12	218
11.	*F + B + P*	None	TBZ dip	61	28	4	1	7	11	218
12.	*F + B + P*	None	Pro dip	69	18	11	0	1	13	155
13.	*F + B + P*	TBZ(2 sprays)	None	64	22	5	1	8	14	194
14.	*F + B + P*	Pro(2 sprays)	None	64	26	5	1	5	10	216
15.	*F + B + P*	Paa(2 sprays)	None	61	31	3	0	5	8	209
16.	*F + B + P*	TBZ(1 spray)	None	63	29	4	2	3	9	222
17.	*F + B + P*	Pro(1 spray)	None	63	28	5	2	3	10	200
18.	*F + B + P*	None	TBZ spray	64	25	5	1	5	11	215
19.	*F + B + P*	None	Pro spray	63	27	3	2	4	10	221
20.	*F + B + P*	None	Paa spray	65	26	4	1	3	9	212

Table 4 Storage assessment of bulb rots in narcissus bulbs cv Carlton following defoliation and inoculum and fungicide application (1996 experiment). Angle-transformed data as used in analysis of variance (aov)

Treatment				Mean percentage of bulbs (angle transformed)					
Ref	Pathogen	Fungicide (pre-lifting)	Fungicide (post-lifting)	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	All rots
1.	None (not defoliated)	None	None	52.6	31.4	12.1	8.0	10.4	18.1
2.	None	Water only	None	55.9	29.1	10.7	4.3	10.2	15.9
3.	*Fusarium* (F)	None	None	50.9	30.9	13.1	7.8	14.4	21.4
4.	*Botrytis* (B)	None	None	54.1	29.7	10.6	4.9	13.2	18.1
5.	*Penicillium* (P)	None	None	54.1	30.7	12.5	2.4	9.9	16.8
6.	*F + B*	None	None	52.8	32.1	10.5	4.9	11.7	16.7
7.	*F + P*	None	None	50.4	32.1	12.7	10.3	12.0	20.6
8.	*B + P*	None	None	51.4	32.3	13.1	5.7	11.5	18.7
9.	*F + B + P*	None	None	53.3	30.4	12.6	4.1	10.8	18.1
10.	*F + B + P*	None	For dip	51.1	31.6	13.4	5.8	13.2	20.2
11.	*F + B + P*	None	TBZ dip	51.3	31.9	11.1	3.8	15.1	19.5
12.	*F + B + P*	None	Pro dip	56.2	21.0	18.4	1.9	5.0	20.2
13.	*F + B + P*	TBZ(2 sprays)	None	53.3	27.8	13.1	6.5	15.5	21.8
14.	*F + B + P*	Pro(2 sprays)	None	53.0	30.6	12.1	6.0	12.2	18.6
15.	*F + B + P*	Paa(2 sprays)	None	51.5	33.5	10.0	0	13.0	16.6
16.	*F + B + P*	TBZ(1 spray)	None	52.6	32.2	11.1	7.0	10.0	16.8
17.	*F + B + P*	Pro(1 spray)	None	52.3	31.6	12.2	6.2	10.1	18.0
18.	*F + B + P*	None	TBZ spray	53.3	30.1	12.2	5.8	12.9	19.0
19.	*F + B + P*	None	Pro spray	52.9	31.3	9.9	7.7	12.1	17.8
20.	*F + B + P*	None	Paa spray	53.7	30.9	11.6	6.3	10.3	17.0
	SED (38 df)			2.27	3.91	2.64	2.33	2.29	2.55
	Significance (1-factor aov)								
	20 treatments			ns	ns	ns	*	*	ns
	Significance (factorial aov)								
	unflailed v. top-bashed			ns	ns	ns	ns	ns	ns
	inoculated group v. fungicide group			ns	ns	ns	ns	ns	ns
	F. v. no *Fusarium*			ns	ns	ns	*	ns	ns
	B. v. no *Botrytis*			ns	ns	ns	ns	ns	ns
	P. v. no *Penicillium*			ns	ns	ns	ns	ns	ns
	interaction between F + B or none			*	ns	ns	**	ns	*
	interaction between F + P or none			ns	ns	ns	ns	ns	ns
	interaction between B + P or none			ns	ns	ns	ns	ns	ns
	interaction between F + B + P or none			ns	ns	ns	ns	ns	ns
	pre-lift sprays v. post-lift treatments			ns	ns	ns	ns	ns	ns
	between post-lift fungicide treatments			ns	ns	*	ns	**	ns
	between pre-lift fungicide treatments			ns	ns	ns	*	ns	ns

Table 5 Storage assessment of bulb rots in narcissus bulbs cv Dutch Master following defoliation and inoculum and fungicide application (1996 experiment). Non-transformed data (see Table 6 for angle transformed data and results of analysis of variance)

Treatment				Mean percentage of bulbs						Mean no. bulbs per plot
Ref	Pathogen	Fungicide (pre-lifting)	Fungicide (post-lifting)	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	All rots	
1.	None (not defoliated)	None	None	91	5	1	0	3	4	160
2.	None	Water only	None	91	6	1	1	1	3	193
3.	*Fusarium* (F)	None	None	92	4	2	1	1	4	184
4.	*Botrytis* (B)	None	None	94	3	1	1	2	4	172
5.	*Penicillium* (P)	None	None	95	4	1	0	0	1	179
6.	*F + B*	None	None	92	5	2	0	2	3	195
7.	*F + P*	None	None	90	7	1	0	2	3	191
8.	*B + P*	None	None	89	6	1	1	3	5	199
9.	*F + B + P*	None	None	95	2	1	1	2	3	165
10.	*F + B + P*	None	For dip	92	5	1	0	3	3	185
11.	*F + B + P*	None	TBZ dip	93	2	0	2	3	5	197
12.	*F + B + P*	None	Pro dip	94	3	1	1	1	3	132
13.	*F + B + P*	TBZ(2 sprays)	None	93	2	1	1	2	4	185
14.	*F + B + P*	Pro(2 sprays)	None	94	4	2	1	0	2	186
15.	*F + B + P*	Paa(2 sprays)	None	92	2	2	1	4	7	159
16.	*F + B + P*	TBZ(1 spray)	None	94	4	1	1	2	3	180
17.	*F + B + P*	Pro(1 spray)	None	92	5	2	1	1	3	195
18.	*F + B + P*	None	TBZ spray	91	5	1	1	3	5	202
19.	*F + B + P*	None	Pro spray	96	3	1	0	1	2	185
20.	*F + B + P*	None	Paa spray	92	5	0	1	2	3	179

Table 6 Storage assessment of bulb rots in narcissus bulbs cv Dutch Master following defoliation and inoculum and fungicide application (1996 experiment). Angle-transformed data as used in analysis of variance (aov)

