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LATE SEASON HERBICIDES FOR DAFFODILS

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AUTHENTICATION

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For precise reporting, herbicides have been referred to by their product names. No endorsement is intended of products mentioned, nor criticism of those not mentioned.

PRACTICAL SECTION

Objective and background

There have been few herbicide trials with daffodils in the UK in recent years. Most approved herbicides are for pre-emergence or early-post-emergence use, and so are unsuitable for late-season use after the previous herbicide seal has been broken by the action of flower picking. The objective of this project was to test a range of herbicides applied at various stages, including just after cropping, to determine effective and safe treatments.

Summary

A trial was set up in 1994 at HRI-Kirton to test mixtures of Flexidor 125 plus Butisan S, Unicrop Flowable Diuron, Fortrol or Goltix WG, applied pre-emergence, early-post-emergence or post-cropping, as part of a herbicide programme with Profalon (pre-emergence) and Fortrol (early-post-emergence). These treatments were compared with a standard herbicide programme of Profalon (pre-emergence), Fortrol (early-post-emergence) and Basagran (post-flowering). A single late application of Fortrol plus Basagran, post-flowering, was also tested. Control plots were either handweeded or were left untended. Flowers were cropped each year at a commercial stage of picking.

In the unweeded control plots, weed cover increased steadily each year, reaching over 90 per cent by the time of crop senescence. All herbicide programmes tested - the standard programme, the late treatment and the 12 experimental programmes with Flexidor - controlled weeds successfully, and weed cover did not exceed 13 per cent in the first year or 2 per cent in the second, in any treatment. There was little practical difference in weed control between the different herbicide programmes, although using a post-cropping application of Flexidor plus Diuron, Fortrol or Goltix produced entirely weed-free plots.

Post-cropping applications of Flexidor plus Diuron or Fortrol resulted in yellowing of the crop foliage in both years, with milder symptoms when Flexidor plus Diuron was used early-post-emergence (first year only), when Basagran was used post-flowering (first year only), and when Flexidor plus Goltix was used post-cropping (second year only).

When Flexidor plus Diuron had been used post-cropping, flower yield was greatly reduced in the following year, stem length and flower size also being reduced; bulb yields were reduced by one-third, compared with plots from the standard herbicide programme, with fewer large bulbs being produced. Using Flexidor plus Fortrol post-cropping reduced flower yield in the following year and reduced bulb yield by 20 per cent. Smaller reductions in bulb yield (less than 10%) were seen when Flexidor plus Goltix had been applied post-cropping and when Flexidor plus Diuron had been given early-post-emergence; these treatments did not reduce flower yields. Herbicide programmes not specifically mentioned here produced no adverse effects on bulb or flower yield or quality.

Bulbs from all field treatments were subsequently forced as a mid-season crop in the next year, 1996/97. Post-cropping application of Flexidor plus Fortrol resulted in a reduced flower crop, and post-cropping application of Flexidor plus Diuron significantly reduced flower size.

Generally, post-cropping herbicide application delayed cropping (but only by a day) and reduced flower size by up to a few mm. Other treatments did not affect the yield or quality of forced flowers.

Action points for growers

1. Flexidor 125, in combination with Butisan S, Unicrop Flowable Diuron, Fortrol or Goltix WG, is a safe and effective herbicide treatment for pre-crop-emergence application in daffodils.

2. The same mixtures, with the exception of Flexidor 125 plus Unicrop Flowable Diuron, is safe and effective when applied soon after crop emergence.

3. Flexidor 125 plus Butisan S is safe and effective when applied just after flower cropping.

4. Care should be exercised in using Basagran as a late-season (post-flowering) treatment: it should not be used under dry conditions.

5. The above findings apply to herbicides only when used at the rates, etc, stated in the body of this report. The findings are based on a single trial with one variety, Carlton.

6. If Flexidor 125 is used in the second year of daffodil growing, at the rate used in this study (2 litres of product/ha), the land should be deep-ploughed to avoid the possibility of residues affecting some subsequent crops.

Please note that the above products do not have label approvals for this use. They can however be used under the Long Term Arrangements for Extension of Use which allows pesticides approved for use on an edible crop to be used off label on a non edible crop. Safety precautions and statutory conditions relating to use as specified on the label must be observed. Pesticides must only be used in the same situation as that on the product label i.e. outdoor or protected. This use is at the growers own risk.

Practical and financial benefits from study

The range of safe and effective herbicides suitable for use in daffodil crops has been usefully extended, including identifying Flexidor 125 plus Butisan S as a useful treatment to apply at a late stage, after flower cropping.

EXPERIMENTAL SECTION

Introduction

Herbicide recommendations for the daffodil crop date largely from MAFF-funded trials carried out at Kirton and Rosewarne in the 1960s and 1970s. Since then, as for many other horticultural crops, agrochemical companies have not been able to justify field trials with newer products. Alternative herbicides have, of course, been tried by growers on an 'own risk' basis. Products such as those containing isoxaben (eg, Flexidor) or pendimethalin (eg, Sovereign) have given good results with daffodil crops. Some herbicides, however, have been reported to cause damage to daffodil crops under certain circumstances (eg, dalapon, MCPA), while residues from sulphonyl-urea herbicides applied to previous crops have also resulted in damage. The advent of new herbicides and crop considerations prompted this herbicide trial on daffodils, which was set up with levy-funding at HRI Kirton in 1994.

During the dormant season, when there is no crop foliage above ground, daffodil crops are kept weed-free by the application of paraquat-based herbicides. Contact herbicides are also used in the summer between the daffodil's two growing years, provided the ridges are sealed so that herbicide cannot seep down cracks in the soil and reach the bulb or its old, decaying shoot tissue. In the growing season, the main requirements are to control weeds (1) which grow up with the crop and are therefore highly competitive, and (2) which develop dense swards late in the second growing season and can clog bulb-lifting machinery. In recent years, a further consideration has become important: it is now the widespread practice for crops to have their flowers picked, as has always been the case in the South-West. This means that the 'herbicide seal' on the soil surface is seriously compromised, leading to late-season weed growth. Late-season weed control is a particular difficulty as most herbicides approved for bulbs are limited to pre-emergence or early-post-emergence use, in practice meaning not after the daffodil shoots are 10 cm high. The application of herbicides late in the growing season may also cause problems for another reason: this is the time when next year's flowers are being initiated, and herbicides might affect their normal development.

Current herbicides with label approval for daffodils or bulbs generally are listed below, with the applicable timing. Most are based on chlorpropham.

