Project title:	Narcissus: control of volunteer potatoes in narcissus
Project number:	BOF 46
Project Leader:	Mr Jim Briggs, ADAS Park Farm (October 1999-August 2001) Ms Sam Brown, ADAS Park Farm (September 2001-March 2002) Ms Jo Fitzpatrick, ADAS Arthur Rickwood (March 2002-May 2002)
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Key Words:	Narcissus, volunteer potato, herbicides, weed control, Dow Shield, Starane 2, Betosip, Nortron, Totril, Dosaflo

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over two years. The conditions under which the experiment was carried out and the results obtained have been reported with detail and accuracy. However because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results especially if they are used as the basis for commercial product recommendations.

Reference in this report to an active ingredient or trade name does not imply that the product is currently approved for use for potato control in narcissus. This trial was undertaken to screen active ingredients with potential for use in narcissus crops.

AUTHENTICATION

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

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PRACTICAL SECTION FOR GROWERS

Commercial benefits of the project

This project has shown that the herbicide Dow Shield (clopyralid) applied at a rate of 1litre/ha to a crop of narcissus cv ice Follies post-flowering, will provide moderate control of potato volunteers (approx. 35% reduction in emergence in year after treatment) whilst causing no damage to the narcissus crop. Dow Shield was also shown to provide effective control of thistles.

Background and objectives

Narcissus and potatoes are commonly grown within the same rotation to capitalise on shared equipment and facilities. Within the potato industry, higher marketing standards now result in more under-sized potatoes being returned to the soil where they compete with the following narcissus crops. Whilst appropriate control strategies are used in crops preceding narcissus, there is no specific information on control of potatoes in narcissus crops themselves.

There are two main problems associated with using herbicides for the control of volunteer potatoes in the narcissus crop: a) time of application and b) the extreme sensitivity of narcissus to treatments applied post-flowering in April-May. Narcissus is particularly sensitive to herbicide damage after flowering as this is the time when next year's leaves and flowers begin to develop in the bulb. Unfortunately, this coincides with the first opportunity that the grower has to control the newly emerged, rapidly growing potato volunteers.

A recent LINK project funded by MAFF (BPC 807/151) and the British Potato Council (BPC) has investigated rotational control of potato volunteers within arable rotations. The study evaluated the scale of the problem, the potential for disease and virus carry-over on volunteers, and in part the evaluation of strategies for control. Similar studies have also recently been completed by the Sugar Beet Research and Education Council (SBREC) (RG 7394A) on control of volunteer potatoes in rotations containing sugar beet, where, as with narcissus, they exert considerable competitive pressure. These studies have indicated that herbicides are unable to provide consistently reliable control on their own, and that an integrated control strategy is required to control volunteer potatoes, making use of cultivation and crop competition effects as well as a planned approach to chemical control throughout

the cropping rotation. Poor control in a single season can undermine good control achieved in previous years.

The integration of control in narcissus crops with measures in other arable crops will help achieve an integrated approach to control in the whole farm situation.

The commercial objectives of this project were to screen herbicide active ingredients, which have been shown to provide some degree of control of potato volunteers in other arable and horticultural crops, for their efficacy and safety in narcissus crops. Selective active ingredients were applied at a range of typical dose rates, in various sequences and at different timings to evaluate their effects on crop safety and efficiency of volunteer potato control.

Summary of results and conclusions

Herbicide application

Herbicides were applied either alone or in combination to a narcissus crop of cultivar Ice Follies, when potato volunteers were at three different growth stages; 5-10 cm, 10-20 cm and 25-30 cm tall. Potatoes were planted in the crop to ensure an even flush of potatoes across the trial site. The timings for herbicide application related to optimum applications for control of volunteer potatoes (derived from use in other crops) and also provided a range of vigour in potato crop growth at the time of treatment. Potato growth was very rapid in the year of treatment (May 2000) and treatments involving sequences had to be applied in quick succession between 8 and 22 May (Table A).

Table A. Herbicide treatments used in the field experiment and applied in May 2000

Treatment number	Application timing – potatoes at 5-10 cm	10-20 cm	20-30 cm
1 (unplanted control)	-	-	-
2 (untreated control)	-	-	-
3 (untreated control)	-	-	-
4 (untreated control)	-	-	-
5	1 l/ha Dow Shield		
6		1 l/ha Dow Shield	
7	1 l/ha Dow Shield	1 l/ha Dow Shield	
8	2 l/ha Starane		
9		2 l/ha Starane	
10	2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield		
11		2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield	
12	2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield	2.0 l/ha Starane 2	
13		1.0 l/ha Totril + 1.0 l/ha Starane 2	
14			5.5 l/ha Dosaflo

Active ingredient list:
Dow Shield = Clopyralid (200 g/l)
Starane 2 = Fluroxypyr (200 g/l)
Betosip = Phenmedipham (114 g/l)
Nortron = Ethofumesate (500 g/l)
Totril = Ioxynil (225 g/l)
Dosaflo = Metoxuron (500 g/l)

During bulb dormancy in September 2000, an application of glyphosate was planned for half of each plot when sufficient potato haulm re-growth was present. Glyphosate applied in the autumn is frequently used by the industry to control groundkeepers. In the trial the autumn flush of potato growth was very slow and adverse weather conditions in October delayed the application of glyphosate until 3 November 2000. At this stage only a few potatoes had emerged, and they were between 5-10 cm tall. Follow up assessments of volunteer populations were made in 2001.

Control of volunteer potatoes

The glyphosate treatment applied in November 2000 had negligible effects on potato volunteers (because of late potato emergence) and on the narcissus crop. Under the right seasonal conditions, however, this could still be an important method of volunteer potato control.

In 2000, the year of herbicide treatment, efficacy of herbicides for volunteer potato control (based on haulm phytotoxicity scores) changed over the course of the growth period May to July 2000. Of the best treatments at 21 days after herbicide application (June), the effects of Totril, Dosaflo and Starane 2 were outgrown by July, while the effects of all Dow Shield treatments increased with time. Dow Shield was more effective when applied alone, rather than in a tank mix with Betosip and Nortron.

In the year of herbicide application (2000), Dosaflo provided the best control of weeds other than volunteer potatoes. Treatment with Starane 2 or Betosip + Norton + Dow Shield also reduced weed cover, with greater effect when applied in early May than in mid-May.

The best residual control of potato stem populations in 2001 (the year after treatment) was achieved with Dosaflo (30 % reduction) or an early application of Dow Shield used alone at 1.0 l/ha (38 % reduction). Dosaflo exhibited no residual symptoms on the potato foliage, while Dow Shield used alone or in mixtures with Betosip and Nortron caused slight yellowing and twisting of potato stems but not complete death. None of the herbicide treatments reduced tuber chitting or increased tuber rotting after harvest.

None of the herbicide treatments proved to be completely effective in controlling volunteer potatoes. Good control relies on the integration of both cultural and chemical means. Single applications of a herbicide rarely give effective control, particularly where emergence of volunteers is staggered, and in open crops such as narcissus where crop competition is very low.

Crop safety of narcissus

In the year of herbicide application (2000), visual damage on narcissus foliage resulted from all Starane 2 treatments (alone and in mixtures) and also Dosaflo at 25-30 cm. In contrast, Betosip + Nortron + Dow Shield at 5-10 cm and the three Dow Shield only treatments, showed no visual damage compared with the untreated control treatments.

In 2001, there were no consistent effects of herbicide treatments on narcissi foliage but the number of damaged flowers was higher with Betosip + Nortron + Dow Shield (5-10 cm) or Dosaflo, compared with an untreated control treatment. There were no significant treatment effects on the number of flowers produced, or on the yield of bulbs.

In addition, there were no significant residual effects of herbicide treatment in relation to marketable yields of flowers forced in the winter of 2001/2002. The onset of flowering was delayed compared to untreated controls but overall flower production was unaffected.

Conclusion

Overall, the most effective herbicide treatment in this study was Dow Shield. This caused significant damage to volunteer potato foliage in the first year (2000) and resulted in low potato emergence (38 % reduction compared with controls) in the second year (2001). It was also safe to the narcissus crop with respect to bulb yield, flower production and marketability.

