Project title:	Evaluation of potential alternative herbicides for narcissus following the loss of active ingredients
Project number:	BOF 73
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Report:	Final report, 2012
Previous report:	
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Location of project:	Fosdyke, Lincolnshire
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Date project completed (or expected completion date):	30 November 2012

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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with 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.

AUTHENTICATION

We declare that this work was done under our 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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CONTENTS

GROWER SUMMARY

Headline

The following products showed promise for weed control in narcissus:

- post flower-cropping: Wing-P + Barton WG# (pendimethalin/dimethenamid-P + florasulam), Stomp Aqua + Kerb Flo (pendimethalin + propyzamide),Stomp Aqua + Butryflow (pendimethalin + bromoxynil);
- dormant period: Intruder, Ceancrop Amigo (chlorpropham) + Sencorex SC (metribuzin) tank-mix. Chikara (flazasulfuron) also looked promising but authorisation for OPP is unlikely in the near future.

#Barton (new, WG formulation of florasulam) was in trial, the company have now decided to continue manufacture of Boxer (SC florasulam) as a specialist product for narcissus. Boxer is safe (BOF 52) at all timings and has an EAMU.

Background

The narcissus crop is grown for three or more years and weeds reduce yield and quality of flowers and bulbs. Weeds also interfere with picking and bulb lifting. Frequent use of the current limited range of herbicides can lead to a build-up of weed species that may escape control and risk development of resistance. Several options have been lost and herbicide dose rates have been reduced, for example metazachlor to 1000 g a.i./ha (equivalent to Butisan S 2.0 L/ha) to be applied now 'over three years'. Obtaining authorisation of herbicide application pre-cropping is difficult because of operator exposure to 'dislodgeable residues' at flower cropping. In previous trials (BOF 52) there were very few weeds at this stage suggesting that focussing on treatments post cropping would yield the greatest benefits.

Weeds germinate after soil disturbance by flower pickers and Lawson (1976) showed that weeds have the greatest effect if they are not controlled during the period after flowering when narcissus bulbs begin floral initiation. Weeds should therefore be removed post-cropping, before the period of flower initiation and bulb increase.

The aim of this trial was therefore to find safe effective herbicide alternatives post-cropping (Trial A). Whilst a trial was in progress however, it made sense to assess persistent residual herbicides applied during the dormant period in order to also widen the range of treatments available at this stage and perhaps avoid the need for a pre-cropping treatment and this was done in a separate area (Trial B).

Summary

The herbicide screening trials were in a three-year down crop cv. Tamsyn in its' second year in 2011 on a light silt soil at Fosdyke, South Lincolnshire. All treatments were applied at single and double 'overlap' rates in two replicates. The weather after post-cropping application was very dry from March 2011 and there was no significant rainfall until the end of June 2011. This reduced the risk of damage resulting from leaching of soil-acting residual herbicides. The autumn and winter were unusually mild, but picking flower buds on the farm crop was interrupted by snow in February 2012 when temperatures dropped to minus 17°C.

Trial A Post-cropping herbicide treatments applied 4 March 2011

Trial A post-cropping treatments were selected that had residual soil and foliar activity. Herbicides were applied when there were a few patches of small nettle, groundsel and ivy-leaved speedwell – all at cotyledon stage. Plots were monitored for herbicide damage to narcissus foliage, for weed control until 23 June 2011 when the untreated narcissus leaves had completely senesced and were detachable from the bulb, after dormancy for leaf and bud emergence; and for any effects on flower quality.

Herbicide Treatments Trial A

Trial A. Herbicides treatments were applied post-cropping at single and double rates in 200L/ha water volume on 4 March 2011.

	Herbicide Product	*Active substance*	*Product l or kg/ha*
0.	Untreated	-	-
1.	Callisto	Mesotrione	1.5L
1x2	Callisto	Mesotrione	1.5L x2
2.	Wing-P + Barton WG	pendimethalin/dimethenamid-P+florasulam	4.0L + 10g
2x2	Wing-P + Barton WG	pendimethalin/dimethenamid-P+florasulam	(4.0L + 10g)x2
3.	HDCH1+ Stomp Aqua + Goltix	confidential + pendimethalin+metamitron	2.0L+2.9L+2.8L
3x2	HDCH1+ Stomp Aqua + Goltix	confidential + pendimethalin+metamitron	(2.0L+2.9L+2.8L)x2
4.	Defy + Sencorex SC	prosulfocarb + metribuzin	2.5L + 0.58L
4x2	Defy + Sencorex SC	prosulfocarb + metribuzin	(2.5L + 0.58L)x2
5.	Butryflow + Stomp Aqua	bromoxynil + pendimethalin	1.0L + 2.9L
5x2	Butryflow + Stomp Aqua	bromoxynil + pendimethalin	(1.0L + 2.9L)x2
6.	Cadou Star	flufenacet/isoxaflutole	0.425 kg
6x2	Cadou Star	flufenacet/isoxaflutole	0.425 kg x 2
7.	Stomp Aqua + Kerb Flo	pendimethalin + propyzamide	2.9L + 3.0L
7x2	Stomp Aqua + Kerb Flo	pendimethalin + propyzamide	(2.9L + 3.0L)x2
8.	Sumimax	Flumioxazin	100ml
8x2	Sumimax	Flumioxazin	100ml x2