Treatment				Mean percentage of bulbs (angle transformed)					
Ref	Pathogen	Fungicide (pre-lifting)	Fungicide (post-lifting)	Healthy bulbs	Mummified bulbs	Whole bulb rot	Basal rot	Neck rot	All rots
1.	None (not defoliated)	None	None	73.4	9.5	6.7	1.5	9.5	12.0
2.	None	Water only	None	73.3	13.9	3.6	5.1	5.0	8.8
3.	*Fusarium* (F)	None	None	73.8	11.2	7.3	4.0	6.2	11.0
4.	*Botrytis* (B)	None	None	75.5	9.2	6.5	3.5	5.6	10.7
5.	*Penicillium* (P)	None	None	77.7	10.7	4.2	1.5	1.3	6.0
6.	*F + B*	None	None	73.9	12.3	5.7	2.8	6.7	10.1
7.	*F + P*	None	None	71.8	14.5	6.3	2.9	7.2	10.3
8.	*B + P*	None	None	71.1	13.8	6.0	3.3	7.6	12.1
9.	*F + B + P*	None	None	77.3	7.2	3.7	3.7	6.4	10.3
10.	*F + B + P*	None	For dip	73.2	12.6	3.3	1.4	9.4	10.5
11.	*F + B + P*	None	TBZ dip	74.9	8.1	1.4	7.4	9.8	12.6
12.	*F + B + P*	None	Pro dip	76.2	8.2	5.6	4.1	4.1	9.3
13.	*F + B + P*	TBZ(2 sprays)	None	75.4	7.7	4.4	6.2	8.4	12.1
14.	*F + B + P*	Pro(2 sprays)	None	76.7	10.1	6.9	3.4	1.9	8.5
15.	*F + B + P*	Paa(2 sprays)	None	73.1	6.4	7.8	4.0	11.0	14.5
16.	*F + B + P*	TBZ(1 spray)	None	75.8	10.9	4.0	2.3	5.7	8.9
17.	*F + B + P*	Pro(1 spray)	None	73.9	12.1	6.2	3.4	6.0	10.0
18.	*F + B + P*	None	TBZ spray	72.2	11.8	5.1	4.1	10.2	12.3
19.	*F + B + P*	None	Pro spray	77.8	9.1	4.8	1.9	4.3	7.5
20.	*F + B + P*	None	Paa spray	74.2	12.7	1.9	5.5	5.6	9.1
	SED (38 df)			3.52	4.32	2.52	2.29	2.97	2.18
	Significance (1-factor aov)								
	20 treatments			ns	ns	ns	ns	ns	ns
	Significance (factorial aov)								
	unflailed v. top-bashed			ns	ns	ns	ns	ns	ns
	inoculated group v. fungicide group			ns	ns	ns	ns	ns	ns
	F. v. no *Fusarium*			ns	ns	ns	ns	ns	ns
	B. v. no *Botrytis*			ns	ns	ns	ns	ns	ns
	P. v. no *Penicillium*			ns	ns	ns	ns	ns	ns
	interaction between F + B or none			ns	ns	ns	ns	ns	*
	interaction between F + P or none			ns	ns	ns	ns	ns	ns
	interaction between B + P or none			ns	ns	ns	ns	ns	ns
	interaction between F + B + P or none			ns	ns	ns	ns	ns	ns
	pre-lift sprays v. post-lift treatments			ns	ns	*	ns	ns	ns
	between post-lift fungicide treatments			ns	ns	ns	ns	ns	ns
	between pre-lift fungicide treatments			ns	ns	ns	ns	*	*

Table 7 Percentage of bulbs mummified at lifting for cv Carlton in the 1997 neck rot experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments Spraying/inoculation	Defoliation	% bulbs mummified at lifting	
Untreated	None	0.5	(3.3)
	Flailed	0.7	(4.6)
	Flailed (covered)	0.9	(5.3)
	Burnt-over	1.1	(5.7)
Fungicide (early)	None	0.5	(3.1)
	Flailed	1.5	(6.9)
	Flailed (covered)	1.4	(6.4)
	Burnt-over	0.5	(4.1)
Fungicide (late)	None	1.2	(6.1)
	Flailed	1.0	(5.6)
	Flailed (covered)	0.8	(4.2)
	Burnt-over	3.1	(9.9)
Inoculum (spore)	None	1.0	(5.6)
	Flailed	1.5	(5.5)
	Flailed (covered)	1.7	(7.2)
	Burnt-over	1.7	(6.9)
Inoculum (mycelium)	None	0.9	(5.4)
	Flailed	1.4	(6.3)
	Flailed (covered)	0.2	(2.2)
	Burnt-over	0.8	(4.8)
SED (38 df)		-	(2.15)
Significance			
Spraying/inoculum			NS
Defoliation			NS
Interaction			NS

Table 8 Percentage of bulbs with neck rot, at four assessment dates, for cv Carlton in the 1997 neck rot experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments		% bulbs with neck rot							
Spraying/inoculation	Defoliation	Date 1		Date 2		Date 3		Date 4	
Untreated	None	1.0	(3.3)	0.7	(2.8)	2.1	(6.4)	0.8	(4.1)
	Flailed	0.0	(0.0)	0.0	(0.0)	1.7	(7.3)	0.7	(2.9)
	Flailed (covered)	1.2	(3.6)	2.2	(8.4)	7.1	(14.4)	0.9	(3.1)
	Burnt-over	0.6	(2.6)	1.6	(5.8)	2.7	(7.1)	0.0	(0.0)
Fungicide (early)	None	0.5	(2.4)	0.9	(4.5)	2.0	(6.3)	0.0	(0.0)
	Flailed	2.4	(7.0)	1.6	(5.9)	2.8	(9.6)	0.0	(0.0)
	Flailed (covered)	1.9	(4.6)	1.7	(7.3)	1.7	(4.3)	0.4	(2.1)
	Burnt-over	0.5	(2.4)	0.4	(2.1)	2.1	(6.9)	0.0	(0.0)
Fungicide (late)	None	1.2	(3.6)	0.4	(2.2)	0.8	(3.0)	1.3	(5.3)
	Flailed	1.8	(7.6)	1.2	(3.7)	0.7	(2.9)	0.4	(2.1)
	Flailed (covered)	0.6	(2.5)	2.2	(8.2)	1.7	(6.0)	0.5	(2.2)
	Burnt-over	0.6	(2.5)	1.4	(5.5)	2.3	(6.8)	0.5	(2.3)
Inoculum (spore)	None	2.4	(8.6)	1.9	(6.5)	1.6	(7.2)	1.3	(5.2)
	Flailed	2.3	(8.5)	1.2	(3.7)	1.7	(6.0)	0.4	(2.1)
	Flailed (covered)	0.0	(0.0)	0.8	(4.3)	0.9	(4.3)	0.0	(0.0)
	Burnt-over	1.9	(4.6)	2.1	(4.5)	0.9	(3.1)	0.8	(4.3)
Inoculum (mycelium)	None	0.0	(0.0)	0.4	(2.1)	0.4	(2.1)	0.0	(0.0)
	Flailed	1.0	(4.7)	1.2	(5.1)	3.1	(10.1)	0.4	(2.1)
	Flailed (covered)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
	Burnt-over	0.0	(0.0)	0.4	(2.1)	2.3	(8.6)	0.0	(0.0)
SED (38 df)		-	(3.71)	-	(3.42)	-	(4.15)	-	(2.63)
Significance									
Spraying/inoculum		NS		NS		NS		NS	
Defoliation		NS		NS		NS		NS	
Interaction		NS		NS		NS		NS	

Table 9 Percentage of bulbs with basal rot at assessment dates 2 to 4, and percentage bulbs with whole-bulb rot at assessment date 4, for cv Carlton in the 1997 neck rot experiment. (No bulbs with basal rot occurred on assessment 1, and none with whole-bulb rot on assessments 1 to 3). Means in parenthesis are angle-transformed data used for statistical analysis