Products	Active ingredients	Latest time of application
Atlas Brown	Chlorpropham + pentanochlor	Pre-emergence
Croptex Chrome*	Chlorpropham + fenuron	Pre-emergence
Atlas Red	Chlorpropham + cresylic acid + fenuron	Just before emergence
CIPC (various products)	Chlorpropham	Up to 5 cm crop growth
Fortrol	Cyanazine	Up to 10 cm
Profalon	Chlorpropham + linuron	Up to 10 cm
Basagran	Bentazone	Post-flowering

* approval for use in protected bulbs; this does not prevent its use outdoors under current pesticide legislation.

A typical herbicide programme (in each year of the two-year-down crop cycle) might consist of pre-emergence Profalon followed by Fortrol at early-post-emergence, with a paraquat-based herbicide used in the dormant periods. The recommended post-emergence herbicides were, in the earlier trials, tested up to only a relatively early post-emergence stage (say 10 cm tall shoots), because a good treatment then should control weeds until the end of the growing season, in the absence of soil disturbance due to the activity of flower picking. In any case, it is difficult to apply herbicide to the surface once the crop foliage has grown and spread to meet in the rows. There does not appear to be any physiological significance in the use of the '10 cm' restriction, it was merely a practical consideration, so, possibly, it might in fact be safe to use these post-emergence materials somewhat later on. Basagran, exceptionally, was approved for use at a post-flowering stage, so this material could be used late-season. However, there are practical difficulties in applying herbicides then, and Basagran has some shortcomings such as the limited range of species controlled and its temperature-dependent activity.

The HDC trial was set up to test new herbicide programmes, with particular reference to late-season treatments. The late-season application was to be given as soon as practical after the conclusion of flower picking (carried out at the commercial 'pencil' stage), before the foliage spreads to cover the ground between the ridges. At a time of buoyant bulb prices, the increased bulb yield resulting from eliminating competition from weeds may be financially significant. Weed competition has been shown in trials to reduce daffodil bulb yield by around 10 per cent under normal conditions, and by considerably more under conditions of water stress.

From the large number of possible experimental treatments which could have been tested, there seemed to be good prospects for using Flexidor 125 in combination with other herbicides, some of which have contact action. Four herbicides were selected: Butisan S, Unicrop Flowable Diuron, Fortrol and Goltix WG. These Flexidor mixtures were tested at three dates - pre-emergence, early-post-emergence, and after flower cropping. To maintain a credible weed control programme throughout the season, Profalon was used pre-emergence and Fortrol at early-post-emergence, as part of a programme with the Flexidor mixtures. These experimental programmes were compared with a standard programme of Profalon pre-emergence, Fortrol early-post-emergence and Basagran at the end of flowering. Finally, to see if a late-season treatment could be useful even when all earlier applications had been missed for some reason, some plots were left untreated until after flowering, when a mixture of Fortrol plus Basagran was applied. Crop quality and bulb and flower yields were recorded, and bulbs from the field trial were subsequently forced, to determine whether the herbicide treatments (many applied when the following year's flower bud is being formed) led to any shortcomings in the forced crop.

Materials and methods

Plant material

Bulbs of *Narcissus* cv. Carlton, grade 10-12 cm (circumference, slotted riddle), were taken from stocks grown at HRI Kirton. They received standard treatments after lifting in July 1994, including a post-lifting fungicide dip, drying initially on a letter box drying wall at 35°C for three days followed by continued drying and storage at ambient temperatures under

fans, hot-water treatment (HWT) in early-August, and continued storage at ambient temperatures under fans until planting. Both the post-lifting dip and the HWT tank contained formaldehyde, thiabendazole and non-ionic wetter at the recommended rates.

During storage, bulbs were weighed out into 45 lots of 10 kg each for planting in experimental plots; batches of additional bulbs were weighed out for planting as guard areas around the experimental plots.

Crop husbandry

Bulbs were planted in ridges in the field on 26 September 1994. The trial area had been previously ridged and the plots (each consisting of a 7.5 m long length of ridge) and guard areas (1 m long at either end of the plots, plus a 9.5 m long length of the ridge on either side of the plot) were marked in. This arrangement gave a planting density of 17.5 t/ha with the ridges at 0.76 m centres. At planting, bulbs were laid evenly in the ridge bottoms and the ridges were split back.

Husbandry followed good commercial practice for eastern England, except that experimental herbicide treatments were used (see below). Fertilisers were applied according to analysis and recommendations, potash in the base before cultivation and nitrogen as a top-dressing pre-emergence in the first year. Dormant season weed control was by pre-emergence application of diquat + paraquat. To prevent weed spread from the untreated pathways into the plots, paths were rotovated as necessary. Observations were made from pathways to avoid damaging the herbicide seal on the plots. From emergence, the crop received a regular fungicide programme (involving iprodione, chlorothalonil, mancozeb, benomyl and vinclozolin), with five sprays in the first year and three sprays in the second. In both years, flowers were cropped at the commercial ('pencil') stage, using normal commercial practices.

Herbicide treatments

Details of herbicides used and application rates were as listed below, rates being either those recommended in the case of herbicides with label recommendations for use on narcissus, or extrapolated from other recommended rates where there was no label for narcissus:

Profalon (200 g chlorpropham and 100 g linuron/litre; Hortichem), used at 11.2 litres/ha

Fortrol (500 g cyanazine/litre; Cyanamid), used at 5.2 litres/ha (except for treatment 16 which was half-rate)

Basagran (480 g bentazone/litre; BASF), used at 3.0 litres/ha (except for treatment 16 which was half-rate)

Flexidor 125 (125 g isoxaben/litre; DowElanco), used at 2.0 litres/ha

Butisan S (500 g metazachlor/litre; BASF), used at 2.5 litres/ha

Unicrop Flowable Diuron (500 g diuron/litre; Unicrop), used at 1.75 litres/ha

Goltix WG (70% metamitron w/w; Bayer), used at 4.0 kg/ha

The herbicide programmes tested were:

Treatment		Pre-emergence	Early-post-emergence	Post-cropping* or Post-flowering**
1.	Control (untreated)	-	-	-
2.	Control (handweeded)	-	-	-
3.	Standard programme	Profalon	Fortrol	Basagran**
4.		Flexidor + Butisan	Fortrol	-
5.		Profalon	Flexidor + Butisan	-
6.		Profalon	Fortrol	Flexidor + Butisan*
7.		Flexidor + Diuron	Fortrol	-
8.		Profalon	Flexidor + Diuron	-
9.		Profalon	Fortrol	Flexidor + Diuron*
10.		Flexidor + Fortrol	Fortrol	-
11.		Profalon	Flexidor + Fortrol	-
12.		Profalon	Fortrol	Flexidor + Fortrol*
13.		Flexidor + Goltix	Fortrol	-
14.		Profalon	Flexidor + Goltix	-
15.		Profalon	Fortrol	Flexidor + Goltix*
16.	Late treatment	-	-	Fortrol + Basagran**