+ = tank-mix; new formulations 10g Barton = 50ml Boxer; 0.58L Sencorex SC = 0.5kg Sencorex WG

Crop Safety and Weed Control

Some herbicides caused leaf damage and premature senescence and in the following year resulted in delays; a reduction in bud numbers and lower bulb yields were also likely, but

bulb yield was not recorded. Weeds also have an impact but under dry conditions tall species (fat-hen and small nettle) were not vigorous and they did not shade the crop on untreated plots until late June. Black-bindweed not controlled by Cadou Star completely over-ran the ridges and had an effect. Although groundsel was not controlled by Stomp Aqua + Kerb (treatment 7), it covered the bottom of the ridge and was suppressed by the crop.

Three herbicide tank-mixes appeared safe:

Stomp Aqua + Kerb Flo (2.9 + 3.0) L/ha, there was no damage from this single dose rate and negligible effects from the double dose. Groundsel was not controlled by Stomp Aqua or Kerb Flo (see table below), but the tank-mix was effective on tall species and Kerb, which is persistent, provided long term control of fat-hen. After dormancy the most advanced narcissus were on the Stomp + Kerb plots, the only ones free from fat-hen during early dormancy and where was no damage. By 27 January there were more buds at cropping stage than on untreated plots and greater number of total buds for single and double doses. A tank-mix with Barton, Wing-P or Butryflow would be needed to control groundsel to avoid increasing problems in following crops but crop safety would need to be tested as this combination was not tested in the trial reported here.

Wing-P + Barton (4.0 L + 10g) /ha at single dose was safe and gave the best weed control - plots were weed-free until senescence on 23 June. The dimethenamid-P component of Wing-P gave long-term control of groundsel. Barton, which is foliar-acting, controlled weeds that had already emerged. Compared with untreated plots cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced.

Butryflow + Stomp Aqua (1.0 + 2.9) L/ha also appeared very safe at the single dose rate. However, Butryflow, a contact-acting herbicide, killed groundsel present at the time of application, but more emerged later. Cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced.

Four herbicide treatments were not safe:

Sumimax(100ml/ha) caused the most severe damage (see Appendix 1) - scorch to narcissus foliage and flowers, and premature senescence by the end of May, a month earlier than untreated plots. The narcissus bulbs therefore had very little time to initiate new flowers. Emergence after dormancy was delayed, and leaf height reduced. At cropping stage 27 January there were very few flower buds on Sumimax plots at single dose and none for the double dose. A few more emerged later. Sumimax plots became weedy earlier than other treatments.

The other three treatments also reduced the time for flower initiation because of damage to the foliage. The main herbicide effects were loss of turgidity (leaves floppy) followed by early leaf senescence compared with untreated narcissus.

Defy + Sencorex(2.5 + 0.583) L/ha caused the most damage: loss of leaf wax, slight scorch followed by loss of leaf turgour, then early senescence. Defy contains a powerful wetter, and this increased the effect of Sencorex. There was delayed emergence after dormancy and on 27 January a very large reduction in total bud numbers for single and double dose rates although narcissus was weed-free until the 23 June.

HDCH1 + Stomp Aqua + Goltix (2.0 + 2.9 + 2.8) L/ha although initial effects were less severe, after dormancy there was a delay and reduction in number of buds at cropping stage and in total bud numbers for both dose rates. Weed control was very good.

Callisto 1.5 L/ha appeared safe at this single dose, but not at double dose where leaves showed some yellowing. However, severe damage from both dose rates was seen after dormancy: leaf emergence was slightly delayed, crop thinning was seen on 27 January and there was a reduction in total bud numbers for single and double dose rates. Callisto performed well on the weed species in this trial but gaps pre-weed-emergence include knotgrass and annual meadow-grass.