Treatments Spraying/inoculation	Defoliation	% bulbs with basal rot			%with whole bulb rot,
		Date 2	Date 3	Date 4	Date 4
Untreated	None	3.9 (10.8)	6.0 (13.7)	1.5 (7.1)	4.0 (11.0)
	Flailed	0.8 (4.2)	6.6 (14.4)	3.4 (10.0)	6.0 (13.9)
	Flailed (covered)	0.9 (3.2)	1.7 (7.5)	1.8 (6.0)	5.3 (12.5)
	Burnt-over	0.4 (2.0)	5.4 (13.2)	1.6 (5.8)	8.0 (16.1)
Fungicide (early)	None	0.0 (0.0)	6.8 (14.9)	1.4 (5.5)	3.5 (10.7)
	Flailed	1.2 (5.1)	2.9 (9.0)	2.1 (6.7)	5.6 (13.5)
	Flailed (covered)	1.7 (7.3)	2.1 (8.0)	0.8 (4.3)	2.5 (8.9)
	Burnt-over	0.8 (4.2)	4.2 (11.7)	1.2 (5.0)	4.2 (11.2)
Fungicide (late)	None	0.4 (2.1)	5.0 (12.7)	1.2 (6.3)	4.9 (12.1)
	Flailed	1.2 (5.1)	3.2 (10.1)	0.0 (0.0)	4.3 (12.0)
	Flailed (covered)	0.9 (4.4)	4.9 (12.4)	1.3 (3.9)	5.3 (12.6)
	Burnt-over	0.5 (2.2)	3.3 (8.6)	0.5 (2.3)	4.7 (11.9)
Inoculum (spore)	None	2.3 (7.1)	6.7 (12.3)	0.8 (3.0)	1.3 (5.2)
	Flailed	1.0 (3.2)	5.5 (13.5)	1.2 (5.1)	6.9 (15.2)
	Flailed (covered)	1.7 (6.0)	3.7 (10.9)	0.0 (0.0)	3.9 (10.8)
	Burnt-over	2.0 (7.9)	6.1 (13.4)	4.1 (11.6)	4.9 (12.7)
Inoculum (mycelium)	None	0.8 (3.0)	3.7 (11.1)	1.3 (5.2)	6.6 (14.3)
	Flailed	1.1 (4.9)	3.1 (9.8)	0.0 (0.0)	4.8 (12.3)
	Flailed (covered)	0.9 (3.1)	3.0 (9.5)	1.3 (5.2)	2.2 (6.5)
	Burnt-over	1.6 (5.7)	6.4 (14.5)	1.5 (4.1)	3.9 (9.3)
SED (38 df)		- (3.62)	- (3.54)	- (3.37)	- (3.68)
Significance					
Spraying/inoculum		NS	NS	NS	NS
Defoliation		NS	NS	NS	NS
Interaction		NS	NS	NS	NS

Table 10 Percentage of bulbs mummified at lifting for cv Dutch Master in the 1997 neck rot experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments Spraying/inoculation	Defoliation	% bulbs mummified at lifting	
Untreated	None	0.2	(2.2)
	Flailed	0.2	(2.8)
	Flailed (covered)	0.1	(0.9)
	Burnt-over	0.0	(0.0)
Inoculum (early)	None	0.4	(2.8)
	Flailed	0.2	(1.3)
	Flailed (covered)	0.3	(2.3)
	Burnt-over	0.2	(2.3)
Inoculum (late)	None	0.2	(1.3)
	Flailed	0.2	(1.8)
	Flailed (covered)	0.1	(0.9)
	Burnt-over	0.1	(0.9)
Fungicide + inoculum (early)	None	0.2	(2.3)
	Flailed	0.1	(1.2)
	Flailed (covered)	0.3	(3.2)
	Burnt-over	0.0	(0.0)
Fungicide + inoculum (late)	None	0.2	(2.8)
	Flailed	0.2	(1.9)
	Flailed (covered)	0.2	(1.9)
	Burnt-over	0.1	(1.3)
SED (38 df)		-	(1.44)
Significance			
Spraying/inoculum			NS
Defoliation			NS
Interaction			NS

Table 11 Percentage of bulbs with neck rot, at five assessment dates, for cv Dutch Master in the 1997 neck rot experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments Spraying/inoculation	Defoliation	% bulbs with neck rot Date 1		Date 2		Date 3		Date 4		Date 5	
Untreated	None	1.2	(6.4)	3.3	(9.6)	2.0	(6.7)	1.0	(3.4)	0.0	(0.0)
	Flailed	1.9	(6.2)	2.7	(9.0)	1.3	(5.3)	0.0	(0.0)	0.0	(0.0)
	Flailed (covered)	0.4	(2.1)	4.2	(11.8)	1.5	(5.6)	0.0	(0.0)	0.3	(1.7)
	Burnt-over	1.2	(5.1)	2.3	(8.5)	0.5	(2.4)	0.5	(2.3)	0.0	(0.0)
Inoculum (early)	None	0.8	(4.2)	1.4	(5.5)	0.5	(2.3)	0.5	(2.2)	0.0	(0.0)
	Flailed	3.5	(8.6)	1.0	(4.5)	1.4	(5.5)	1.9	(6.5)	0.0	(0.0)
	Flailed (covered)	2.4	(7.4)	1.4	(5.3)	1.5	(5.7)	0.0	(0.0)	0.0	(0.0)
	Burnt-over	1.4	(5.6)	1.4	(5.5)	1.1	(4.8)	0.0	(0.0)	0.0	(0.0)
Inoculum (late)	None	3.2	(10.2)	2.0	(8.0)	0.5	(2.4)	0.0	(0.0)	0.6	(2.5)
	Flailed	2.4	(8.3)	3.2	(9.7)	1.6	(5.9)	2.5	(9.0)	0.0	(0.0)
	Flailed (covered)	0.8	(4.1)	3.3	(10.3)	1.6	(5.8)	0.5	(2.3)	0.0	(0.0)
	Burnt-over	3.2	(10.2)	1.0	(4.5)	0.5	(2.3)	0.0	(0.0)	0.0	(0.0)
Fungicide + inoculum (early)	None	1.6	(5.7)	1.6	(7.2)	0.9	(4.5)	1.0	(4.7)	0.0	(0.0)
	Flailed	2.0	(6.5)	2.0	(8.0)	0.0	(0.0)	0.5	(2.4)	0.0	(0.0)
	Flailed (covered)	1.0	(3.3)	1.3	(5.1)	1.5	(5.6)	0.0	(0.0)	0.0	(0.0)
	Burnt-over	0.8	(4.3)	2.8	(9.6)	0.0	(0.0)	0.4	(2.0)	0.0	(0.0)
Fungicide + inoculum (late)	None	2.4	(8.8)	4.5	(12.2)	1.3	(3.7)	0.5	(2.3)	0.6	(2.5)
	Flailed	2.1	(6.7)	2.7	(9.1)	2.5	(7.4)	0.0	(0.0)	0.0	(0.0)
	Flailed (covered)	0.8	(3.1)	4.4	(12.1)	2.4	(7.3)	0.0	(0.0)	0.0	(0.0)
	Burnt-over	2.0	(6.3)	1.1	(3.4)	0.4	(2.1)	0.0	(0.0)	0.3	(1.7)
SED (38 df)		-	(4.05)	-	(2.94)	-	(3.71)	-	(2.33)	-	(1.36)
Significance											
Spraying/inoculum			NS		*		NS		NS		NS
Defoliation			NS		NS		NS		*		NS
Interaction			NS		NS		NS		*		NS