Action points for growers

- Growers need to ensure that harvesting of previous potato crops is as efficient as possible.
- Volunteer potato growth is most susceptible to herbicide application when the potato plants are 5-10 cm tall.
- Of all the herbicide treatments applied, the 'safest' in these trials, **on cultivar Ice Follies only**, was Dow Shield applied at 1 litre/ha. **Other varieties may respond differently.** However, in commercial practice, where spot treatments of Dow Shield has been used to control patches of thistles in a narcissus crop, some crop damage has been evident in subsequent years.
- Glyphosate remains an effective treatment for the control of volunteer potatoes despite the poor control in this trial due to delayed emergence of volunteers.
- This experiment was completed on fen soils (25 % organic matter) in Cambridgeshire. Plant growth and subsequent herbicide applications may respond differently on other soil types.

Anticipated Practical and Financial Benefits

In narcissus, weed competition has been shown in experiments to reduce narcissus bulb yield by approximately 10% under normal conditions, with a considerably higher reduction under conditions of water stress. In sugar beet, yield reductions of up to 16% have been recorded in ADAS experiments due to volunteer potato competition (Mills & Cleal, 1996). Narcissus bulb yield could be reduced by a similar amount to sugar beet, given the crop's dependence on adequate moisture at the time of bulking from mid-April onwards. This could represent a reduction in output of approximately £1,160/ha for bulbs alone. There could be a further reduction of flower yield, costing the grower some £500/ha, depending on the season. This work should help significantly to reduce these likely losses associated with volunteer potato infestation of narcissus.

Table B. Summary of the effect of herbicide treatment on control of volunteer potatoes (2000-2002)

CONTROL OF VOLUNTEER POTATOES: - NO EFFECT, * SLIGHT EFFECT, ** MODERATE EFFECT, *** GOOD EFFECT

Treatment	**Control of volunteer potatoes**					
	Kill of foliage (2000)	Reduction in potato emergence (2001)	Kill of foliage (2001)	Reduction in potato tubers lifted (2001)	Reduction in tubers chitted (2001)	Increase in tubers rotted (2001)
1-4 Controls	-	-	-	-	-	-
5 Dow Shield (5-10 cm)	**	***	*	**	-	-
6 Dow Shield (10-20 cm)	**	**	*	-	-	-
7 Dow Shield (5-10 & 10-20 cm)	**	*	*	-	-	-
8 Starane 2 (5-10 cm)	*	*	-	**	-	-
9 Starane 2 (10-20 cm)	*	-	-	-	-	-
10 Betosip + Nortron+ Dow Shield (5-10 cm)	**	*	*	-	-	-
11 Betosip + Nortron + Dow Shield (10-20 cm)	*	_	*	-	-	-
12 Betosip + Nortron + Dow Shield (5-10 cm) then Starane 2 (10-20 cm)		*	*	-	-	-
13 Totril and Starane 2 (10-20 cm)	*	-	-	-	-	-
14 Dosaflo (25-30 cm)	-	***	-	**	-	-

Table C. Summary of the effect of herbicide treatment on safety to narcissus (2000-2002)

Safety to narcissus: - no damage or adverse effect, + slight damage, ++ moderate damage, +++ severe damage

	Safety to narcissus							
Treatment	No. flowers 2000	Crop foliage 2000	No. flowers 2001	Crop foliage 2001	Crop flowers 2001	Bulb yield 2001	Forced flowers 2002	Vase life 2002
1-4 Controls	-	-	-	-	-	-	-	-
5 Dow Shield (5-10 cm)	-	+	-	-	-	-	-	-
6 Dow Shield (10-20 cm)	-	+	-	-	-	-	-	-
7 Dow Shield (5-10 & 10-20 cm)	-	+	-	-	-	-	-	-
8 Starane 2 (5-10 cm)	-	+++	-	-	-	-	-	-
9 Starane 2 (10-20 cm)	-	++	-	-	-	-	-	-
10 Betosip + Nortron+ Dow Shield (5-10 cm)	-	++	-	-	+	-	-	-
11 Betosip + Nortron + Dow Shield (10-20 cm)	-	+	-	-	-	-	-	+
12 Betosip + Nortron + Dow Shield (5-10 cm) then Starane 2 (10-20 cm)	-	+++	-	-	-	-	-	-
13 Totril and Starane 2 (10-20 cm)	-	++	-	-	-	-	-	-
14 Dosaflo (25-30 cm)	-	+++	-	-	+	-	-	-

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SCIENCE SECTION

Introduction

Narcissus and potatoes are often grown in the same rotation. As a result of the increasing quality demands of potato markets, more of the smaller and out-grade potatoes are returned to the soil at harvest. Volunteers arising from potatoes left after harvesting provide significant competition with the narcissus in following years. Volunteer potatoes are notoriously difficult to control.

The control of volunteer potatoes has been widely studied in arable rotations and vegetable crops. In cereals, Roundup (glyphosate) applied pre-harvest at 4 l/ha (1.44 kg a.i./ha) to control volunteer potatoes has been registered for use for many years. The presence of soft lush growth of potatoes improves the level of control (Lutman, 1993). The potatoes must have active foliage growth to allow efficient uptake of the chemical leading to effective reductions in foliage and tubers (Cleal, Hayward & Rawlings, 1993). In sugar beet, the combined use of Betanal (phenmedipham) and Dow Shield (clopyralid) was effective in suppressing potato volunteers and gave residual control of volunteers, but the timing of application was critical to success. Earlier application, targeting potatoes before tuber initiation suppressed foliage growth, but later applications during tuber initiation reduced tuber numbers returned to the soil (May & Hilton, 1993). In onions, Starane 2 (fluroxypyr), Dow Shield, Totril (ioxynil) and Dosaflo (metoxuron) (HDC projects FV 54, FV 54b, FV 54c) gave effective control of potato volunteers; Dosaflo in particular can be effective on peat soils (Runham, Davies & Leatherland, 1993). Other work by Bond (1993) evaluated sequential sprays of Totril, Starane 2 and Dow Shield for their control of potatoes in a range of vegetable crops. Of these, mixtures containing Starane 2 gave the best suppression of potatoes, but no treatment controlled them completely. Onions and leeks were tolerant of these products but other broad-leaved crops were more susceptible.

The scientific objectives of the current work were to determine if herbicides showing activity in other crops could potentially be used to control volunteer potatoes without damaging the narcissus crop. To be of practical value to growers, herbicides used to control volunteer

potatoes in narcissus should provide effective control of volunteer potatoes, exhibit no direct or residual phytotoxicity to narcissus (i.e. either in the field or when forced the following year), have no impact on narcissus bulb yield or flower quality, and have a residual effect on subsequent appearance of potato volunteers.

The study was carried out in two phases. In the first phase, a field experiment was carried out (October 1999 - November 2001) in which herbicide treatments were applied to a narcissus crop artificially planted with potato tubers. The direct effects of herbicides on potato volunteers and narcissus were monitored in 2000 and reported in the BOF 46 Year 1 Annual Report. Herbicide effects on narcissus and potato volunteers were subsequently monitored in 2001 (results presented in this report). In the second phase, narcissus bulbs harvested from the field experiment in 2001 were assessed for residual herbicide effects on foliage growth and flower quality by forcing (December 2001 - March 2002).

Materials and methods

Field experiment

The experiment was done at ADAS Arthur Rickwood, on a peaty soil containing 25% organic matter. The site had not been treated with sulfonyl-urea herbicides in the previous 12 months.

Treatments

The herbicide treatments applied in spring 2000 are detailed in Table 1. The treatments consisted of 10 herbicide regimes that were compared with an untreated control treatment. In addition, a further treatment was incorporated where no potatoes were buried and no herbicides were applied. This treatment was used to derive an estimate of the competitive effects of volunteer potatoes on narcissus. Each treatment was split, with an autumn glyphosate treatment applied when narcissus were dormant and a flush of potato volunteers appeared in autumn 2000. Half of each plot was left untreated and half was treated with a full dose of glyphosate. The herbicide treatments were applied on three dates, according to the growth stage of the potatoes. The herbicide treatments at 5-10 cm were applied on 8 May, the 10-20 cm treatments were applied on 15 May, and the 25-30 cm treatment was applied on 22

May 2000. Glyphosate was applied as Roundup at 4 l ha^{-1} in 450 l water ha^{-1} on 30 Nov 2000.