Marginal crop safety:

Cadou Star: dose rates tested 0.45kg/ha (lower than the normal cereal dose) and 0.45kg/ha x 2 caused some yellowing of the foliage. The 0.45kg/ha dose appeared safe but there was stunting, delay and fewer buds on plots treated with the double dose, although this may have been caused partly by earlier crop suppression from the black bindweed which overran the crop. It does not control black-bindweed and it also has a weakness on knotgrass, both spring-germinating.

Flower quality

In 2012 on trial area A, flower buds were not cropped and were left to open in the field so that flower development and quality could be assessed. Snow on 4 February (10cm) and 9 February, and temperatures down to minus17°C on 11 February caused damage to leaf tips, and some buds subsequently failed to open. A few (< 1%) flowers with abnormalities were recorded on all plots. However, there were no differences between herbicide treatments and untreated narcissus. None of the herbicide treatments affected flower quality (see table). There were no signs of perianth fusing or cup malformations and anthers were fully formed.

Some post-cropping herbicide treatments in 2011 caused leaf damage and premature senescence and in the following year resulted in delays in bud cropping stage which is unacceptable for a variety grown for early market, a reduction in bud numbers, and reduced vigour. Assessments of open flowers (13 March) showed there were also delays in flower opening as a result of herbicide damage. A subsequent effect on bulb yield (not recorded) was likely. However, flower quality was not affected.

Crop tolerance scores, flower yield and quality scores for herbicides treatments applied post cropping on 4 March 2011 (Trial A).

		Date:	*26/5/11*	*27/1/12*			*13/3/12*
	Herbicide Product	*Product L or kg /ha*	*crop score (% s)*	*crop score*	*buds cs/6 m*	*total buds/ m*	*quality score*
0	Untreated	-	10 (10)	10	16	73	5
1	Callisto	1.5 L	8.5 (20)	6 th d	5	51	5
1x2	Callisto	1.5 L x 2	6 (35)	4 th d	1	44	5
2	Wing-P + Barton	4.0 L + 10g	10 (10)	10	17	78	5
2x2	Wing-P + Barton	(4.0 L + 10g) x 2	9 (15)	9.5	18	78	5
3	HDCH1+Stomp Aqua+Goltix	2.0 L+ 2.9 L+2.8 L	6.5 (30)	7	3	56	5
3x2	HDCH1+Stomp Aqua+Goltix	(2.0 L+ 2.9 L+2.8 L)x2	4 (40)	6 d	1	32	5
4	Defy + Sencorex SC	2.5L + 0.58L	4 (40)	5 d	2	35	5
4x2	Defy + Sencorex SC	(2.5L + 0.58L) x2	3 (50)	4 d	1	25	5
5.	Butryflow + Stomp Aqua	1.0L + 2.9 L	10 (10)	10	13	81	5
5x2	Butryflow + Stomp Aqua	(1.0L + 2.9 L)x2	9 (15)	9	9	69	5
6	Cadou Star	0.425 kg	7.5 y (20)	10#	13	77	5
6x2	Cadou Star	0.425 kg x 2	5 y (30)	7st d#	4	51	5
7	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	10 (10)	10	31	86	5
7x2	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	9 (15)	10	36	89	5
8	Sumimax	100ml	1 (95)	2th d	0	7	5
8x2	Sumimax	100ml x2	0 (100)	1th d	0	0	5

Assessments following treatment:
Crop tolerance scores (0=complete kill; 7=acceptable damage; 10=no damage)
% s = % leaves senesced.
After dormant period:
number of buds (35cm length) at cropping stage (cs) on 6m ridge;
total number of buds/m ridge,
Quality of open flowers - abnormality, malformation, size (score 1=unacceptable; 5 no herbicide effect = untreated)

= infestation of black bindweed after cropping; d = delay; th= thinning; st= stunting; y = yellowing

Cropping buds on the farm crop began on 27 January 2012 and finished 25 February. There was a wide variation in bud numbers on untreated plots and the reductions on treatments apparent in the table above give indications only.

Percentage weed cover by species and total recorded on plots on 25 May (82 days after treatment) and total on 23 June (111 days after treatment after crop senescence) following post cropping herbicide treatments on 4 March 2011 (trial A).