Table 12 Percentage of bulbs with basal rot at assessment dates 2 to 5 (there was none in sample 1), and with whole-bulb rot at sample dates 4 and 5 (none occurred in earlier samples) for cv Dutch Master in the 1997 neck rot experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments Spraying/ inoculation	Defoliation	% bulbs with basal rot				% with whole-bulb rot	
		Date 2	Date 3	Date 4	Date 5	Date 4	Date 5
Untreated	None	1.8 (7.4)	2.3 (8.5)	0.9 (4.5)	0.0 (0.0)	4.6 (11.9)	1.0 (4.5)
	Flailed	0.4 (2.0)	4.3 (11.9)	1.4 (3.9)	0.0 (0.0)	5.1 (12.1)	4.0(11.5)
	Flailed (covered)	1.3 (5.3)	1.9 (6.5)	0.4 (2.2)	0.4 (2.0)	1.9 (6.5)	2.2 (8.2)
	Burnt-over	0.7 (3.8)	2.6 (7.5)	1.5 (4.0)	0.0 (0.0)	0.0 (0.0)	1.3 (5.3)
Inoculum (early)	None	1.2 (6.3)	5.9 (13.6)	1.6 (5.8)	0.0 (0.0)	1.4 (3.9)	1.8 (4.4)
	Flailed	1.0 (4.5)	4.0 (10.8)	1.9 (6.2)	0.3 (1.9)	1.4 (3.9)	2.8 (7.8)
	Flailed (covered)	0.0 (0.0)	4.1 (11.1)	1.5 (5.7)	0.3 (1.9)	2.5 (5.3)	4.4(11.5)
	Burnt-over	0.4 (2.0)	3.8 (10.9)	0.5 (2.4)	0.7 (4.0)	2.8 (7.5)	1.8 (7.6)
Inoculum (late)	None	1.0 (4.5)	1.7 (4.3)	1.1 (3.5)	0.0 (0.0)	1.8 (6.2)	1.3 (6.5)
	Flailed	1.0 (5.8)	5.0 (12.8)	4.8(10.2)	0.4 (2.0)	5.4 (13.2)	4.9(10.5)
	Flailed (covered)	1.3 (5.2)	3.2 (6.0)	0.5 (2.3)	0.0 (0.0)	0.5 (2.4)	1.4 (5.3)
	Burnt-over	0.3 (1.9)	5.5 (13.2)	1.3 (3.8)	0.6 (2.5)	1.8 (6.4)	5.2(12.7)
Fungicide+ inoculum (early)	None	0.3 (1.8)	5.2 (12.5)	0.5 (2.4)	0.3 (1.9)	3.8 (10.8)	2.8 (7.8)
	Flailed	2.1 (6.8)	3.2 (9.6)	1.5 (5.7)	0.7 (2.8)	3.6 (10.8)	0.7 (2.8)
	Flailed (covered)	0.3 (1.9)	2.0 (6.6)	0.5 (2.3)	0.3 (1.9)	1.5 (4.1)	1.3 (6.5)
	Burnt-over	1.3 (5.0)	1.9 (6.4)	0.7 (2.8)	0.5 (3.3)	1.1 (4.8)	1.3 (5.1)
Fungicide+ inoculum (late)	None	0.9 (4.4)	2.7 (7.8)	0.5 (2.3)	0.3 (1.9)	4.1 (9.5)	2.4 (7.3)
	Flailed	1.7 (7.2)	2.0 (6.4)	0.0 (0.0)	0.0 (0.0)	1.5 (5.6)	2.3 (8.6)
	Flailed (covered)	1.0 (4.7)	1.5 (7.1)	1.5 (5.6)	0.0 (0.0)	4.0 (8.6)	3.4 (9.8)
	Burnt-over	0.9 (4.3)	4.4 (11.9)	0.0 (0.0)	0.0 (0.0)	2.8 (9.5)	0.7 (3.9)
SED (38 df)		- 3.08	- (4.24)	- (4.09)	- (2.10)	- (4.43)	- (4.03)
Significance							
Spraying/inoculum		NS	NS	NS	NS	NS	NS
Defoliation		NS	NS	NS	NS	NS	NS
Interaction		NS	NS	NS	NS	NS	NS

Table 13 Percentage of bulbs with neck rot when assessed immediately after lifting (no other types of bulb rot were found at this assessment): cv Carlton in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with neck rot	
C, F, no inoculum	0	(0)
C, F, inoculum (April)	2	(7)
C, F, inoculum (May)	1	(3)
C, F, inoculum (June)	4	(10)
C, F, inoculum (3x)	1	(4)
C, F, mycelium (June)	0	(0)
C, F, flail + inoculum	4	(11)
C, F, flail	0	(0)
C, F, top-bash + inoculum	1	(4)
C, F, top-bash	1	(5)
C, NF, no inoculum	4	(11)
C, NF, inoculum (April)	13	(21)
C, NF, inoculum (May)	6	(12)
C, NF, inoculum (June)	2	(5)
C, NF, inoculum (3x)	1	(3)
C, NF, mycelium (June)	7	(15)
C, NF, flail + inoculum	2	(7)
C, NF, flail	6	(14)
C, NF, top-bash + inoculum	3	(9)
C, NF, top-bash	0	(0)
NC, F, no inoculum	1	(5)
NC, F, inoculum (April)	3	(9)
NC, F, inoculum (May)	1	(4)
NC, F, inoculum (June)	1	(3)
NC, F, inoculum (3x)	1	(7)
NC, F, mycelium (June)	3	(3)
NC, F, flail + inoculum	1	(11)
NC, F, flail	3	(9)
NC, F, top-bash + inoculum	2	(5)
NC, F, top-bash	1	(11)
NC, NF, no inoculum	1	(4)
NC, NF, inoculum (April)	3	(10)
NC, NF, inoculum (May)	1	(4)
NC, NF, inoculum (June)	3	(8)
NC, NF, inoculum (3x)	2	(7)
NC, NF, mycelium (June)	1	(3)
NC, NF, flail + inoculum	4	(11)
NC, NF, flail	4	(9)
NC, NF, top-bash + inoculum	1	(5)
NC, NF, top-bash	4	(11)
SED (78df)	-	(4.3)
Significance		
Cropping (C)	NS	
Fungicide (F)	***	
Treatments (T)	NS	
C x F	NS	
C x T	NS	
F x T	NS	
C x F x T	***	