All herbicides were applied in 450 litres of water/ha, using a medium quality spray, this being an acceptable common practice derived from the individual recommendations. Treatments were applied via an Oxford Precision Sprayer, the whole area of a plot with its 'picture frame' guard area being treated. Sprays were applied in the mornings, within the period 9:00 to 11:30 hours. In the first year, the pre-emergence treatments were given on 9 December 1994,

early-post-emergence treatments on 9 February 1995, post-cropping treatments (treatments 4-15) on 31 March, and post-flowering applications (treatments 3 and 16) on 3 May 1995. In the second year, the corresponding dates were 18 December 1995, 6 March 1996, 24 April 1996 and 21 May 1996. Two sets of control plots were not treated with herbicides; in one set weeds were allowed to grow unchecked, and in the other weeds were removed by hand when cover reached 10 per cent (on 17 May in 1995 and on 3 June in 1996) and again at the end of the first growing season (mid-July). The first of these controls allows the weed population and any resultant competition with the crop to be assessed, while the second allows any phytotoxicity of the herbicides to be checked.

Assessments

Prior to, and in the early stage of, crop emergence, three plots (selected at random) were checked weekly each year, recording the number of shoots per plot and their average length. In the first year, first emergence was recorded in week 2 (1995), and by week 6 about 95 per cent of bulbs had emerged and the tallest shoots were about 10 to 15 cm long, this stage being used to trigger the early-post-emergence sprays. In 1995-96, first emergence occurred in week 51 (1995), and the stage for early-post-emergence sprays in week 10 (1996).

Plots were checked weekly for weed growth, recording the total percentage weed cover in the recorded plot and the weed species present.

Crop appearance was monitored about weekly after the start of herbicide treatments, recording any visual differences from controls and plots treated with the standard herbicide programme.

Flowers were cropped at the commercial ('pencil') stage three times per week. In 1995 there were seven cropping dates from 8 March to 22 March, and in 1996, six dates from 5 April to 19 April. The number of flowers cropped from each plot at each date was recorded. Samples of 10 stems from each plot were taken on a middle harvest date, stored dry at 1°C and 90 per cent relative humidity for 5 days, then placed in plain water in a standard vase-life room. The vase-life room was maintained at 18°C and 65 per cent relative humidity, with 12 hours light per day from a bank of tubular fluorescent lamps. Stem length was measured at cropping. The diameter of fully open flowers was measured, the quality of flowers was checked, and the vase-life (number of days until the tips of the perianth segments began to senesce) was recorded.

The bulbs were lifted on 4 July 1996, immediately after flailing off the foliage. The bulbs were dried in trays by fans at ambient temperatures. When surface-dry, bulbs were cleaned by hand (offset bulbs were separated only if they were easily removed during cleaning). Bulbs were graded, recording the number and weight of bulbs in each grade. The visual quality of bulbs was also checked. For each of the 45 field plots, bulbs of grades 10-12 and 12-14 cm (circumference) were allocated for forcing in winter 1996/97.

Bulb forcing trial

Bulbs allocated for forcing (grade 10-12 and 12-14 cm bulbs from each of the 45 field plots) were transferred to a cold store (9°C) on 10 September 1996. On 22 October, after 6 weeks of storage ('pre-cooling'), bulbs were planted in unamended peat (medium grade sphagnum

peat) in wooden 'dual purpose trays' (61 x 45 x 11 cm), were thoroughly watered, and returned to the 9°C store. For planting, a layer of peat (*ca.* 6 cm deep) was placed in the tray, 60 bulbs were evenly placed across the tray by hand, and the bulbs were covered with further peat to the top of the tray. For each of the field plots one tray was planted for each grade of bulbs (there were insufficient bulbs of 12/14 cm grade to plant full trays of 60 bulbs for two replicates of treatment 9 and for one replicate of treatment 12). After planting, bulbs in store were inspected at least weekly to ensure that the peat remained sufficiently moist.

After total cold storage of 16 weeks, the trays were moved on 31 December 1996 to benching in a 'Venlo' glasshouse (minimum maintained temperature 16°C, automatic ventilation at 18°C). Bulbs of the two grades were placed in separate areas of the glasshouse, but the plots were fully randomised within the grades. In the glasshouse, trays were inspected weekly and watered as needed.

Marketable blooms were cropped daily each morning at the 'fat pencil' stage. Stems were graded by total length (including the bud), and the daily crop in each grade was recorded. The crop was examined for any abnormal bud or foliage characteristics (including foliage colouration). At the end of the cropping period, the numbers of any unmarketable blooms and of bulbs which had produced non-viable flowers were noted, along with the reason for failure.

Ten representative blooms from each tray, taken near the middle of the cropping period, were taken for vase-life testing. These blooms were first stored vertically for 5 days, dry, in a cold store at 1°C and 90% relative humidity, to simulate a storage/transport phase. Groups of ten blooms were placed in a vase of plain water in a vase-life test room with fresh air circulation, at 18°C and 65% relative humidity under tubular florescent lighting (12 hours per day). Flower diameter was recorded across the widest dimension of fully opened flowers, when flower quality was also checked. The individual dates of flower senescence (taken as the start of withering of the tips of the outer three perianth segments) were recorded.

Design and statistical analysis

The field experiment was designed as a randomised block, with three replicate blocks and 15 treatments. However, to accommodate a 16th treatment (late herbicide application), only two replicate plots were used for each of the two controls and treatment 16, these being allocated among the three blocks in balanced pairs. For the glasshouse trial, the two bulb grades used were treated as two separate experiments, within which the plots were fully randomised.

Data were subjected to an analysis of variance which was structured to make comparisons both between the controls, the standard programme and the late treatment (mostly with reduced replication; treatments 1,2,3 and 16), and within the factorial structure (herbicide x application time) of the Flexidor treatments (treatments 4 to 15). In the tables of results, the SED and statistical significance are given for both sets of treatments. For all practical purposes, however, it was found that the SED values for the 12 Flexidor treatments were similar to those from a simple analysis of variance in which missing values were entered for the missing replicates and all 16 treatments were compared. In the case of two treatments which grew poorly in the field, there were insufficient bulbs of the larger grade to provide enough bulbs of three plots for forcing, and these plots were treated as 'missing values'.

In the case of data on weed cover, results were clear cut, and formal statistical analyses were not considered worthwhile.