Table 1. Herbicide treatments used in the field experiment and applied in 2000

Treatment number	Application timing – potatoes at 5-10 cm	10-20 cm	20-30 cm
1 (unplanted control)	-	-	-
2 (untreated control)	-	-	-
3 (untreated control)	-	-	-
4 (untreated control)	-	-	-
5	1 l/ha Dow Shield		
6		1 l/ha Dow Shield	
7	1 l/ha Dow Shield	1 l/ha Dow Shield	
8	2 l/ha Starane		
9		2 l/ha Starane	
10	2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield		
11		2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield	
12	2.5 l/ha Betosip + 1.5 l/ha Nortron + 0.5 l/ha Dow Shield	2.0 l/ha Starane 2	
13		2.0 l/ha Totril + 1.0 l/ha Starane 2	
14			5.5 l/ha Dosaflo

Active ingredient list:
Dow Shield = Clopyralid (200 g/l)
Starane 2 = Fluroxypyr (200 g/l)
Betosip = Phenmedipham (114 g/l)
Nortron = Ethofumesate (500 g/l)
Totril = Ioxynil (225 g/l)
Dosaflo = Metoxuron (500 g/l)

Experiment design

The experiment was laid out as a randomised block split-plot design, with four replicates of each herbicide treatment and 12 replicates of the untreated control (planted with volunteers), giving a total of 112 sub-plots. Each plot comprised two planted ridges of 5 m length, with a 1 m guard between plots and a 5 m guard around the experiment area. Volunteer potatoes (cv. Maris Piper) were planted at the rate of 33,000 tubers ha^{-1} (3.3 tubers m^{-2}). Half of the tubers were planted together with the bulbs on 17 October 1999 at 20 cm depth, and the other half were planted on 9 March 2000 at 10 cm depth to simulate a staggered flush of potato emergence, more typical of a field situation. Spring planting also insured the study against loss of the autumn planted tubers through frost kill. The narcissus cultivar used was Ice Follies, grade 12-14 cm, hot water-treated on 8-9 September 1999. The Ice Follies were planted in standard ridges at a rate of 17.5 t ha^{-1} on 17 October 1999.

Assessments

Narcissus bulbs and potatoes emerging in 2001 from plots treated with herbicides in 2000 were assessed for herbicide effects as follows:

Narcissus assessments:

1. Narcissus growth (height in cm) was assessed on six occasions from emergence to flowering. This was done by taking 10 height measurements per plot and calculating the average height.
2. Narcissus emergence was assessed on one occasion (20 March 2001) by counting the number of flower heads and buds per plot.
3. Phytotoxicity symptoms affecting narcissus flower development were assessed on 11 April 2001 by counting in each plot the number of i) flowers which had not fully opened, showing a ballooning effect, ii) flowers with less than six petals, iii) undamaged flowers, iv) ‘deformed’ inner flowers, and v) senesced flowers where phytotoxic effects could not be determined. This was done on a l m length of ridge per plot.
4. Symptoms of phytotoxicity on narcissus foliage were assessed on 10 May, 21 May, 10 June and 2 July 2001 (Table 2). This was done on a 1 m length of ridge per plot
5. Yield (kg/plot) of bulbs at lifting.

Potato assessments:

1. Potato emergence was assessed on 30 April and 25 May 2001 by counting the number of potato stems per plot.
2. Potato foliage was assessed for herbicide damage on 10 June and 2 July 2001 using a scoring system (Table 2).
3. At harvest, the number of potatoes tubers recovered in the harvest area was recorded, and samples were retained and assessed for viability and rots attributable to herbicide damage.

Table 2. Scoring system for assessing phytotoxicity in narcissus and potatoes

Score	Narcissus symptoms	Potato symptoms
0	No damage	No damage
1	Slightly drooping foliage	Slight twisting/yellowing
2	Moderately drooping foliage	Moderate twisting/yellowing
3	Majority of foliage drooping and yellowing	Severe twisting/yellowing
4	Dead	Dead

Forcing experiment

Bulbs harvested from the field experiment in 2001 were grown on under controlled conditions to investigate the residual affects, if any, of herbicide treatment on the subsequent growth of narcissus.

After grading, 100 bulbs from each treatment were removed from the 12-14 cm grade and stored in nets at 18ºC until mid-September. The temperature was then lowered to 9 ºC for six weeks. In late October, the bulbs were planted into wooden forcing trays (61 x 45 x 11 cm). A layer (*c*. 6 cm) of peat (unamended sphagnum peat with a pH above 4.5) was placed in the bottom of the tray. The bulbs were placed on this and covered with another layer of peat. These were well-watered and then placed back in the store at 9 ºC for a further 10 weeks. The trays were inspected weekly and kept watered, as appropriate. The trays were then placed in a glasshouse in a randomised design and grown on. The flowers were picked daily, and assessed for stem length and any phytotoxic effects. Vase-life was also assessed by placing a sample of 10 flowers into water and counting the number of days until the perianth began to brown or shrivel.

Data analysis

The data was analysed using analysis of variance (ANOVA). Where the ANOVA showed statistical significance, Duncan's Multiple Range test was used to assess pairwise differences between treatments. In this test, treatment means are calculated for each treatment and these are ordered in ascending order together with their standard error. Duncan's test then systematically makes a pair-wise comparison of these ordered means and places treatments in the same (assigned the same suffix letter) or different (different suffix letter) group depending on whether the treatment pair is adjudged not to be statistically significantly different or otherwise respectively. This test can be regarded as a 'batting order' for treatment effects but a real assessment of any two treatments can only properly be assessed using a experiment designed for this purpose.

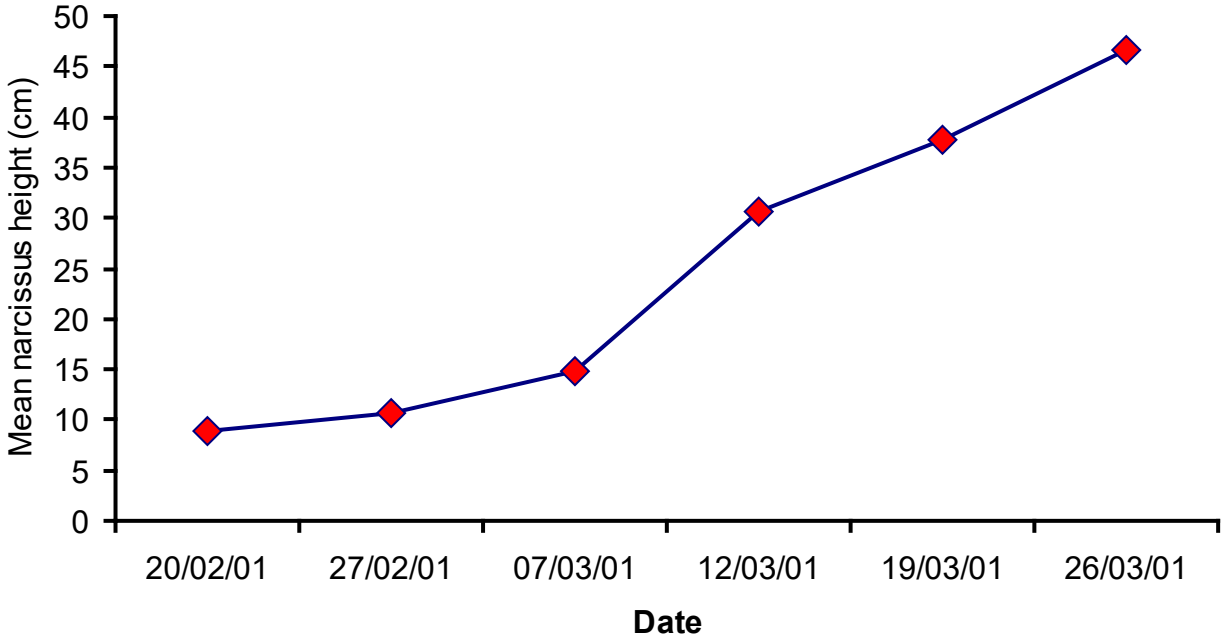
Score data is not appropriate for ANOVA, and was analysed using Friedman's test, a non-parametric ANOVA-style test. In this test, where score data rather than continuous data are available, treatment effects are ranked relative to each other rather than in each block and ranks are then summed or averaged over blocks. Where the Friedman's test showed statistical difference, a multiple range test for non-parametric data was performed. Using pair-wise treatment comparisons of say the sum of ranks, it can be assessed whether a particular pair of treatments is significantly different. (Siegel and Castellan 1988).