Table 14 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 4 weeks after lifting: non-dipped bulbs of cv Carlton in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots					
	Neck rot		Basal rot		Overall %	
C, F, no inoculum	3	(9)	0	(0)	3	(9)
C, F, inoculum (April)	3	(7)	1	(4)	4	(11)
C, F, inoculum (May)	2	(7)	1	(3)	3	(8)
C, F, inoculum (June)	4	(11)	1	(5)	5	(13)
C, F, inoculum (3x)	3	(7)	1	(4)	4	(9)
C, F, mycelium (June)	3	(8)	1	(5)	4	(11)
C, F, flail + inoculum	2	(7)	1	(4)	3	(8)
C, F, flail	1	(3)	1	(3)	1	(4)
C, F, top-bash + inoculum	25	(30)	5	(12)	30	(33)
C, F, top-bash	3	(9)	0	(0)	3	(9)
C, NF, no inoculum	1	(4)	1	(3)	2	(5)
C, NF, inoculum (April)	3	(8)	1	(3)	3	(9)
C, NF, inoculum (May)	3	(10)	0	(0)	3	(10)
C, NF, inoculum (June)	5	(10)	0	(0)	5	(10)
C, NF, inoculum (3x)	3	(8)	1	(3)	4	(9)
C, NF, mycelium (June)	1	(3)	1	(4)	2	(5)
C, NF, flail + inoculum	1	(4)	0	(0)	1	(4)
C, NF, flail	3	(5)	0	(0)	3	(5)
C, NF, top-bash + inoculum	3	(10)	2	(7)	5	(13)
C, NF, top-bash	1	(3)	0	(0)	1	(3)
NC, F, no inoculum	1	(3)	0	(0)	1	(3)
NC, F, inoculum (April)	6	(11)	0	(0)	6	(11)
NC, F, inoculum (May)	3	(7)	1	(4)	4	(9)
NC, F, inoculum (June)	9	(17)	1	(4)	11	(19)
NC, F, inoculum (3x)	13	(21)	4	(9)	17	(24)
NC, F, mycelium (June)	14	(22)	3	(10)	17	(24)
NC, F, flail + inoculum	8	(13)	1	(3)	9	(16)
NC, F, flail	1	(5)	1	(3)	2	(8)
NC, F, top-bash + inoculum	17	(24)	8	(16)	25	(30)
NC, F, top-bash	2	(7)	1	(3)	3	(3)
NC, NF, no inoculum	0	(0)	1	(5)	1	(5)
NC, NF, inoculum (April)	1	(3)	1	(5)	2	(7)
NC, NF, inoculum (May)	8	(16)	0	(0)	8	(16)
NC, NF, inoculum (June)	3	(9)	1	(3)	3	(10)
NC, NF, inoculum (3x)	11	(18)	2	(7)	13	(21)
NC, NF, mycelium (June)	5	(12)	1	(4)	6	(14)
NC, NF, flail + inoculum	5	(12)	2	(5)	7	(14)
NC, NF, flail	1	(3)	0	(0)	1	(3)
NC, NF, top-bash + inoculum	11	(16)	4	(9)	15	(19)
NC, NF, top-bash	0	(0)	1	(3)	1	(3)
SED (78df)	-	(5.0)	-	(3.9)	-	(5.2)
Significance						
Cropping (C)	*		NS		***	
Fungicide (F)	**		NS		***	
Treatments (T)	***		***		***	
C x F	NS		NS		NS	
C x T	**		NS		*	
F x T	*		NS		*	
C x F x T	NS		NS		NS	

Table 15 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 4 weeks after lifting: dipped bulbs of cv Carlton in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots Neck rot		Basal rot		Overall %	
C, F, no inoculum	1	(3)	0	(0)	1	(3)
C, F, inoculum (April)	0	(0)	1	(3)	1	(3)
C, F, inoculum (May)	0	(0)	0	(0)	0	(0)
C, F, inoculum (June)	0	(0)	0	(0)	0	(0)
C, F, inoculum (3x)	2	(7)	3	(7)	5	(12)
C, F, mycelium (June)	2	(7)	0	(0)	2	(7)
C, F, flail + inoculum	0	(0)	0	(0)	0	(0)
C, F, flail	0	(0)	0	(0)	0	(0)
C, F, top-bash + inoculum	11	(19)	6	(13)	17	(24)
C, F, top-bash	0	(0)	0	(0)	0	(0)
C, NF, no inoculum	0	(0)	1	(3)	1	(3)
C, NF, inoculum (April)	1	(3)	0	(0)	1	(3)
C, NF, inoculum (May)	1	(4)	0	(0)	1	(4)
C, NF, inoculum (June)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (3x)	0	(0)	0	(0)	0	(0)
C, NF, mycelium (June)	0	(0)	0	(0)	0	(0)
C, NF, flail + inoculum	0	(0)	0	(0)	0	(0)
C, NF, flail	0	(0)	0	(0)	0	(0)
C, NF, top-bash + inoculum	2	(7)	0	(0)	2	(7)
C, NF, top-bash	1	(3)	0	(0)	1	(3)
NC, F, no inoculum	0	(0)	1	(5)	1	(5)
NC, F, inoculum (April)	1	(3)	0	(0)	1	(3)
NC, F, inoculum (May)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (June)	0	(0)	1	(4)	1	(4)
NC, F, inoculum (3x)	0	(0)	1	(3)	1	(3)
NC, F, mycelium (June)	0	(0)	0	(0)	0	(0)
NC, F, flail + inoculum	1	(3)	0	(0)	1	(3)
NC, F, flail	0	(0)	0	(0)	0	(0)
NC, F, top-bash + inoculum	8	(16)	4	(9)	12	(20)
NC, F, top-bash	1	(0)	0	(0)	0	(0)
NC, NF, no inoculum	1	(3)	0	(0)	1	(3)
NC, NF, inoculum (April)	1	(5)	0	(0)	1	(5)
NC, NF, inoculum (May)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (June)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (3x)	1	(3)	0	(0)	1	(3)
NC, NF, mycelium (June)	0	(0)	0	(0)	0	(0)
NC, NF, flail + inoculum	0	(0)	0	(0)	0	(0)
NC, NF, flail	0	(0)	0	(0)	0	(0)
NC, NF, top-bash + inoculum	5	(10)	1	(4)	6	(12)
NC, NF, top-bash	0	(0)	0	(0)	0	(0)
SED (78df)	-	(2.6)	-	(2.4)	-	(3.2)
Significance						
Cropping (C)	NS		***		NS	
Fungicide (F)	NS		***		**	
Treatments (T)	***		**		***	
C x F	NS		NS		NS	
C x T	NS		NS		NS	
F x T	**		**		***	
C x F x T	NS		NS		NS	

Table 16 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 8 weeks after lifting: non-dipped bulbs of cv Carlton in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots Neck rot		Basal rot		Whole-bulb rot		Overall %	
C, F, no inoculum	0	(0)	0	(0)	2	(7)	2	(7)
C, F, inoculum (April)	0	(0)	3	(9)	4	(11)	7	(14)
C, F, inoculum (May)	3	(9)	2	(8)	2	(7)	7	(15)
C, F, inoculum (June)	1	(5)	3	(6)	7	(15)	12	(19)
C, F, inoculum (3x)	2	(7)	1	(5)	7	(15)	11	(19)
C, F, mycelium (June)	3	(8)	1	(5)	9	(17)	13	(20)
C, F, flail + inoculum	1	(3)	1	(3)	5	(11)	7	(14)
C, F, flail	0	(0)	1	(3)	4	(9)	5	(10)
C, F, top-bash + inoculum	3	(8)	7	(16)	28	(32)	38	(38)
C, F, top-bash	0	(0)	0	(0)	2	(5)	2	(5)
C, NF, no inoculum	0	(0)	0	(0)	1	(3)	1	(3)
C, NF, inoculum (April)	0	(0)	1	(3)	1	(3)	1	(5)
C, NF, inoculum (May)	2	(7)	2	(5)	6	(14)	10	(18)
C, NF, inoculum (June)	0	(0)	0	(0)	1	(3)	1	(3)
C, NF, inoculum (3x)	2	(7)	3	(8)	3	(5)	7	(15)
C, NF, mycelium (June)	1	(3)	0	(0)	2	(7)	3	(8)
C, NF, flail + inoculum	1	(3)	1	(4)	1	(3)	3	(7)
C, NF, flail	0	(0)	1	(3)	1	(3)	1	(4)
C, NF, top-bash + inoculum	0	(0)	1	(5)	12	(20)	13	(21)
C, NF, top-bash	1	(3)	0	(0)	0	(0)	1	(3)
NC, F, no inoculum	0	(0)	1	(3)	2	(6)	3	(8)
NC, F, inoculum (April)	0	(0)	0	(0)	4	(11)	4	(11)
NC, F, inoculum (May)	1	(3)	3	(7)	9	(16)	12	(19)
NC, F, inoculum (June)	1	(5)	2	(7)	13	(21)	16	(23)
NC, F, inoculum (3x)	3	(10)	1	(3)	9	(17)	13	(21)
NC, F, mycelium (June)	2	(8)	0	(0)	7	(15)	9	(17)
NC, F, flail + inoculum	0	(0)	3	(8)	16	(23)	19	(25)
NC, F, flail	0	(0)	1	(5)	2	(7)	3	(10)
NC, F, top-bash + inoculum	2	(5)	3	(8)	30	(33)	35	(36)
NC, F, top-bash	0	(0)	1	(4)	3	(8)	5	(9)
NC, NF, no inoculum	0	(0)	0	(0)	1	(3)	1	(3)
NC, NF, inoculum (April)	0	(0)	1	(3)	3	(10)	4	(12)
NC, NF, inoculum (May)	4	(9)	2	(7)	6	(14)	12	(20)
NC, NF, inoculum (June)	1	(3)	0	(0)	3	(9)	4	(11)
NC, NF, inoculum (3x)	1	(4)	2	(5)	11	(19)	14	(22)
NC, NF, mycelium (June)	2	(5)	3	(9)	7	(16)	13	(21)
NC, NF, flail + inoculum	1	(3)	2	(7)	7	(14)	9	(17)
NC, NF, flail	0	(0)	1	(3)	3	(5)	3	(6)
NC, NF, top-bash + inoculum	1	(3)	1	(5)	13	(20)	15	(21)
NC, NF, top-bash	1	(3)	0	(0)	1	(5)	2	(7)
SED (78df)	-	(3.5)	-	(4.0)	-	(4.9)	-	(5.2)
Significance								
Cropping (C)	NS		NS		***		**	
Fungicide (F)	NS		NS		***		***	
Treatments (T)	***		***		***		***	
C x F	NS		NS		NS		NS	
C x T	NS		NS		NS		NS	
F x T	NS		NS		NS		*	
C x F x T	NS		NS		NS		NS	