Results

Weed control 1995

Weed cover for 1995 is summarised in Table 1 and Figure 1. A full list of the weed species found in plots of each herbicide treatment at the end of the season is given in Table 2.

In the untreated plots, the weed population started to build from mid-April, increasing steadily to reach over 90 per cent cover by the time the crop had completely died down in early-July. Initially the main weeds were groundsel and mayweed, with black bindweed, common chickweed, knotgrass, redshank and volunteer cereals featuring later. In treatment 16, where no herbicides were applied until early-May, when Fortrol and Basagran were given, this treatment succeeded in taking out most weeds, after which weed cover increased no more quickly than in other treatments.

The standard treatment (treatment 3; Profalon, Fortrol and Basagran programme) showed only a very slow, late and limited increase in weed cover, reaching 5 per cent by the end of the growing season. In all the other treatments also, no significant weed cover was seen until mid-June, and, even by mid-July, cover did not exceed 13 per cent in any treatment. The standard herbicide programme, the late treatment, and all 12 experimental programmes, successfully controlled weeds, with little practical difference between them. Programmes which included a post-cropping treatment with Flexidor 125 plus Unicrop Flowable Diuron, Fortrol or Goltix WG were especially effective.

Weed control 1996

Weed cover for 1996 is summarised in Table 3 and Figure 2. In untreated plots, weeds increased rapidly from early-April, reaching almost 100 per cent cover by early-June; this was almost entirely due to mayweed. In other plots, the spectrum of weeds was wider - mainly black bindweed, groundsel, knotgrass, redshank and sow thistles - although not as varied as in the previous year (Table 4).

In the non-sprayed, hand-weeded plots, the weed population built up slowly, and to a much lesser extent than in the first year. In the late (Basagran plus Fortrol) treatment, weed populations also built up slowly, and the late application effectively checked the small weed population. In all other treatments - both the standard programme (treatment 3) and the Flexidor test mixtures (treatments 4-15) - weed cover was slight, reaching 1 to 2 per cent by early-June with little or no further increase. There was little practical difference between all these treatments (treatments 3-15). As found in the first year, programmes which included a post-cropping treatment with Flexidor 125 plus Unicrop Flowable Diuron, Fortrol or Goltix WG were highly effective.

Crop performance 1995

Statistical analysis showed that there were no significant differences between treatments in the number of flowers cropped per plot, or of the stem length and flower diameter of samples. This confirmed the uniformity of plots at the start of the trial.

Plots which had received Flexidor 125 plus Unicrop Flowable Diuron or Fortrol after cropping developed yellowish, less erect foliage by May. Plots which had received Flexidor 125 plus Unicrop Flowable Diuron early-post-emergence showed noticeable but milder symptoms. Plots treated with Basagran post-flowering (either as part of the standard programme or as the late treatment) also had somewhat poorer foliage than controls by late-May. These visual impressions were confirmed when foliage was scored on a scale of 1 (yellow) to 5 (dark green) (Table 5). As the foliage became senescent, these differences became less obvious, and were difficult to see by late-June, when the crop foliage was about 80 per cent senescent (Table 5). In the first year of the trial no other adverse effects were noted.

Crop performance 1996

As found in the previous year, plants which had received a post-cropping application of Flexidor 125 and Unicrop Flowable Diuron (or, to a lesser extent, Flexidor 125 plus Fortrol or Goltix WG) developed yellowish foliage (Table 5). This effect of late-season Flexidor plus Diuron was evident even in the later stages of foliar senescence (Table 5). The non-weeded controls showed faster senescence, this year, than many other treatments, presumably as a result of stress due to the considerable weed growth.

There was a marked reduction in yield of flowers in plots treated post-cropping with Flexidor 125 plus Unicrop Flowable Diuron (from 373 flowers per plot in the standard herbicide programme to 270 per plot in this treatment) and, to a lesser extent, in plots which received Flexidor 125 plus Fortrol post-cropping (to 327 per plot) (Table 6). In the late Flexidor plus Diuron treatment, flower size and stem length were significantly reduced, and there was also a suggestion of reduced vase-life with this treatment (Table 6). No other herbicide programmes produced clear detrimental effects on flower yields or quality. In the vase-life room, no other flower defects were apparent in any treatment.

Bulb yields

Bulb weights and numbers are given in Table 7. In plots treated post-cropping with Flexidor 125 plus Unicrop Flowable Diuron, there was a considerable yield reduction (34%) compared with plots from the standard herbicide programme. Smaller yield reductions occurred using Flexidor 125 plus Fortrol post-cropping (20% reduction), Flexidor 125 plus Goltix WG post-cropping (8%) or Flexidor 125 plus Fortrol early-post-emergence (5%). Most of this loss occurred in the larger grades of bulbs (>10 cm). Bulb quality (soundness and visual quality) were satisfactory in all treatments.

Bulb forcing

The number of marketable blooms produced, their distribution to length grades, and mean length, are shown in Tables 8 (for 10/12 cm grade bulbs) and 9 (12/14 cm grade). There

were few significant effects of herbicide treatments on the total number of marketable flowers produced. The only important effect was a reduction in flower numbers following previous post-cropping application of Flexidor + Fortrol, an effect seen only in the larger grade of forced bulbs, and probably a result of the poorer growth seen in the field with this treatment. There were also few significant differences in mean stem length or in the numbers of blooms in different length grades; these were related to differences between non-weeded and hand-weeded control plots, not to different herbicide applications. Only very low numbers of unmarketable flowers were produced (<1 per tray), these being mostly short, late-flowering 'scrubs'. No stem, bud or foliage defects (including changes in foliage colour) were seen in any plots during glasshouse forcing.

Information on flower cropping dates is given in tables 10 and 11 for the two grades of bulbs forced. No significant effects of different herbicide treatments are indicated in these Tables, although other analyses showed a slight (1 day) delay in the start of cropping, with small grade bulbs only, following the post-cropping application of herbicides. Bulbs from the hand-weeded control plots appeared consistently and significantly earlier to cropping than those from the non-weeded controls. Vase-life data for samples of flowers from the forcing trial are given in Table 12. There were no significant differences between treatments. Flower sizes are also shown in Table 12: the only significant effect was a reduction in flower size in bulbs previously treated with Flexidor + Diuron at the post-cropping stage. Other analyses indicated a general trend for smaller flowers where herbicide had been applied at later stages, although the difference between pre-emergence and post-cropping applications amounted only to 4 mm. No flower defects were observed in any treatment in the vase-life room.