Results

Field experiment

Narcissus emergence began in early January 2001. Flowering began in mid-March and the crop was at full flowering in early April (Figure 1). The bulbs were lifted in early July and dried prior to grading.

Figure 1. Height of narcissus in field experiment from emergence to flowering



Effect of herbicide treatment on narcissus flower development and foliage senescence

There were no significant differences between the number of flowers per plot (Table 3). Data for the individual flower deformity characteristics was unsuitable for statistical analysis because of the occurrence of many zero values (Table 4). However, examination of the data on undamaged flowers confirmed that both Betosip+Nortron+Dow Shield at 5-10 cm (57 %) and Dosaflo at 25-30 cm (68 %) produced fewer undamaged flowers than an untreated control (87 %) and some other herbicide treatments. Starane 2 at 5-10 or 10-20 cm resulted in the highest number of undamaged flowers (85-86 %), comparable with the untreated control. There were no consistent, significant effects of any herbicide treatment on damage to narcissus foliage (Table 5).

Effect of herbicide treatment on narcissus bulb yield.

There were no significant differences between the effects of herbicide treatments on mean narcissus bulb yield in each size grade or the mean weight of rotten bulbs (Table 6).

Effect of herbicide treatment on the emergence of potatoes

The autumn 2000 glyphosate treatment was applied in November, due to delayed potato emergence and adverse weather conditions. Effects of glyphosate on the volunteer potato population (and the narcissus crop) in 2001 were negligible (data not presented).

In the season following herbicide treatment, potato emergence was significantly lower in Dosaflo-treated plots when volunteers were treated at 25-30 cm height. Dow Shield reduced potato emergence when applied at either 5-10 cm or 10-20 cm volunteer stem height, although effects were only significant at the earliest timing (compared to the untreated control) (Table 7).

Effects of herbicide treatment on potato foliage

Although some phytotoxicity symptoms were observed on the potato foliage (Table 8), these were slight and there were no significant differences between treatments. However it was noticeable that all treatments including Dow Shield tended to give mean phytotoxicity scores >1, while other herbicide treatments scored <1. Dosaflo exhibited no symptoms on the foliage.

Effects of herbicide treatments on potato tuber yield

Although data were unsuitable for analysis, there was a notable effect of herbicide treatments on the number of tubers recovered at harvest, with fewer tubers recovered from plots treated with Starane 2 (5-10 cm), Dosaflo and Dow Shield (5-10 cm), compared with two of the untreated controls (Table 9). The tubers were stored and examined for any effects of herbicides on chitting. There was no apparent reduction in tuber chitting due to herbicides, in comparison with the untreated controls. Tuber rots after storage were very variable between treatments and there was no consistent trend relating to any particular herbicide treatment.

Forcing experiment

Number and quality of flowers harvested

There were no significant effects of treatment on the number of flowers harvested (Table 10). Data for percentage of marketable flowers and short stems were unsuitable for analysis but overall, Betosip + Norton + Dow Shield (5-10 cm) followed by Starane 2 (10-20 cm) produced both the highest number of marketable flowers and the lowest number of short stems. The percentage of deformed stems was very similar for all of the treatments, suggesting that there was no long-term phytotoxic effect from any of the herbicide treatments. The average numbers of flowers harvested per day was also unaffected by herbicide treatments (Table 11).

Number of total flowers harvested per week

There were no significant differences between treatments in the number of flowers harvested on a weekly basis (Table 12). However, there was a trend for narcissus in the untreated control treatments to flower a few days earlier than those treated with herbicide.

Number of marketable flowers harvested each week

Compared to the untreated controls, and despite differences in the onset of flowering noted above, there were no consistent significant effects of herbicide treatments on the weekly harvest of marketable flowers.

Number of unmarketable flowers harvested each week

The total number of flowers with short stems was few, and therefore data were unsuitable for analysis (Table 14). The numbers of short stems in herbicide-treated plots were similar to or less than those in the untreated control. The number of short stems from plots treated with Betosip + Nortron + Dow Shield (5-10 cm) followed by Starane (10-20 cm), was consistently low. A small number of deformed flowers were recorded each week (Table 15). Where data were suitable for standard analysis of variance (second and third harvests), there were no significant differences between treatments.

Residual effects of the herbicides on vase life

Herbicide treatment had no effect on the vase life of flowers before browning/shrivelling of the perianth. However, flower size was significantly affected by some treatments (Table 16). Treatment 11 (Betosip+Nortron+Dow Shield applied at 10-20 cm potato volunteer height) produced slightly but significantly smaller flowers (85 mm) than two of the control treatments and Treatment 7 (91 mm) (Dow Shield applied at 5-10 cm and 10-20 cm potato volunteer height).

Overall Conclusions

- In the narcissus crop, a heavy infestation of potatoes (3.3 plants m^{-2}) planted in 1999 did not have a significant effect either on narcissus flower counts or bulb yields in 2001. Bulb yields in 2001 were 4 % lower in the control treatment where potato volunteers were planted compared with the unplanted control.
- The glyphosate treatment applied in November 2000 had a negligible effect on potato volunteers (because of late potato emergence) and on the narcissus crop. Under the right seasonal conditions, however, this remains an important method of volunteer potato control.
- None of the herbicide treatments proved to be completely effective in controlling volunteer potatoes. Good control relies on the integration of both cultural and chemical means. Single applications of a herbicide rarely give effective control, particularly where emergence of volunteers is staggered, and in open crops such as narcissus where crop competition is very low.
- In 2000, efficacy of herbicides for volunteer potato control, (based on haulm phytotoxicity scores), changed over the course of the growth period May to July 2000. Of the best treatments at 21 days after herbicide application (June), the effects of Totril, Dosaflo and Starane 2 were outgrown by July, while the effects of all Dow Shield treatments increased with time. Dow Shield was more effective when applied alone, rather than in a tank mix with Betosip and Nortron.
- In the year of herbicide application (2000), Dosaflo provided the best control of weeds other than volunteer potatoes. Treatment with Starane 2 or Betosip + Norton + Dow Shield also reduced weed cover, with greater effect when applied in early May than in mid-May.
- The best residual control of potato stem populations in 2001 was achieved with Dosaflo or an early application of Dow Shield used alone (1.0 l/ha). Dosaflo exhibited no residual symptoms on the potato foliage, while Dow Shield used alone or in mixtures with Betosip and Nortron caused slight yellowing and twisting of potato stems but not complete death. None of the herbicide treatments reduced tuber chitting or increased tuber rotting after harvest.
- In the year of herbicide application (2000), visual damage on narcissus foliage resulted from all Starane 2 treatments (alone and in mixtures) and also Dosaflo at 25-30 cm. In

contrast, Betosip + Nortron + Dow Shield at 5-10 cm and the three Dow Shield only treatments, showed no visual damage compared with the untreated control treatments.

- In 2001, there were no consistent effects of herbicide treatments on narcissus foliage but the number of undamaged flowers was higher with Betosip + Nortron + Dow Shield (5-10 cm) or Dosaflo, compared with an untreated control. There were no significant treatment effects on the number of flowers produced, or on the yield of bulbs.
- In addition, there were no residual effects of herbicide treatment in relation to marketable yields of flowers forced in 2002. The onset of flowering was delayed compared to untreated controls but overall flower production was unaffected.
- Overall, the most effective treatment both in terms of potato volunteer phytotoxicity, reduction in volunteer emergence the following year, and narcissus crop safety was Dow Shield.