Table 17 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 8 weeks after lifting: dipped bulbs of cv Carlton in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots							
	Neck rot		Basal rot		Whole-bulb rot		Overall %	
C, F, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, F, inoculum (April)	0	(0)	0	(0)	1	(3)	1	(3)
C, F, inoculum (May)	0	(0)	0	(0)	1	(3)	1	(3)
C, F, inoculum (June)	0	(0)	0	(0)	0	(0)	0	(0)
C, F, inoculum (3x)	0	(0)	0	(0)	0	(0)	0	(0)
C, F, mycelium (June)	0	(0)	0	(0)	1	(3)	1	(3)
C, F, flail + inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, F, flail	0	(0)	0	(0)	0	(0)	0	(0)
C, F, top-bash + inoculum	1	(3)	2	(5)	7	(15)	9	(17)
C, F, top-bash	0	(0)	0	(0)	1	(3)	1	(3)
C, NF, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (April)	2	(8)	1	(3)	1	(3)	3	(10)
C, NF, inoculum (May)	0	(0)	0	(0)	1	(3)	1	(3)
C, NF, inoculum (June)	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (3x)	0	(0)	4	(7)	3	(9)	7	(13)
C, NF, mycelium (June)	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, flail + inoculum	0	(0)	0	(0)	1	(4)	1	(4)
C, NF, flail	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, top-bash + inoculum	0	(0)	3	(5)	2	(7)	5	(10)
C, NF, top-bash	0	(0)	1	(3)	1	(3)	1	(5)
NC, F, no inoculum	0	(0)	0	(0)	2	(5)	2	(5)
NC, F, inoculum (April)	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (May)	1	(3)	0	(0)	1	(3)	1	(4)
NC, F, inoculum (June)	0	(0)	0	(0)	2	(8)	2	(8)
NC, F, inoculum (3x)	0	(0)	1	(3)	0	(0)	1	(3)
NC, F, mycelium (June)	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, flail + inoculum	0	(0)	0	(0)	1	(3)	1	(3)
NC, F, flail	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, top-bash + inoculum	2	(7)	7	(15)	5	(12)	15	(21)
NC, F, top-bash	0	(0)	1	(3)	1	(3)	1	(4)
NC, NF, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (April)	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (May)	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (June)	0	(0)	0	(0)	0	(4)	1	(4)
NC, NF, inoculum (3x)	0	(0)	1	(3)	1	(3)	1	(4)
NC, NF, mycelium (June)	1	(4)	0	(0)	1	(3)	2	(7)
NC, NF, flail + inoculum	0	(0)	1	(2)	1	(0)	1	(3)
NC, NF, flail	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, top-bash + inoculum	1	(3)	0	(0)	6	(8)	7	(9)
NC, NF, top-bash	1	(3)	0	(0)	0	(0)	1	(3)
SED (78df)	-	(1.6)	-	(2.7)	-	(3.4)	-	(4.2)
Significance								
Cropping (C)	NS		NS		NS		NS	
Fungicide (F)	NS		NS		NS		NS	
Treatments (T)	**		***		***		***	
C x F	NS		*		NS		NS	
C x T	**		NS		NS		NS	
F x T	**		NS		NS		*	
C x F x T	NS		NS		NS		NS	

Table 18 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed immediately after lifting: cv Dutch Master in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots					
	Neck rot		Basal rot		Overall %	
C, F, no inoculum	3	(9)	0	(0)	3	(9)
C, F, inoculum (April)	3	(8)	1	(3)	3	(9)
C, F, inoculum (May)	2	(7)	0	(0)	2	(7)
C, F, inoculum (June)	3	(7)	0	(0)	3	(7)
C, F, inoculum (3x)	7	(12)	0	(0)	7	(12)
C, F, mycelium (June)	3	(8)	0	(0)	3	(8)
C, F, flail + inoculum	2	(7)	0	(0)	2	(7)
C, F, flail	3	(9)	0	(0)	3	(9)
C, F, top-bash + inoculum	3	(8)	0	(0)	3	(8)
C, F, top-bash	3	(6)	0	(0)	3	(6)
C, NF, no inoculum	3	(8)	0	(0)	3	(8)
C, NF, inoculum (April)	4	(12)	0	(0)	4	(12)
C, NF, inoculum (May)	5	(13)	0	(0)	5	(13)
C, NF, inoculum (June)	3	(6)	0	(0)	3	(6)
C, NF, inoculum (3x)	1	(5)	0	(0)	1	(5)
C, NF, mycelium (June)	4	(9)	0	(0)	4	(9)
C, NF, flail + inoculum	3	(7)	0	(0)	3	(7)
C, NF, flail	4	(11)	0	(0)	4	(11)
C, NF, top-bash + inoculum	8	(16)	1	(3)	9	(17)
C, NF, top-bash	6	(12)	0	(0)	6	(12)
NC, F, no inoculum	2	(7)	0	(0)	2	(7)
NC, F, inoculum (April)	1	(3)	0	(0)	1	(3)
NC, F, inoculum (May)	1	(3)	0	(0)	1	(3)
NC, F, inoculum (June)	5	(13)	0	(0)	5	(13)
NC, F, inoculum (3x)	1	(4)	0	(0)	1	(4)
NC, F, mycelium (June)	3	(9)	0	(0)	3	(9)
NC, F, flail + inoculum	2	(7)	0	(0)	2	(7)
NC, F, flail	3	(8)	0	(0)	3	(8)
NC, F, top-bash + inoculum	3	(10)	0	(0)	3	(10)
NC, F, top-bash	1	(3)	0	(0)	1	(3)
NC, NF, no inoculum	1	(4)	0	(0)	1	(4)
NC, NF, inoculum (April)	3	(8)	0	(0)	3	(8)
NC, NF, inoculum (May)	7	(15)	0	(0)	7	(15)
NC, NF, inoculum (June)	5	(10)	0	(0)	5	(10)
NC, NF, inoculum (3x)	6	(14)	0	(0)	6	(14)
NC, NF, mycelium (June)	3	(9)	0	(0)	3	(9)
NC, NF, flail + inoculum	2	(7)	0	(0)	2	(7)
NC, NF, flail	0	(0)	0	(0)	0	(0)
NC, NF, top-bash + inoculum	7	(12)	0	(0)	7	(12)
NC, NF, top-bash	3	(9)	0	(0)	3	(9)
SED (78df)	-	(5.3)	-	(0.9)	-	(5.3)
Significance						
Cropping (C)	NS		NS		NS	
Fungicide (F)	NS		NS		NS	
Treatments (T)	NS		NS		NS	
C x F	NS		NS		NS	
C x T	NS		NS		NS	
F x T	NS		NS		NS	
C x F x T	NS		NS		NS	