Discussion

In this trial, conducted on a site with a high and varied weed population, all herbicide programmes tested were effective in controlling weeds: there was little practical difference between the various programmes tested. Choice of herbicides, therefore, will depend on the weed spectrum to be controlled, and, very importantly, on evidence that the herbicides used do not have harmful effects on the crop. In the field, crop damage was most obvious when Flexidor 125 plus Unicrop Flowable Diuron or Flexidor 125 plus Fortrol had been used post-cropping, resulting in yellowish foliage and a marked reduction in flower yield, flower quality and bulb yield. Similar, but less severe, damage resulted from using Flexidor 125 plus Goltix WG post-cropping, or Flexidor 125 plus Unicrop Flowable Diuron even at early-post-emergence. Mild foliar symptoms were seen, in the first year of the trial only, where Basagran had been applied post-flowering, but this effect did not persist to reduce flower and bulb yield in the second year. The detrimental effect of Basagran may have been due to the dry conditions in early-May 1995, when the application was made.

When bulbs from the various herbicide treatments were forced in the following year, the only adverse findings resulted from post-cropping applications. Using Flexidor 125 plus Fortrol at that stage led to reduced flower production when forced, while using Flexidor 125 plus Unicrop Flowable Diuron at this stage slightly reduced flower size in the forced crop. Indeed, there was a trend for all post-cropping herbicide treatments to produce slightly later, smaller flowers, although as the delay was no more than one day, and the flower size reduction amounted to a few mm at most, the post-cropping application of Flexidor 125 plus Goltix WG

or Butisan S did not, for all practical purposes, affect the quality of the forced crop. All these effects on subsequent forcing were probably a result of reduced bulb size.

The results of trials of this type are dependent on weather and other conditions, unless the work can be repeated over a number of years. On the basis of this single trial, however, mixtures of Flexidor 125 plus Unicrop Flowable Diuron should not be used early-post-emergence or post-cropping, Flexidor 125 plus Fortrol or Goltix WG should not be used post-cropping, and care should be exercised in using Basagran post-flowering in hot, dry weather. As part of a herbicide programme, however, Flexidor 125 plus Butisan S, Unicrop Flowable Diuron, Fortrol or Goltix WG could safely be used pre-emergence, Flexidor 125 plus Butisan S, Fortrol or Goltix WG safely early-post-emergence, or Flexidor 125 plus Butisan S safely post-cropping. These recommended herbicide treatments have no detrimental effect when bulbs are subsequently forced.

Concerns have recently been expressed by DowElanco, that the use of Flexidor 125 at the rate of 2 litres of product per ha in the second year of daffodil growing could lead to residues affecting some subsequent crops, if the land is not deep-ploughed after the bulb crops. This caution should be noted in any further use of the product on daffodils.

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Fig. 1 The development of weed cover in each treatment from week 17 (28 April) to week 28 (13 July), 1995

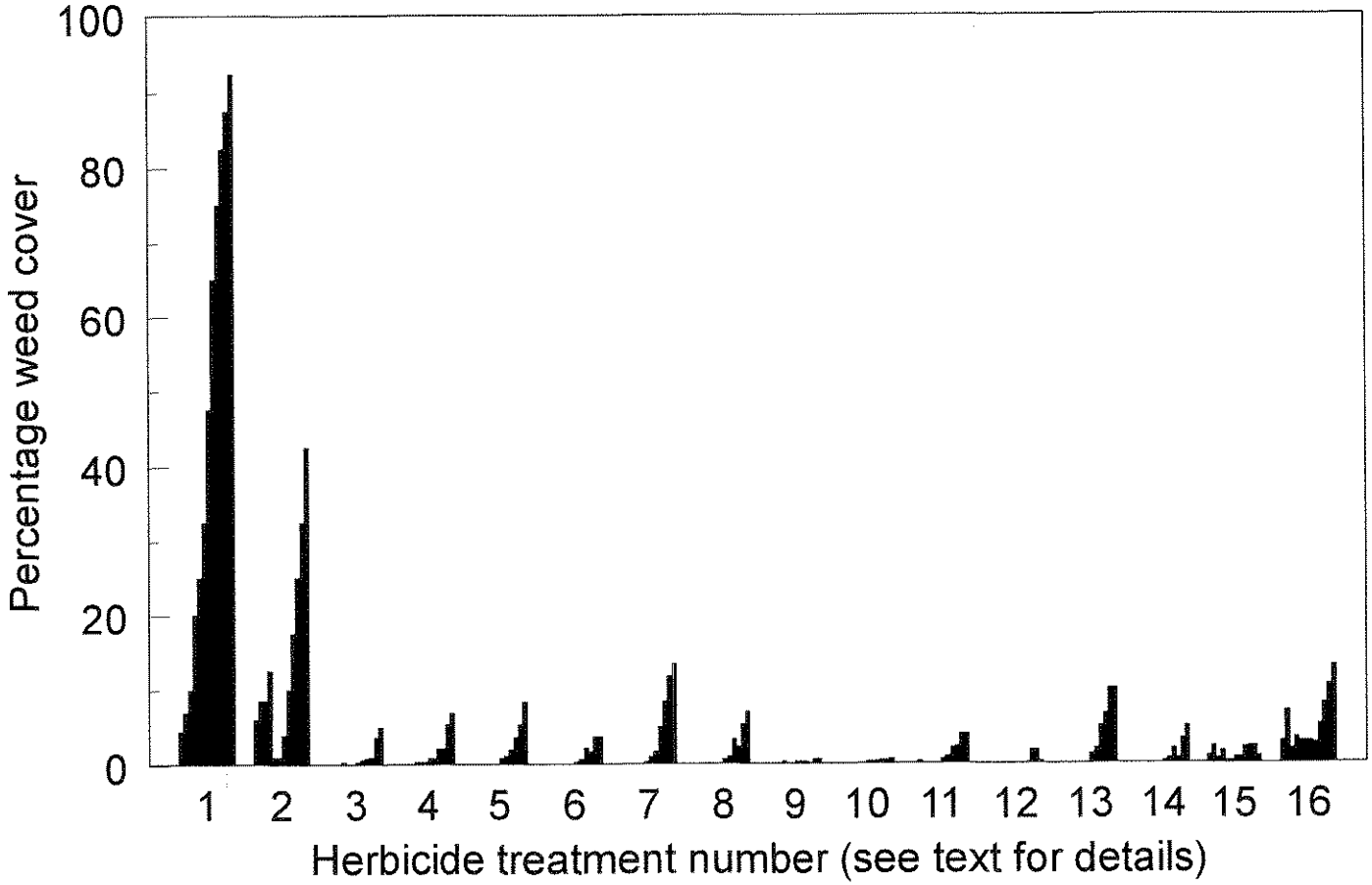

Fig. 2 The development of weed cover in each treatment from week 14 (1 April) to week 27 (1 July), 1996