TECHNOLOGY TRANSFER

- Growers walk held at ADAS Arthur Rickwood on 24 May 2000
- Project presented to HDC Bulb Seminar on 21 November 2000
- Planned Grower Walk's for 2001 were cancelled due to the Foot and Mouth Disease outbreak
- Results presented at the ADAS National Bulb Consultancy Centre meeting on 21 March 2002
- Features in HDC Project News
- Features in ADAS Bulb Notes
- Article to be published in The Grower with HDC permission, Summer 2002

Table 3. Narcissus flower counts on 21 March 2001

	Treatment	Mean number of flowers per plot
1	No volunteers and no herbicides	678.5
2	Volunteers, no herbicides	679.0
3	Volunteers, no herbicides	641.7
4	Volunteers, no herbicides	679.6
5	Dow Shield at 5-10cm	651.1
6	Dow Shield at 10-20cm	694.1
7	Dow Shield at 5-10cm and 10-20cm	696.7
8	Starane 2 at 5-10cm	683.9
9	Starane 2 at 10-20cm	664.7
10	Betosip + Nortron + Dow Shield at 5-10cm	690.1
11	Betosip + Nortron + Dow Shield at 10-20cm	672.6
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	670.6
13	Totril + Starane 2 at 10-20cm	682.0
14	Dosaflo at 25-30cm	693.7
	SED (78 df)	23.75
	P-value	ns

(SED = standard error of the difference between means, df = error degrees of freedom, ns = not significant)

Table 4. Effects of herbicides on flower development in narcissus on 11 April 2001[a]

	Treatment	Symptom				Undamaged flowers
		Ballooning	Less Petals	Deformed Perianth	Senesced	
1	No volunteers and no herbicides	0.00 (0.0)	0.50 (0.7)	0.25 (0.3)	12.50 (17.5)	58.20 (81.5)b
2	Volunteers, no herbicides	0.00 (0.0)	0.13 (0.2)	0.25 (0.4)	15.88 (23.9)	50.10 (75.5)ab
3	Volunteers, no herbicides	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	17.25 (24.7)	52.60 (75.3)ab
4	Volunteers, no herbicides	0.00 (0.0)	0.13 (0.2)	0.25 (0.4)	8.13 (12.5)	56.70 (86.9)b
5	Dow Shield at 5-10cm	0.00 (0.0)	0.00 (0.0)	0.38 (0.6)	9.75 (15.4)	53.10 (84.0)ab
6	Dow Shield at 10-20cm	0.00 (0.0)	0.00 (0.0)	0.63 (1.0)	10.63 (17.2)	50.70 (81.8)ab
7	Dow Shield at 5-10cm and 10-20cm	0.00 (0.0)	0.25 (0.4)	0.25 (0.4)	14.13 (21.5)	51.00 (77.7)ab
8	Starane 2 at 5-10cm	0.00 (0.0)	0.00 (0.0)	0.38 (0.6)	8.63 (13.8)	53.60 (85.6)ab
9	Starane 2 at 10-20cm	0.00 (0.0)	0.25 (0.3)	0.50 (0.7)	10.00 (13.8)	61.50 (85.2)b
10	Betosip + Nortron + Dow Shield at 5-10cm	15.38 (20.5)	0.75 (1.0)	1.63 (2.2)	14.63 (19.5)	42.60 (56.8)a
11	Betosip + Nortron + Dow Shield at 10-20cm	1.25 (1.9)	0.38 (0.6)	0.75 (1.1)	15.83 (23.7)	48.60 (72.7)ab
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	1.37 (1.9)	0.38 (0.5)	0.38 (0.5)	11.63 (16.3)	57.70 (80.8)b
13	Totril + Starane 2 at 10-20cm	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	16.00 (24.4)	49.60 (75.6)ab
14	Dosaflo at 25-30cm	0.00 (0.0)	0.00 (0.0)	0.63 (1.0)	19.50 (31.5)	41.70 (67.5)a
	SED (78 df)	-	-	-	-	5.570
	P-value	skewed	skewed	skewed	skewed	0.031

[a]Data from all flowers in a 1m length of ridge; percentage data in parentheses ; SED = standard error of the difference between means, df = error degrees of freedom.

Table 5. Mean phytotoxicity scores of narcissus foliage in 2001

	Treatment	Narcissus phytotoxicity (0-4)[a]			
		10 May	21 May	10 June	2 July
1	No volunteers and no herbicides	1.25	2.50	3.00	4.00
2	Volunteers, no herbicides	1.00	2.00	3.00	4.00
3	Volunteers, no herbicides	0.75	2.38	3.00	4.00
4	Volunteers, no herbicides	0.88	2.13	3.00	4.00
5	Dow Shield at 5-10 cm	1.38	2.75	3.00	4.00
6	Dow Shield at 10-20 cm	1.25	2.38	3.00	4.00
7	Dow Shield at 5-10 cm and 10-20 cm	1.00	2.63	3.00	4.00
8	Starane 2 at 5-10 cm	0.88	2.63	3.00	4.00
9	Starane 2 at 10-20 cm	0.75	2.13	3.00	4.00
10	Betosip + Nortron + Dow Shield at 5-10 cm	1.38	2.88	3.00	4.00
11	Betosip + Nortron + Dow Shield at 10-20 cm	0.88	2.25	3.00	4.00
12	Betosip + Nortron + Dow Shield at 5-10 cm and Starane 2 at 10-20 cm	0.88	2.50	3.00	4.00
13	Totril + Starane 2 at 10-20 cm	1.50	2.38	3.00	4.00
14	Dosaflo at 25-30 cm	1.25	2.50	3.00	4.00
	P-value (df=13)	ns	0.034	ns	ns

[a]0 = no damage, 1 = slightly drooping foliage, 2 = moderately drooping foliage, 3 = majority of foliage drooping and yellowing, 4 = dead.

Data analysed using Friedman's Test (ns = not significant, df = error degrees of freedom).

Table 6. Mean narcissus bulb weights (kg) by grade after cleaning and air-drying (2001)

		Grade (cm)						Rotten bulbs
	Treatment	<8	8-10	10-12	12-14	14-16	>16	
1	No volunteers and no herbicides	1.22	4.03	8.22	11.06	6.30	7.76	0.61
2	Volunteers, no herbicides	1.26	4.05	7.37	10.58	5.62	7.99	0.88
3	Volunteers, no herbicides	1.21	4.20	8.09	10.09	6.65	7.02	0.55
4	Volunteers, no herbicides	1.14	4.23	7.82	10.31	6.73	6.94	0.62
5	Dow Shield at 5-10 cm	1.03	3.82	7.46	10.09	5.01	8.03	0.56
6	Dow Shield at 10-20 cm	1.35	4.58	8.59	11.44	6.85	8.56	0.62
7	Dow Shield at 5-10cm and 10-20 cm	1.28	4.49	8.70	11.27	5.75	7.57	0.61
8	Starane 2 at 5-10 cm	1.34	4.40	8.49	10.98	6.51	7.60	0.54
9	Starane 2 at 10-20 cm	1.22	4.00	7.64	11.07	5.75	7.86	0.48
10	Betosip + Nortron + Dow Shield at 5-10 cm	1.34	4.38	8.46	11.06	6.44	7.14	0.34
11	Betosip + Nortron + Dow Shield at 10-20 cm	1.17	4.21	8.11	11.50	6.47	8.35	0.52
12	Betosip + Nortron + Dow Shield at 5-10 cm and Starane 2 at 10-20 cm	1.36	4.36	7.86	11.21	6.32	7.45	0.62
13	Totril + Starane 2 at 10-20 cm	1.32	4.30	7.54	10.90	5.84	6.34	1.64
14	Dosaflo at 25-30 cm	1.38	4.83	7.64	11.19	5.62	7.43	0.46
	SED (78 df)	0.105	0.322	0.493	0.704	0.622	0.914	-
	P-value	ns	ns	ns	ns	ns	ns	skewed

(SED = standard error of the difference between means, df = error degrees of freedom).

Table 7. Numbers of potato shoots per plot on 25 May 2001

	Treatment	Mean number of shoots per plot	
1	No volunteers and no herbicides	0.00	(a)
2	Volunteers, no herbicides	12.50	(def)
3	Volunteers, no herbicides	11.75	(cdef)
4	Volunteers, no herbicides	13.50	(ef)
5	Dow Shield at 5-10 cm	7.87	(b)
6	Dow Shield at 10-20 cm	9.38	(bc)
7	Dow Shield at 5-10cm and 10-20 cm	10.13	(bcd)
8	Starane 2 at 5-10 cm	9.63	(bcd)
9	Starane 2 at 10-20 cm	14.38	(f)
10	Betosip + Nortron + Dow Shield at 5-10 cm	10.75	(bcde)
11	Betosip + Nortron + Dow Shield at 10-20 cm	13.38	(ef)
12	Betosip + Nortron + Dow Shield at 5-10 cm and Starane 2 at 10-20 cm	10.38	(bcd)
13	Totril + Starane 2 at 10-20 cm	12.50	(def)
14	Dosaflo at 25-30 cm	8.75	(b)
	SED (78 df)	1.316	
	p-value	<.001	

Note: Values that share a common letter do not differ significantly at the 5% level.
Duncan's suffixes are shown in parentheses .
(SED = standard error of the difference between means, df = error degrees of freedom).