Table 19 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 4 weeks after lifting: non-dipped bulbs of cv Dutch Master in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots Neck rot		Basal rot		Overall %	
C, F, no inoculum	2	(7)	5	(12)	7	(15)
C, F, inoculum (April)	1	(4)	7	(15)	9	(16)
C, F, inoculum (May)	1	(4)	6	(13)	7	(15)
C, F, inoculum (June)	2	(7)	9	(17)	11	(19)
C, F, inoculum (3x)	1	(5)	11	(19)	12	(20)
C, F, mycelium (June)	3	(9)	10	(18)	13	(20)
C, F, flail + inoculum	3	(10)	3	(9)	7	(14)
C, F, flail	1	(3)	1	(3)	1	(5)
C, F, top-bash + inoculum	9	(16)	11	(18)	20	(26)
C, F, top-bash	0	(0)	1	(3)	1	(3)
C, NF, no inoculum	2	(7)	5	(12)	7	(14)
C, NF, inoculum (April)	1	(3)	3	(7)	3	(10)
C, NF, inoculum (May)	2	(7)	0	(0)	2	(7)
C, NF, inoculum (June)	1	(3)	1	(3)	1	(5)
C, NF, inoculum (3x)	3	(10)	5	(12)	8	(16)
C, NF, mycelium (June)	1	(3)	5	(8)	6	(11)
C, NF, flail + inoculum	2	(7)	4	(11)	6	(14)
C, NF, flail	1	(3)	1	(3)	1	(5)
C, NF, top-bash + inoculum	3	(9)	8	(16)	11	(19)
C, NF, top-bash	0	(0)	2	(5)	2	(5)
NC, F, no inoculum	1	(4)	5	(13)	7	(15)
NC, F, inoculum (April)	1	(0)	7	(15)	7	(15)
NC, F, inoculum (May)	1	(3)	7	(15)	7	(16)
NC, F, inoculum (June)	5	(12)	10	(18)	15	(23)
NC, F, inoculum (3x)	7	(16)	10	(18)	17	(25)
NC, F, mycelium (June)	5	(12)	12	(20)	17	(24)
NC, F, flail + inoculum	3	(8)	7	(15)	11	(19)
NC, F, flail	4	(11)	3	(7)	7	(14)
NC, F, top-bash + inoculum	12	(19)	17	(24)	29	(32)
NC, F, top-bash	1	(5)	1	(3)	2	(7)
NC, NF, no inoculum	3	(10)	3	(9)	6	(14)
NC, NF, inoculum (April)	3	(8)	11	(17)	13	(21)
NC, NF, inoculum (May)	1	(3)	9	(17)	9	(18)
NC, NF, inoculum (June)	3	(5)	3	(8)	5	(11)
NC, NF, inoculum (3x)	3	(9)	9	(17)	12	(20)
NC, NF, mycelium (June)	1	(5)	5	(12)	6	(14)
NC, NF, flail + inoculum	2	(7)	8	(16)	10	(18)
NC, NF, flail	0	(0)	7	(15)	7	(15)
NC, NF, top-bash + inoculum	11	(19)	15	(22)	25	(30)
NC, NF, top-bash	1	(3)	1	(4)	2	(7)
SED (78df)	-	(4.2)	-	(4.6)	-	(4.5)
Significance						
Cropping (C)	*		***		***	
Fungicide (F)	NS		**		***	
Treatments (T)	***		***		***	
C x F	NS		NS		NS	
C x T	NS		NS		NS	
F x T	NS		*		*	
C x F x T	NS		NS		NS	

Table 20 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 4 weeks after lifting: dipped bulbs of cv Dutch Master in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots					
	Neck rot		Basal rot		Overall %	
C, F, no inoculum	0	(0)	1	(3)	1	(3)
C, F, inoculum (April)	0	(0)	1	(4)	1	(4)
C, F, inoculum (May)	0	(0)	0	(0)	0	(0)
C, F, inoculum (June)	0	(0)	0	(0)	0	(0)
C, F, inoculum (3x)	1	(3)	1	(3)	1	(4)
C, F, mycelium (June)	0	(0)	0	(0)	0	(0)
C, F, flail + inoculum	0	(0)	0	(0)	0	(0)
C, F, flail	0	(0)	0	(0)	0	(0)
C, F, top-bash + inoculum	7	(13)	2	(7)	9	(17)
C, F, top-bash	0	0	0	(0)	0	(0)
C, NF, no inoculum	0	(0)	0	(0)	0	(0)
C, NF, inoculum (April)	2	(5)	0	(0)	2	(5)
C, NF, inoculum (May)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (June)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (3x)	1	(3)	0	(0)	1	(3)
C, NF, mycelium (June)	0	(0)	0	(0)	0	(0)
C, NF, flail + inoculum	0	(0)	1	(3)	1	(3)
C, NF, flail	1	(3)	0	(0)	1	(3)
C, NF, top-bash + inoculum	1	(4)	0	(0)	1	(4)
C, NF, top-bash	0	(0)	0	(0)	0	(0)
NC, F, no inoculum	1	(3)	0	(0)	1	(3)
NC, F, inoculum (April)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (May)	1	(3)	0	(0)	1	(3)
NC, F, inoculum (June)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (3x)	0	(0)	0	(0)	0	(0)
NC, F, mycelium (June)	0	(0)	1	(3)	1	(3)
NC, F, flail + inoculum	1	(3)	1	(4)	2	(5)
NC, F, flail	0	(0)	1	(5)	1	(5)
NC, F, top-bash + inoculum	4	(11)	1	(3)	5	(12)
NC, F, top-bash	0	(0)	0	(0)	0	(0)
NC, NF, no inoculum	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (April)	0	(0)	1	(3)	1	(3)
NC, NF, inoculum (May)	1	(5)	0	(0)	1	(5)
NC, NF, inoculum (June)	1	(3)	0	(0)	1	(3)
NC, NF, inoculum (3x)	0	(0)	0	(0)	0	(0)
NC, NF, mycelium (June)	1	(3)	1	(4)	2	(5)
NC, NF, flail + inoculum	0	(0)	1	(3)	1	(3)
NC, NF, flail	0	(0)	0	(0)	0	(0)
NC, NF, top-bash + inoculum	2	(7)	1	(4)	3	(8)
NC, NF, top-bash	0	(0)	0	(0)	0	(0)
SED (78df)	-	(2.9)	-	(2.6)	-	(3.5)
Significance						
Cropping (C)	NS		NS		NS	
Fungicide (F)	NS		NS		NS	
Treatments (T)	***		NS		***	
C x F	NS		NS		NS	
C x T	NS		NS		NS	
F x T	NS		NS		NS	
C x F x T	NS		NS		NS	