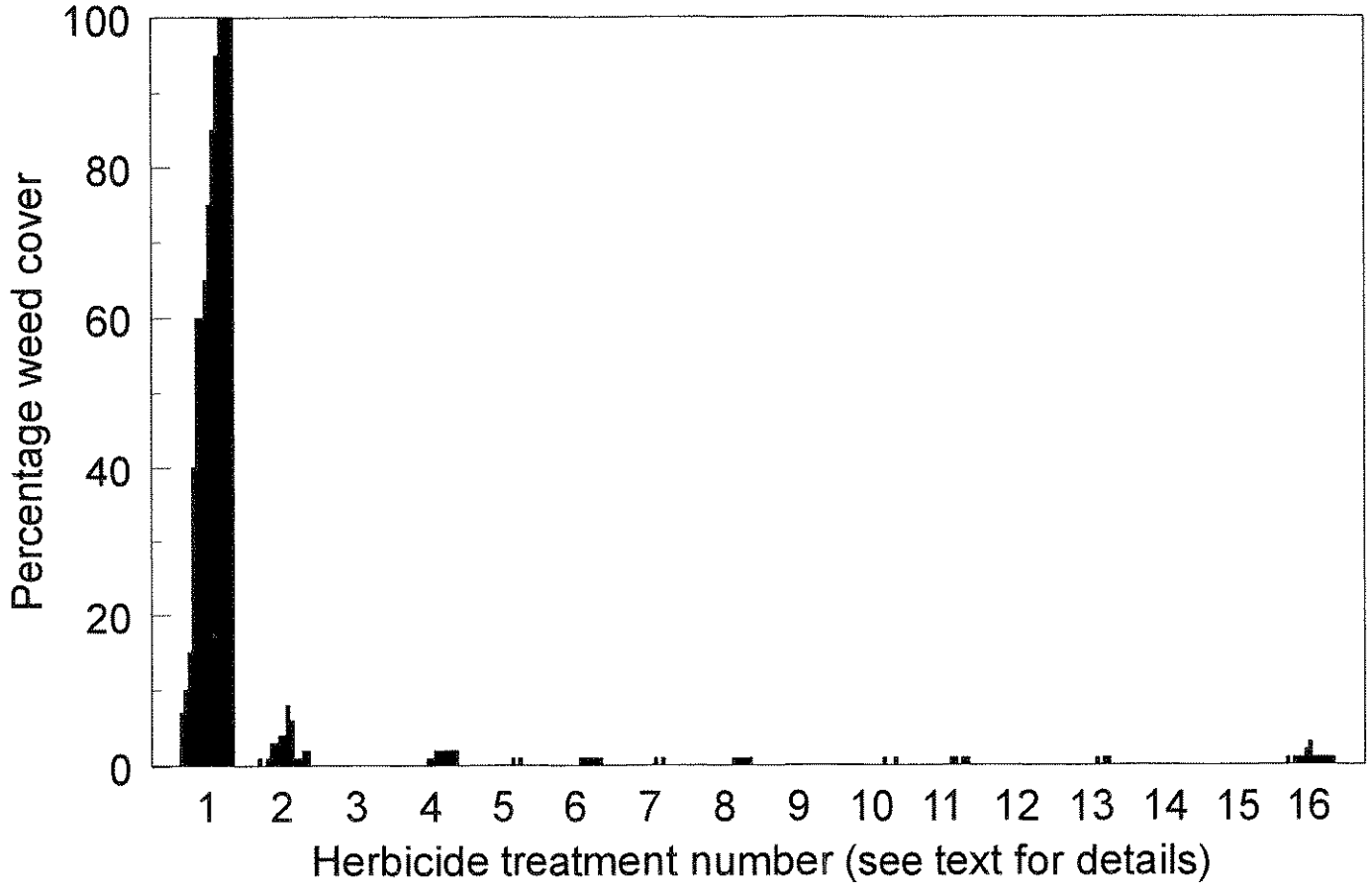

Table 1 Mean weed cover (percentage) for the various herbicide treatments in the first year of the trial, from 28 April (week 17) to 13 July 1995 (week 28). See text for treatment details

	Week no.											
Treatment	17	18	19	20	21	22	23	24	25	26	27	28
1	5	7	10	20	25	33	48	65	75	83	88	93
2	6	9	9	13	1	1	4	10	18	25	33	43
3	0	0	0	0	0	0	0	1	1	1	4	5
4	0	0	0	0	0	0	1	1	2	2	5	7
5	0	0	0	0	0	0	1	1	2	4	5	8
6	0	0	0	0	0	0	0	1	2	2	4	4
7	0	0	0	0	0	0	1	2	5	8	12	13
8	0	0	0	0	0	0	1	1	3	2	5	7
9	0	0	0	0	0	0	0	0	0	0	1	1
10	0	0	0	0	0	0	0	0	0	1	1	1
11	0	0	0	0	0	0	1	1	2	2	4	4
12	0	0	0	0	0	0	0	0	0	2	2	0
13	0	0	0	0	0	0	1	2	5	7	10	10
14	0	0	0	0	0	0	0	1	2	1	3	5
15	1	2	1	2	0	0	1	1	2	2	2	1
16	3	7	2	4	3	3	3	3	5	8	11	13

Table 2 Weed species in the experimental plots at the end of the first growing season (13 July 1995)

Treatment	Annual meadow grass	Black bindweed	Common chickweed	Creeping thistle	Goosefoot	Groundsel	Knotgrass	Mayweed	Redshank	Shepherds Purse	Small nettle	Sow thistles	Volunteer cereals
1							✓	✓					
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
3		✓					✓				✓		
4		✓	✓	✓			✓		✓				
5		✓	✓				✓	✓	✓				
6		✓		✓		✓		✓					
7		✓				✓	✓		✓				✓
8		✓				✓	✓	✓	✓				✓
9		✓					✓						
10		✓							✓				
11		✓				✓	✓						✓
12						✓	✓						
13		✓	✓			✓	✓		✓				✓
14		✓	✓			✓	✓						✓
15		✓				✓	✓		✓				✓
16					✓	✓	✓	✓					

Table 3 Mean weed cover (percentage) for the various herbicide treatments in the second year of the trial from 1 April (week 14) to 1 July 1996 (week 27). See text for treatment details