Table 8. Mean phytotoxicity scores of potato (2001)

	Treatment	Potato phytotoxicity (0-4)[a] 10 June	2 July
1	No volunteers and no herbicides	0.00	0.00
2	Volunteers, no herbicides	0.13	0.00
3	Volunteers, no herbicides	0.13	0.00
4	Volunteers, no herbicides	0.13	0.13
5	Dow Shield at 5-10cm	1.75	1.75
6	Dow Shield at 10-20cm	1.63	1.63
7	Dow Shield at 5-10cm and 10-20cm	1.75	1.88
8	Starane 2 at 5-10cm	0.13	0.25
9	Starane 2 at 10-20cm	0.63	0.00
10	Betosip + Nortron + Dow Shield at 5-10cm	0.75	1.25
11	Betosip + Nortron + Dow Shield at 10-20cm	1.00	1.00
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	1.13	1.25
13	Totril + Starane 2 at 10-20cm	0.38	0.13
14	Dosaflo at 25-30cm	0.00	0.00
	P-value (df=13)	ns	ns

Data analysed using Friedman's Test (df = error degrees of freedom, ns = not significant).

[a]0 = no damage, 1 = slight twisting/yellowing, 2 = moderate twisting/yellowing, 3 = severe twisting/yellowing, 4 = dead.

Table 9. Mean number of potatoes harvested per plot on 6 July 2001 and percentage of rotten and chitted potatoes on 28 November 2001

	Treatment	Number of tubers at harvest	Percentage tubers		
			Chitted	Not chitted	Rotten
1	No volunteers and no herbicides	-	-	-	-
2	Volunteers, no herbicides	58.70	88.43 (71.5)	1.35 (3.29)	10.22 (16.97)
3	Volunteers, no herbicides	45.50	94.92 (78.2)	1.44 (4.12)	3.64 (7.68)
4	Volunteers, no herbicides	82.60	87.19 (70.0)	2.53 (7.00)	10.28 (16.50)
5	Dow Shield at 5-10cm	28.50	89.55 (74.0)	6.48 (10.21)	3.97 (7.00)
6	Dow Shield at 10-20cm	52.60	87.15 (71.3)	3.77 (5.91)	9.08 (14.45)
7	Dow Shield at 5-10cm and 10-20cm	54.40	96.35 (81.9)	2.30 (5.66)	1.34 (4.10)
8	Starane 2 at 5-10cm	20.90	98.76 (87.5)	0.41 (0.29)	0.84 (2.15)
9	Starane 2 at 10-20cm	66.60	93.79 (77.7)	1.93 (5.55)	4.28 (10.03)
10	Betosip + Nortron + Dow Shield at 5-10cm	33.60	92.56 (77.1)	4.24 (7.10)	3.20 (7.56)
11	Betosip + Nortron + Dow Shield at 10-20cm	67.50	92.59 (76.4)	1.57 (4.98)	5.84 (10.34)
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	37.60	87.59 (72.9)	3.43 (6.59)	8.98 (12.91)
13	Totril + Starane 2 at 10-20cm	45.10	95.07 (79.3)	1.54 (4.39)	3.39 (7.27)
14	Dosaflo at 25-30cm	25.10	86.33 (71.0)	0.66 (1.93)	13.02 (16.97)
	SED (71 df)	-	-	-	4.693
	P-value	skewed	skewed	skewed	0.021

(df = error degrees of freedom). Data shown in parentheses shows angular transforms

Table 10. Mean number of flowers harvested per plot in forcing experiment

	Treatment	Total number and percentage of flowers				
		Harvested	Marketable	Short stems	Deformed	Aborted
1	No volunteers and no herbicides	219.4	178.9 (81.5)	25.3 (11.5)	15.3 (7.0)	3.8
2	Volunteers, no herbicides	223.5	180.5 (80.8)	31.9 (14.3)	11.1 (5.0)	1.3
3	Volunteers, no herbicides	218.4	185.1 (84.8)	21.8 (10.0)	11.5 (5.3)	1.6
4	Volunteers, no herbicides	223.6	198.3 (88.7)	13.9 (6.2)	11.5 (5.1)	0.9
5	Dow Shield at 5-10cm	230.8	202.4 (87.7)	14.4 (6.2)	14.0 (6.1)	1.0
6	Dow Shield at 10-20cm	231.4	195.5 (84.5)	23.0 (9.9)	12.9 (5.6)	1.1
7	Dow Shield at 5-10cm and 10-20cm	235.9	203.9 (86.4)	18.9 (8.0)	13.1 (5.6)	2.0
8	Starane 2 at 5-10cm	230.5	203.4 (88.2)	13.5 (5.9)	13.6 (5.9)	1.3
9	Starane 2 at 10-20cm	230.8	199.3 (86.4)	19.9 (8.6)	11.6 (5.0)	2.1
10	Betosip + Nortron + Dow Shield at 5-10cm	224.8	180.6 (86.4)	29.8 (13.3)	14.4 (6.4)	1.9
11	Betosip + Nortron + Dow Shield at 10-20cm	230.8	201.5 (87.3)	18.4 (8.0)	10.9 (4.7)	0.5
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	229.0	205.1 (89.6)	8.9 (3.9)	15.0 (6.6)	1.0
13	Totril + Starane 2 at 10-20cm	229.3	197.0 (85.9)	16.8 (7.3)	15.5 (6.8)	1.8
14	Dosaflo at 25-30cm	230.1	199.3 (86.6)	17.6 (7.6)	13.3 (5.8)	1.4
	Significance	ns	*	*	ns	*
	SED (13 df)	7.05	11.96	8.92	2.63	1.26

Percentage data in parentheses. (SED = standard error of the difference between means, df = error degrees of freedom).
* = skewed data, not suitable for analysis.

Table 11. Forcing experiment 2002 – mean number of flowers harvested daily per plot

	Treatment	Mean no. harvested	Mean no. of marketable stems	Mean no. of short stems	Mean no. of deformed flowers
1	No volunteers and no herbicides	6.5	5.3	0.7	0.5
2	Volunteers, no herbicides	6.6	5.3	0.9	0.3
3	Volunteers, no herbicides	6.4	5.4	0.6	0.3
4	Volunteers, no herbicides	6.6	5.8	0.4	0.3
5	Dow Shield at 5-10cm	6.8	6.0	0.4	0.4
6	Dow Shield at 10-20cm	6.8	5.8	0.7	0.4
7	Dow Shield at 5-10cm and 10-20cm	6.9	6.0	0.6	0.4
8	Starane 2 at 5-10cm	6.8	6.0	0.4	0.4
9	Starane 2 at 10-20cm	6.8	5.9	0.6	0.3
10	Betosip + Nortron + Dow Shield at 5-10cm	6.6	5.3	0.9	0.4
11	Betosip + Nortron + Dow Shield at 10-20cm	6.8	5.9	0.5	0.3
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	6.7	6.0	0.3	0.4
13	Totril + Starane 2 at 10-20cm	6.7	5.8	0.5	0.5
14	Dosaflo at 25-30cm	6.8	5.9	0.5	0.4
	Significance	ns	*	*	ns
	SED (13 df)	0.21	*	*	0.08

* = skewed data, not suitable for analysis.
(SED = standard error of the difference between means, df = error degrees of freedom).