Table 21 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 8 weeks after lifting: non-dipped bulbs of cv Dutch Master in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots Neck rot		Basal rot		Whole-bulb rot		Overall %	
C, F, no inoculum	1	(3)	3	(9)	3	(9)	7	(15)
C, F, inoculum (April)	1	(3)	5	(12)	10	(18)	15	(23)
C, F, inoculum (May)	0	(0)	1	(3)	8	(16)	9	(17)
C, F, inoculum (June)	2	(5)	6	(12)	5	(12)	13	(20)
C, F, inoculum (3x)	3	(10)	4	(9)	9	(17)	16	(23)
C, F, mycelium (June)	1	(5)	5	(10)	3	(8)	9	(17)
C, F, flail + inoculum	0	(0)	3	(7)	2	(7)	5	(12)
C, F, flail	1	(3)	1	(3)	4	(11)	5	(13)
C, F, top-bash + inoculum	5	(13)	6	(14)	19	(25)	30	(33)
C, F, top-bash	0	(0)	1	(3)	3	(10)	4	(11)
C, NF, no inoculum	0	(0)	1	(3)	3	(9)	3	(10)
C, NF, inoculum (April)	1	(3)	1	(4)	6	(14)	8	(16)
C, NF, inoculum (May)	1	(4)	1	(4)	5	(12)	7	(16)
C, NF, inoculum (June)	0	(0)	2	(7)	3	(7)	5	(10)
C, NF, inoculum (3x)	5	(12)	3	(9)	5	(12)	12	(20)
C, NF, mycelium (June)	1	(3)	1	(5)	4	(9)	6	(14)
C, NF, flail + inoculum	0	(0)	1	(3)	4	(9)	5	(9)
C, NF, flail	0	(0)	5	(10)	11	(18)	15	(22)
C, NF, top-bash + inoculum	0	(0)	5	(13)	8	(16)	13	(21)
C, NF, top-bash	1	(3)	0	(0)	3	(10)	4	(12)
NC, F, no inoculum	0	(0)	5	(12)	5	(13)	10	(18)
NC, F, inoculum (April)	1	(4)	3	(5)	5	(11)	9	(15)
NC, F, inoculum (May)	1	(3)	3	(7)	7	(14)	10	(18)
NC, F, inoculum (June)	2	(7)	5	(11)	7	(15)	15	(22)
NC, F, inoculum (3x)	5	(12)	12	(16)	17	(25)	34	(36)
NC, F, mycelium (June)	3	(7)	5	(12)	11	(19)	19	(25)
NC, F, flail + inoculum	2	(8)	5	(10)	9	(17)	15	(23)
NC, F, flail	2	(7)	3	(9)	15	(22)	19	(25)
NC, F, top-bash + inoculum	9	(17)	14	(21)	12	(20)	35	(36)
NC, F, top-bash	0	(0)	6	(13)	5	(13)	11	(19)
NC, NF, no inoculum	1	(3)	1	(3)	4	(12)	5	(13)
NC, NF, inoculum (April)	2	(7)	6	(13)	9	(17)	17	(24)
NC, NF, inoculum (May)	2	(7)	6	(14)	5	(13)	13	(21)
NC, NF, inoculum (June)	1	(5)	5	(12)	7	(15)	13	(21)
NC, NF, inoculum (3x)	1	(5)	6	(11)	10	(17)	17	(24)
NC, NF, mycelium (June)	1	(3)	5	(13)	3	(7)	9	(17)
NC, NF, flail + inoculum	0	(0)	5	(13)	9	(16)	14	(21)
NC, NF, flail	1	(3)	3	(7)	3	(9)	6	(14)
NC, NF, top-bash + inoculum	2	(7)	3	(9)	15	(22)	20	(26)
NC, NF, top-bash	0	(0)	1	(3)	2	(7)	3	(7)
SED (78df)	-	(3.5)	-	(5.3)	-	(4.4)	-	(4.9)
Significance								
Cropping (C)	*		**		**		***	
Fungicide (F)	**		NS		*		***	
Treatments (T)	***		*		***		**	
C x F	NS		NS		NS		NS	
C x T	NS		NS		NS		NS	
F x T	**		NS		NS		NS	
C x F x T	NS		NS		*		*	

Table 22 Percentage of bulbs with different rots and overall percentage of rotted bulbs, when assessed 8 weeks after lifting: dipped bulbs of cv Dutch Master in the 1998 experiment. Means in parenthesis are angle-transformed data used for statistical analysis

Treatments C, NC = cropped or not F, NF = fungicide sprays or not	% bulbs with rots							
	Neck rot		Basal rot		Whole-bulb rot		Overall %	
C, F, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, F, inoculum (April)	0	(0)	0	(0)	1	(3)	1	(3)
C, F, inoculum (May)	0	(0)	1	(3)	0	(0)	1	(3)
C, F, inoculum (June)	0	(0)	1	(4)	0	(0)	1	(4)
C, F, inoculum (3x)	0	(0)	0	(0)	0	(0)	0	(0)
C, F, mycelium (June)	0	(0)	0	(0)	1	(3)	1	(3)
C, F, flail + inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, F, flail	0	(0)	0	(0)	0	(0)	0	(0)
C, F, top-bash + inoculum	3	(7)	1	(5)	6	(14)	10	(18)
C, F, top-bash	0	(0)	1	(3)	1	(3)	1	(4)
C, NF, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (April)	0	(0)	1	(3)	1	(3)	1	(5)
C, NF, inoculum (May)	0	(0)	1	(3)	0	(0)	1	(3)
C, NF, inoculum (June)	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, inoculum (3x)	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, mycelium (June)	0	(0)	0	(0)	1	(3)	1	(3)
C, NF, flail + inoculum	0	(0)	0	(0)	0	(0)	0	(0)
C, NF, flail	0	(0)	1	(3)	0	(0)	1	(3)
C, NF, top-bash + inoculum	3	(7)	1	(5)	1	(3)	5	(12)
C, NF, top-bash	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (April)	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (May)	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, inoculum (June)	1	(3)	0	(0)	1	(3)	1	(5)
NC, F, inoculum (3x)	0	(0)	0	(0)	0	(0)	0	(0)
NC, F, mycelium (June)	0	(0)	0	(0)	1	(5)	1	(5)
NC, F, flail + inoculum	0	(0)	1	(4)	1	(3)	2	(5)
NC, F, flail	1	(4)	0	(0)	0	(0)	1	(4)
NC, F, top-bash + inoculum	6	(14)	2	(5)	0	(0)	8	(16)
NC, F, top-bash	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, no inoculum	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (April)	1	(3)	0	(0)	0	(0)	1	(3)
NC, NF, inoculum (May)	1	(4)	0	(0)	1	(3)	2	(5)
NC, NF, inoculum (June)	0	(0)	0	(0)	0	(0)	0	(0)
NC, NF, inoculum (3x)	1	(3)	0	(0)	0	(0)	1	(3)
NC, NF, mycelium (June)	0	(0)	1	(3)	0	(0)	1	(3)
NC, NF, flail + inoculum	0	(0)	1	(3)	0	(0)	1	(3)
NC, NF, flail	0	(0)	0	(0)	1	(3)	1	(3)
NC, NF, top-bash + inoculum	1	(5)	2	(7)	2	(4)	5	(13)
NC, NF, top-bash	0	(0)	0	(0)	0	(0)	0	(0)
SED (78df)	-	(2.3)	-	(2.5)	-	(2.3)	-	(3.4)
Significance								
Cropping (C)	NS		NS		NS		NS	
Fungicide (F)	NS		NS		NS		NS	
Treatments (T)	***		**		***		***	
C x F	NS		NS		NS		NS	
C x T	NS		NS		NS		NS	
F x T	NS		NS		NS		NS	
C x F x T	NS		NS		**		NS	

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