Treatment	Week no.													
	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	7	10	15	40	60	60	65	75	85	95	100	100	100	100
2	0	1	0	1	3	3	4	4	8	6	1	1	2	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	1	1	2	2	2	2	2	2
5	0	0	0	0	0	0	0	0	0	1	0	1	0	0
6	0	0	0	0	0	0	0	0	1	1	1	1	1	1
7	0	0	0	0	0	0	0	0	1	0	1	0	0	0
8	0	0	0	0	0	0	0	0	0	1	1	1	1	1
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	1	0	0	1
11	0	0	0	0	0	0	0	0	0	1	1	0	1	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	1	0	1	1	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	1	0	1	1	1	2	3	1	1	1	1	1	1

Table 4 Weed species in the experimental plots at the end of the second growing season (1 July 1996)

Treatment	Annual meadow grass	Black bindweed	Groundsel	Knotgrass	Mayweed	Redshank	Shepherds Purse	Small nettle	Sow thistles	Fat Hen
1					✓					
2			✓	✓	✓	✓	✓		✓	
3				✓						
4		✓							✓	
5										
6				✓					✓	
7		✓				✓				
8		✓	✓			✓				
9										
10		✓		✓				✓		
11		✓	✓	✓		✓				✓
12										
13		✓				✓				
14										
15	✓	✓								
16				✓						

Table 5 Foliage colour score and percentage foliage senescence in different herbicide plots for both years of the experiment

Treatment	Foliage score*		Percentage senescence**	
	1995	1996	1995	1996
1 (control)	5	5	80	70
2 (hand-weeded)	5	5	80	55
3 (standard)	4	5	85	60
4	5	5	80	55
5	5	5	85	55
6	5	5	75	65
7	5	5	80	55
8	4	5	80	65
9	2	2	90	70
10	5	5	80	55
11	5	5	70	55
12	2	3	80	65
13	5	5	75	55
14	5	4	80	55
15	4	4	80	55
16 (late treatment)	4	5	75	65
For comparisons between treatments 1, 2, 3 and 16 ***				
SED (27 df)	0.5	0.4	4.4	6.1
Significance	NS	NS	NS	NS
For comparisons between teatments 4-15				
SED (27 df)	0.4	0.4	3.6	5.0
Significance	***	***	***	NS

*from 1 (yellow) to 5 (dark green) on 11 May 1995 or 4 June 1996

**on 30 June 1995 or 24 June 1996 to nearest 5 per cent

*** for explanation, see statistical section in materials and methods

Table 6 Effects of herbicide treatments on flower yield and quality in 1996

Treatment		Flowers per plot	Stem length (mm)	Flower diameter (mm)	Vase-life (days)
1	(control)	416	383	106	7.2
2	(hand-weeded)	384	381	109	7.1
3	(standard)	373	384	104	7.0
4		398	403	105	7.1
5		399	387	104	6.9
6		377	386	106	7.3
7		367	393	108	7.3
8		372	377	105	7.2
9		270	357	99	6.7
10		406	381	104	7.2
11		366	380	105	7.3
12		327	376	104	7.2
13		381	383	106	7.1
14		385	383	105	7.0
15		372	387	104	7.1
16	(late treatment)	398	367	108	6.8
	For comparisons between treatments 1, 2, 3 and 16				
	SED (27 df)	26.8	14.2	2.1	0.29
	Significance	NS	NS	NS	NS
	For comparisons between treatments 4-15				
	SED (27 df)	21.7	11.5	1.7	0.24
	Significance	*	NS	**	NS

Table 7 Effects of herbicide treatments on bulb yield

Treatment	Weight (kg) per plot			Number per plot		
	Total	<10 cm grade	>10 cm grade	Total	<10 cm grade	>10 cm grade
1 (control)	19.62	7.15	12.48	562	315	246
2 (hand-weeded)	17.91	6.53	11.38	466	260	206
3 (standard)	18.86	7.71	11.14	568	350	219
4	19.68	7.73	11.95	557	328	230
5	19.52	5.81	13.71	508	255	253
6	19.24	7.63	11.61	569	338	231
7	19.17	7.78	11.39	579	351	228
8	19.46	7.12	12.34	523	284	240
9	12.47	7.08	5.39	579	436	143
10	20.09	7.89	12.20	568	332	236
11	17.84	7.41	10.43	523	323	201
12	15.08	7.84	7.24	523	357	166
13	19.26	6.45	12.81	509	271	238
14	19.52	6.96	12.56	512	271	241
15	17.43	6.71	10.72	520	300	220
16 (late treatment)	19.37	7.13	12.25	560	314	246
For comparison between treatments 1, 2, 3 and 16						
SED (27 df)	1.597	1.144	1.665	53.9	61.2	26.5
Significance	NS	NS	NS	NS	NS	NS
For comparison between treatments 4-15						
SED (27 df)	1.296	0.929	1.352	43.8	49.7	21.5
Significance	*	NS	*	NS	NS	*

Table 8 Flower numbers and stem lengths in the forcing trial of 10/12 cm grade bulbs from the herbicide experiment

Treatment		Number of marketable flowers per tray in grades (cm) and in total							Mean stem length (mm)
		<35	35-40	40-45	45-50	50-55	>55	Total	
1	(control)	0	2.6	19.7	41.2	16.8	4.9	85.2	477
2	(hand-weeded)	0	0.1	2.4	43.0	32.4	2.6	80.6	497
3	(standard)	0	0.3	7.0	48.7	33.7	0.7	90.3	490
4		0.3	0.7	5.3	54.3	29.3	1.0	91.0	488
5		0.3	4.3	21.7	47.7	13.7	0.3	88.0	467
6		0	1.3	5.7	50.0	30.0	0.7	87.7	488
7		0	1.0	9.7	43.3	28.7	0.3	83.0	486
8		0.7	0.7	7.7	45.7	27.3	5.0	87.0	490
9		0.7	0	9.7	58.3	20.7	0	89.3	480
10		0	0.7	7.3	53.3	27.7	1.7	90.7	488
11		0.3	2.0	14.0	38.0	20.3	2.0	76.7	477
12		0	0	3.7	39.7	43.3	3.0	89.7	501
13		0	0.3	5.3	44.3	33.0	3.0	86.0	494
14		0	0.3	9.3	45.3	30.0	1.7	86.7	489
15		0	0.3	6.3	43.0	36.0	2.3	88.0	495
16	(late treatment)	0.5	0.3	4.9	39.2	44.8	3.5	93.2	498
	For comparisons between treatments 1, 2, 3 and 16								
	SED (27 df)	-	-	9.09	7.87	9.58	2.45	6.21	13.2
	Significance	-	-	NS	NS	*	NS	NS	NS
	For comparisons between treatments 4-15								
	SED (27 df)	-	-	7.38	6.39	7.78	1.99	5.04	10.7
	Significance	-	-	NS	NS	NS	NS	NS	NS