Table 12. Forcing experiment 2002 - mean number of flowers harvested per week per plot

	Treatment	10-11 Jan	14-18 Jan	21-25 Jan	28 Jan-1 Feb	4-8 Feb	11-15 Feb	18-22 Feb	25 Feb-1 Mar
1	No volunteers and no herbicides	63.1	62.0	54.2	20.8	13.5	4.0	1.5	5.6
2	Volunteers, no herbicides	59.0	65.1	57.6	23.8	17.9	4.75	2.9	1.6
3	Volunteers, no herbicides	64.1	71.0	50.2	20.0	12.0	3.0	1.6	2.0
4	Volunteers, no herbicides	65.7	62.1	46.1	25.8	12.5	5.5	2.9	2.3
5	Dow Shield at 5-10cm	34.7	77.1	74.9	27.9	18.4	3.4	1.3	1.5
6	Dow Shield at 10-20cm	39.1	80.9	71.7	26.3	9.8	3.3	1.5	1.0
7	Dow Shield at 5-10cm and 10-20cm	89.6	77.4	42.6	16.5	8.4	1.9	1.8	1.4
8	Starane 2 at 5-10cm	52.6	74.2	64.5	25.1	8.5	3.4	2.0	2.1
9	Starane 2 at 10-20cm	51.4	54.2	61.9	35.1	16.3	6.8	3.6	3.8
10	Betosip + Nortron + Dow Shield at 5-10cm	36.7	69.1	69.0	29.8	13.8	5.1	2.6	3.4
11	Betosip + Nortron + Dow Shield at 10-20cm	41.5	74.7	70.2	30.3	16.9	3.4	1.0	1.3
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	59.7	76.5	54.4	24.6	11.1	3.5	1.6	1.6
13	Totril + Starane 2 at 10-20cm	30.8	61.5	73.6	34.4	17.5	8.1	3.0	2.9
14	Dosaflo at 25-30cm	56.1	72.0	58.2	25.6	18.3	5.1	1.8	2.2
	Significance	ns	ns	ns	ns	ns	*	*	*
	SED (13 df)	19.84	8.91	11.52	7.71	4.734	*	*	*

* = skewed data, not suitable for analysis.
Duncans suffixes in parentheses

(SED = standard error of the difference between means, df = error degrees of freedom).

Table 13. Forcing experiment (2002) - mean number of marketable flowers harvested per week per plot

	Treatment	10-11 Jan	14-18 Jan	21-25 Jan	28 Jan-1 Feb	4-8 Feb	11-15 Feb	18-22 Feb	25 Feb-1 Mar
1	No volunteers and no herbicides	56.1	50.4 (ab)	46.6	16.6	11.1	2.6	0.8	0.3
2	Volunteers, no herbicides	49.4	51.7 (ab)	48.2	19.9	16.0	2.8	1.6	0.3
3	Volunteers, no herbicides	55.0	63.6 (ab)	44.4	16.0	9.9	1.5	0.4	0.1
4	Volunteers, no herbicides	51.2	53.9 (ab)	40.9	22.8	11.4	4.6	1.9	0.9
5	Dow Shield at 5-10 cm	31.5	69.9 (b)	65.9	23.6	16.1	2.9	0.6	0.3
6	Dow Shield at 10-20 cm	32.4	70.1 (b)	63.2	20.1	8.8	2.4	0.9	0.0
7	Dow Shield at 5-10 cm and 10-20 cm	80.7	69.1 (b)	38.6	12.4	7.1	1.6	0.4	0.0
8	Starane 2 at 5-10 cm	48.0	67.0 (b)	57.5	21.3	7.4	2.8	1.0	0.0
9	Starane 2 at 10-20 cm	45.7	46.4 (a)	56.0	30.8	14.1	5.4	2.0	1.1
10	Betosip + Nortron + Dow Shield at 5-10 cm	31.9	58.7 (ab)	55.6	22.3	12.0	3.4	1.4	0.1
11	Betosip + Nortron + Dow Shield at 10-20 cm	34.0	65.2 (ab)	64.2	27.1	16.0	3.0	0.4	0.1
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20 cm	54.6	68.5 (b)	49.2	21.8	10.3	3.3	1.3	0.4
13	Totril + Starane 2 at 10-20 cm	26.8	52.7 (ab)	66.4	30.4	15.8	6.1	1.1	0.4
14	Dosaflo at 25-30 cm	50.4	63.4 (ab)	51.7	22.0	16.3	3.8	1.0	0.0
	Significance	ns	0.037	ns	ns	ns	*	*	*
	SED (13 df)	18.73	8.36	11.19	7.27	4.557	*	*	*

* = skewed data, not suitable for analysis.
Duncans suffixes in parentheses.
(SED = standard error of the difference between means, df = error degrees of freedom).

Table 14. Forcing experiment (2002) - mean number of flowers with unmarketable stem length harvested per plot each week

	Treatment	10-11 Jan	14-18 Jan	21-25 Jan	28 Jan-1 Feb	4-8 Feb	11-15 Feb	18-22 Feb	25 Feb-1 Mar
1	No volunteers and no herbicides	5.9	7.3	4.4	2.4	1.6	1.4	0.8	1.6
2	Volunteers, no herbicides	8.5	10.0	5.6	3.0	1.5	1.6	1.3	0.4
3	Volunteers, no herbicides	7.1	4.3	3.4	2.8	1.5	1.0	1.0	0.8
4	Volunteers, no herbicides	2.9	4.8	2.1	1.5	0.6	0.4	0.8	0.9
5	Dow Shield at 5-10cm	2.3	2.8	3.8	2.5	1.5	0.3	0.6	0.8
6	Dow Shield at 10-20cm	5.4	7.1	4.1	3.4	0.8	0.8	0.6	0.9
7	Dow Shield at 5-10cm and 10-20cm	6.8	4.8	2.0	2.5	1.0	0.3	1.3	0.4
8	Starane 2 at 5-10cm	3.5	3.5	2.3	1.5	0.8	0.4	0.9	0.8
9	Starane 2 at 10-20cm	3.6	5.6	2.9	3.3	1.3	0.8	1.5	1.0
10	Betosip + Nortron + Dow Shield at 5-10cm	3.8	6.1	9.3	4.9	1.5	1.3	1.3	1.8
11	Betosip + Nortron + Dow Shield at 10-20cm	6.0	6.8	2.3	1.8	0.5	0.0	0.3	0.9
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	3.3	3.3	0.5	0.8	0.3	0.3	0.1	0.5
13	Totril + Starane 2 at 10-20cm	3.0	5.0	2.4	1.1	0.8	1.6	1.6	1.3
14	Dosaflo at 25-30cm	4.4	4.8	2.4	1.9	1.3	1.1	0.6	1.3
	Significance	*	*	*	*	*	*	*	*
	SED (13 df)	*	*	*	*	*	*	*	*

*= skewed data, not suitable for analysis.
(SED = standard error of the difference between means, df = error degrees of freedom).

Table 15. Forcing experiment 2002 - mean number of deformed flowers harvested per plot each week

	Treatment	10-11 Jan	14-18 Jan	21-25 Jan	28 Jan-1 Feb	4-8 Feb	1-15 Feb	18-22 Feb	25 Feb-1 Mar
1	No volunteers and no herbicides	1.3	4.4	3.3	1.8	0.8	0.0	0.0	3.9
2	Volunteers, no herbicides	1.1	3.5	3.8	0.9	0.4	0.4	0.1	1.0
3	Volunteers, no herbicides	2.0	3.1	2.5	1.3	0.6	0.6	0.3	1.1
4	Volunteers, no herbicides	1.6	3.5	3.1	1.5	0.5	0.5	0.3	0.5
5	Dow Shield at 5-10cm	1.0	4.5	5.3	1.8	0.8	0.3	0.0	0.5
6	Dow Shield at 10-20cm	1.4	3.6	4.4	2.8	0.3	0.1	0.0	0.4
7	Dow Shield at 5-10cm and 10-20cm	2.1	3.5	2.0	1.6	0.3	0.0	0.1	1.0
8	Starane 2 at 5-10cm	1.1	3.8	4.8	2.4	0.4	0.3	0.1	0.9
9	Starane 2 at 10-20cm	2.0	2.3	3.0	1.1	0.9	0.6	0.1	1.6
10	Betosip + Nortron + Dow Shield at 5-10cm	1.1	4.3	4.1	2.6	0.3	0.5	0.0	1.5
11	Betosip + Nortron + Dow Shield at 10-20cm	1.5	2.8	3.8	1.4	0.4	0.4	0.4	0.4
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	1.9	4.8	4.6	2.1	0.6	0.0	0.3	0.8
13	Totril + Starane 2 at 10-20cm	1.0	3.8	4.9	2.9	1.0	0.4	0.4	1.3
14	Dosaflo at 25-30cm	1.4	3.9	4.1	1.8	0.8	0.3	0.1	1.0
	Significance	*	ns	ns	*	*	*	*	*
	SED (13 df)	*	1.307	1.247	*	*	*	*	*

* = skewed data, not suitable for analysis.
(SED = standard error of the difference between means, df = error degrees of freedom).