Table 9 Flower numbers and stem lengths in the forcing trial of 12/14 cm grade bulbs from the herbicide experiment

Treatment		Number of marketable flowers per tray in grades (cm) and in total							Mean stem length (mm)
		<35	35-40	40-45	45-50	50-55	>55	Total	
1	(control)	0	1.5	1.5	65.6	46.0	1.3	115.9	495
2	(hand-weeded)	0.5	0.5	18.4	54.6	36.6	2.4	113.0	484
3	(standard)	0	0	4.7	47.0	60.7	5.3	117.7	504
4		0	0	3.0	43.7	61.0	4.7	112.3	505
5		0	2.0	7.0	54.7	52.0	2.0	117.7	494
6		0	0.7	3.0	48.0	56.0	10.0	117.7	506
7		0	0	2.0	44.3	65.7	5.3	117.3	507
8		0.3	0	3.0	38.0	58.7	12.3	112.3	510
9		0	0	1.2	47.7	61.8	2.3	113.0	502
10		0	0	0.7	41.7	67.3	6.0	115.7	509
11		0	0.3	2.0	31.3	68.0	9.3	111.0	513
12		0	0.6	3.6	31.3	58.9	9.8	104.1	507
13		0.3	0	1.7	36.0	66.0	10.0	114.0	512
14		0	0.3	2.0	40.0	64.7	7.3	114.3	508
15		0	0	0.3	45.3	67.7	5.7	119.0	508
16	(late treatment)	0	1.1	1.6	37.3	64.9	7.1	116.1	511
	For comparisons between treatments 1, 2, 3 and 16								
	SED (27 df)	-	-	5.02	10.14	11.43	5.28	3.58	8.97
	Significance	-	-	**	*	NS	NS	NS	*
	For comparisons between treatments 4-15								
	SED (27 df)	-	-	4.08	8.23	9.28	4.28	2.91	7.28
	Significance	-	-	NS	NS	NS	NS	**	NS

Table 10 Cropping dates and periods in the forcing trial of 10/12 cm grade bulbs from the herbicide experiment

Treatment		Time in glasshouse (days) until various cropping stages					Days from 10 to 90% crop
		First	10%	50%	90%	100%	
1	(control)	14.6	16.1	17.1	20.2	22.1	4.1
2	(hand-weeded)	11.9	13.4	15.9	17.9	19.1	4.5
3	(standard)	13.3	15.7	17.0	19.3	20.7	3.7
4		13.3	15.0	17.0	19.0	23.0	4.0
5		13.3	14.7	16.7	19.0	21.3	4.3
6		12.3	14.7	16.7	18.3	20.7	3.7
7		13.0	14.0	16.7	18.3	22.7	4.3
8		13.0	14.7	16.7	18.3	22.0	3.7
9		14.3	16.7	18.0	20.0	22.3	3.3
10		12.3	14.0	16.7	18.3	23.0	4.3
11		13.0	15.0	17.0	18.7	23.3	3.7
12		13.0	15.0	17.0	19.0	21.3	4.0
13		12.3	15.3	17.0	19.7	22.0	4.3
14		13.3	14.3	16.3	18.7	22.7	4.3
15		14.0	15.7	17.0	19.3	23.3	3.7
16	(late treatment)	13.5	15.0	16.9	18.9	20.8	3.9
	For comparisons between treatments 1, 2, 3 and 16						
	SED (27 df)	1.05	0.89	0.67	0.85	1.33	0.63
	Significance	NS	*	NS	*	NS	NS
	For comparisons between treatments 4-15						
	SED (27 df)	0.85	0.72	0.54	0.69	1.08	0.51
	Significance	NS	NS	NS	NS	NS	NS

Table 11 Cropping dates and periods in the forcing trial of 12/14 cm grade bulbs from the herbicide experiment

Treatment		Time in glasshouse (days) until various cropping stages					Days from 10 to 90% crop
		First	10%	50%	90%	100%	
1	(control)	15.3	16.9	18.8	21.4	25.3	4.4
2	(hand-weeded)	11.9	13.8	15.9	17.8	20.5	4.0
3	(standard)	12.7	15.0	17.0	19.3	22.3	4.3
4		14.0	15.3	17.7	19.7	21.3	4.3
5		13.7	15.3	17.3	20.0	21.3	4.7
6		12.7	15.0	17.3	19.3	21.7	4.3
7		12.7	14.3	16.7	18.7	22.7	4.3
8		13.0	15.0	17.3	19.3	23.3	4.3
9		13.7	14.7	16.3	18.3	20.0	3.7
10		13.7	15.3	17.0	19.3	21.3	4.0
11		13.0	14.7	16.7	19.0	22.0	4.3
12		13.0	15.0	17.3	19.7	21.7	4.7
13		13.3	15.3	17.3	19.7	23.0	4.3
14		13.7	15.0	17.0	19.0	22.3	4.0
15		13.7	15.0	17.0	19.3	21.3	4.3
16	(late treatment)	13.3	15.8	17.8	19.8	22.7	4.0
	For comparisons between treatments 1, 2, 3 and 16						
	SED (27 df)	1.13	1.10	0.90	0.98	1.23	0.60
	Significance	*	*	*	**	NS	NS
	For comparisons between treatments 4-15						
	SED (27 df)	0.92	0.89	0.73	0.80	1.00	0.49
	Significance	NS	NS	NS	NS	NS	NS

Table 12 Vase-life and flower diameter data in the forcing trial of 10/12 and 12/14 cm grade bulbs from the herbicide experiments

Treatment		Vase-life (days)		Flower diameter (mm)	
		10/12	12/14	10/12	12/14
1	(control)	5.0	4.9	87	91
2	(hand-weeded)	5.1	5.3	92	92
3	(standard)	4.9	5.3	91	88
4		5.0	5.1	89	91
5		5.0	5.0	92	91
6		5.2	5.6	89	88
7		5.1	5.3	93	91
8		5.1	5.2	87	92
9		5.0	5.1	81	85
10		5.4	5.1	90	91
11		5.0	5.1	89	90
12		5.1	4.9	87	89
13		5.0	5.1	89	92
14		5.1	5.3	90	91
15		5.0	5.0	88	89
16	(late treatment)	5.2	5.1	87	89
	For comparisons between treatments 1, 2, 3 and 16				
	SED (27 df)	0.15	0.32	2.8	
	Significance	NS	NS	NS	NS
	For comparisons between treatments 4-15				
	SED (27 df)	0.12	0.26	2.3	
	Significance	NS	NS	*	NS

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