Table16. Vase life experiment (2002) – mean diameter of flowers and mean number of days until senescence of all flowers

	Treatment	Mean flower diameter (mm)		Number of days until last flower removed
1	No volunteers and no herbicides	87.6	(abc)	7.6
2	Volunteers, no herbicides	89.6	(abc)	7.6
3	Volunteers, no herbicides	90.1	(c)	7.8
4	Volunteers, no herbicides	90.5	(c)	7.1
5	Dow Shield at 5-10cm	85.6	(ab)	7.5
6	Dow Shield at 10-20cm	87.2	(abc)	7.8
7	Dow Shield at 5-10cm and 10-20cm	90.6	(c)	7.0
8	Starane 2 at 5-10cm	87.2	(abc)	7.5
9	Starane 2 at 10-20cm	86.4	(abc)	6.6
10	Betosip + Nortron + Dow Shield at 5-10cm	87.1	(abc)	8.4
11	Betosip + Nortron + Dow Shield at 10-20cm	84.7	(a)	8.2
12	Betosip + Nortron + Dow Shield at 5-10cm and Starane 2 at 10-20cm	87.7	(abc)	7.0
13	Totril + Starane 2 at 10-20cm	86.7	(abc)	7.3
14	Dosaflo at 25-30cm	87.8	(abc)	7.0
	Significance	0.025		ns
	SED (13 df)	1.78		0.56

Duncans suffixes in parenthesis (SED = standard error of the difference between means, df = error degrees of freedom).

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The HDC has previously funded related work on other horticultural crops:

- Bulb onions: Control of volunteer potatoes (FV54, 54b, 54c)
- Spray rate screening of herbicide combinations for control of volunteer potatoes and oilseed rape in onions and leeks (FV 120, FV 120a, (Year 2), FV 120a Part 1 Onions - organic soil type, FV 120a - Year 2 Part II (onions), Part III (leeks).

Appendix 1: Plan of the trial.

REP1		REP2		REP3		REP4	
P1 **T12**	P15 **T11**	P29 **T6**	P43 **T2**	P57 **T2**	P71 **T9**	P85 **T9**	P99 **T4**
P2 **T4**	P16 **T9**	P30 **T1**	P44 **T4**	P58 **T4**	P72 **T7**	P86 **T12**	P100 **T11**
P3 **T6**	P17 **T13**	P31 **T11**	P45 **T3**	P59 **T11**	P73 **T12**	P87 **T1**	P101 **T13**
P4 **T13**	P18 **T2**	P32 **T2**	P46 **T13**	P60 **T9**	P74 **T13**	P88 **T13**	P102 **T9**
P5 **T1**	P19 **T7**	P33 **T4**	P47 **T12**	P61 **T14**	P75 **T1**	P89 **T14**	P103 **T14**
P6 **T9**	P20 **T8**	P34 **T8**	P48 **T6**	P62 **T5**	P76 **T4**	P90 **T3**	P104 **T1**
P7 **T8**	P21 **T4**	P35 **T12**	P49 **T7**	P63 **T10**	P77 **T10**	P91 **T10**	P105 **T10**
P8 **T14**	P22 **T14**	P36 **T14**	P50 **T10**	P64 **T8**	P78 **T8**	P92 **T2**	P106 **T3**
P9 **T5**	P23 **T3**	P37 **T5**	P51 **T11**	P65 **T13**	P79 **T3**	P93 **T8**	P107 **T2**
P10 **T3**	P24 **T10**	P38 **T13**	P52 **T8**	P66 **T6**	P80 **T2**	P94 **T6**	P108 **T7**
P11 **T7**	P25 **T12**	P39 **T10**	P53 **T14**	P67 **T3**	P81 **T14**	P95 **T11**	P109 **T12**
P12 **T11**	P26 **T6**	P40 **T9**	P54 **T1**	P68 **T12**	P82 **T6**	P96 **T4**	P110 **T5**
1m guard→ P13 **T2**	P27 **T1**	P41 **T7**	P55 **T9**	P69 **T7**	P83 **T5**	P97 **T5**	P111 **T8**
5M↑ ↓ P14 **T10**	P28 **T5**	P42 **T3**	P56 **T5**	P70 **T1**	P84 **T11**	P98 **T7**	P112 **T6**

2 ridges

2ridge guard (Not planted) between replicates

= no Glyphosate treatment

= Glyphosate treated

Appendix 2: Trial diary.

Date	Trial Operation
16.09.1999	Trial area subsided and ploughed
05.10.1999	Plot area power harrowed and ridged
07.10.1999	Trial planted
14.10.1999	Blank ridges flattened by rotavator
01.12.1999	Trial observation; No potatoes emerged, no narcissus emerged
20.12.2000	Trial observation; No potatoes emerged, no narcissus emerged
21.01.1999	Trial observation; Very little narcissus emergence, weeds present
24.01.2000	Trial hand sprayed to treat weeds, used Parable at 250ml/20l water.
06.03.2000	Trial observation; Narcissus 10 - 15 cm tall No potato emergence observed, weeds dead.
07.03.2000	Trial observation; Potato chits at 5cm below soil
09.03.2000	Other half of potatoes planted in the ridges
14.03.2000	Trial observation; Narcissus in full flower
16.03.2000	Full flower counts carried out on narcissus
21.03.2000	Trial observation; Potato emergence observed
03.04.2000	Trial observation; Narcissus flowers deteriorating
07.04.2000	Second full flower counts of narcissus carried out
26.04.2000	Potato emergence assessment carried out
08.05.2000	Spray treatments of treatments 5,7,8,10,and 12 carried out
12.05.2000	Routine treatment with Bravo at $3l^{-ha}$ in 300 l $water^{-ha}$
15.05.2000	Treatments 6,7,9,11,12 and 13 applied
22.05.2000	Treatment 14 applied
02.06.2000	First phytotoxicity assessment (5-10cm treatments)
06.06.2000	Second phytotoxicity assessment (10-20 cm treatments)
12.06.2000	Third phytotoxicity assessment (25-30 cm treatments)
26.06.2000	Weed assessment
06.07.2000	Phytotoxicity assessment
24.07.2000	Phytotoxicity assessment
03.08.2000	Potato top growth flailed
03.11.2000	Glyphosate treatment applied
08.12.2000	Trial observation; narcissus 4-5 cm tall
21.03.2001	Bulb emergence count (number of flower head/buds)
11.04.2001	Narcissus flower phytotoxicity assessment
06.04.2001	Routine application with Ronilan 1.0 l/ha in 450 l water/ha
27.04.2001	Routine application with Ronilan 1.0 l/ha in 450 l water/ha
30.04.2001	Potato emergence count
10.05.2001	Narcissus foliage phytotoxicity assessment
21.05.2001	Narcissus foliage phytotoxicity assessment
25.05.2001	Potato emergence count
10.06.2001	Potato and narcissus foliage phytotoxicity assessment
02.07.2001	Potato and narcissus foliage phytotoxicity assessment
05.07.2001	Bulb lifting commenced
09.07.2001	Bulb lifting completed
01.08.2001	Potatoes placed in trays to chit and rots removed
10.08.2001	Bulb grading until 23.08.2001
24.08.2001	Bulbs for forcing trial placed in cold store

28.11.2001	Potato tubers assessed for rots and chits.
18.12.2001	Bulbs moved from cold store to the glasshouse
09.01.2002	Cropping of forcing expt commenced. Vase life expt set up
01.02.2002	Final vase life assessments
01.03.2002	Forcing expt completed.

Farm Spray and Fertiliser Applications

Date	Application Product	Amount
23.09.1999	P fertiliser	50kg
23.09.1999	K fertiliser	100kg
02.02.2000	Fortrol	5.2 l
23.02.2000	Profalon	8.4 l
21.02.2001	Profalon	8.4 l