	Herbicide	*Product L or kg /ha*	*Small nettle*	*Groundsel*	*Black-bindweed*	*Fat-hen*	*TOTAL 25 May*	*TOTAL 23 June*
0.	Untreated	-	35	40	2	20	97	100
1.	Callisto	1.5 L	0	0	0	0	0	10
1x2.	Callisto	1.5 L x 2	0	0	0	0	0	0.5
2.	Wing-P + Barton	4.0 L + 10g	0	0	0	0	0	0
2x2.	Wing-P + Barton	(4.0 L + 10g) x 2	0	0	0	0	0	0
3.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L	0	0	0	0	0	2
3x2.	HDCH1+Stomp Aqua+Goltix	(2.0 L + 2.9 L+ 2.8 L) x2	0	0	0	0	0	0.5
4.	Defy + Sencorex SC	2.5L + 0.58L	0	0	0	0	0	0.5
4x2.	Defy + Sencorex SC	(2.5L + 0.58Lx2	0	0	0	0	0	0
5.	Butryflow + Stomp Aqua	1.0L + 2.9 L	0	0.3	0	0	0.3	3
5x2.	Butryflow + Stomp Aqua	(1.0L + 2.9 L)x2	0	0.3	0	0	0.3	3
6.	Cadou Star	0.425 kg	0	0	3	0	3	10
6x2.	Cadou Star	0.425 kg x 2	0	0	11	0	11	26
7.	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	0	40	0	0	40	70
7x2.	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	0	2	0	0	2	2
8.	Sumimax	100ml	1	1	0	0	2	14
8x2.	Sumimax	100ml x2	0	0.5	0	0.5	1	10

Trial B dormant stage herbicide treatments applied 20 October 2011

Trial B treatments were selected that had persistent soil residual activity, with glyphosate added as a tank-mix for all treatments and also applied to 'untreated' plots to control emerged weeds. Plots were assessed after dormancy for leaf and bud emergence, flower quality and for weed control.

At the growth stage pre-cropping, when narcissus leaves were 5-10 cm tall, another herbicide application would not have been needed following any of the trial B treatments because they were all effective. At bud cropping stage the weeds were too small to affect the flower development or to interfere with picking on any treatment or untreated plots. Flushes of groundsel that were not controlled by some treatments were killed by frost.

Herbicide Treatments Trial B

Trial B herbicides were applied pre-emergence at narcissus dormant stage at single and double rates in 200L/ha water volume on 20 October 2011 (# note Jouster should be applied after 1 November).

	Herbicide (all + Roundup Biactive 3.75L/ha)	*Active substance*	*Product/ha*
0.	Untreated	-	-
1.	Jouster#	Napropamide	7.0L
1.x2	Jouster	Napropamide	7.0L x 2
2.	Ronstar	Oxadiazon	4.0L
2 x2	Ronstar	Oxadiazon	4.0L x 2
3.	Chikara	Flazasulfuron	0.15kg
3 x2.	Chikara	Flazasulfuron	0.15kg x 2
4.	Cadou Star	flufenacet/isoxaflutole	0.85kg
4x2.	Cadou Star	flufenacet/isoxaflutole	0.85kg x 2
5.	Intruder + Sencorex SC	chlorpropham + metribuzin	2.0L (fb 2.0 L) + 0.88L
5.x2	Intruder + Sencorex SC	chlorpropham + metribuzin	(2.0L (fb 2.0L) + 0.88L) x2
6.	Intruder + Linurex 50SC	chlorpropham + linuron	2.0L (fb 2.0L) + 1.2L
6x2	Intruder + Linurex 50SC	chlorpropham + linuron	(2.0L (fb 2.0L) + 1.2L) x2

fb= followed by; + = tank-mix; 0.88 L Sencorex SC = 0.75kg Sencorex WG;

Chikara at 0.15 kg/ha appeared very safe to the crop. It is the most expensive (at this dose rate), but the most persistent herbicide. There were no differences in leaf height, number of flower buds at cropping stage, and total bud numbers between treated and untreated plots. It was the most effective on the weeds at this site. However, it does not control fat-hen or annual meadow-grass.

Intruder + Sencorex {2.0 (followed by 2.0) + 0.88} L/ha, there were no differences in leaf height, number of flower buds at cropping stage, and total bud numbers between treated and untreated plots. Intruder (chlorpropham) does not control groundsel, and the tank-mix with Sencorex was more effective than the standard treatment of Intruder + Linurex 50SC and the cost is similar. Sencorex could be a useful replacement for linuron.

Jouster 7.0 L/ha appeared safe to narcissus but it has a limited weed spectrum, although it would control willowherb.

Cadou Star at single dose rate 0.85 kg/ha caused some yellowing of narcissus foliage when it emerged, but otherwise no damage. It is less persistent than some of the other treatments.

Ronstar 4.0 L/ha was not safe to the crop. It delayed emergence, leaves were stunted and all were damaged. Leaf tips were scorched by herbicide as they emerged but the flower

buds enclosed within the leaves were not affected. Damage was more severe from the double dose. The number of flower buds at cropping stage, and total bud numbers were lower than untreated narcissus. Weed control was good but it would not control chickweed. The cropping delay, potential for effect on the bulb resulting from leaf damage and high cost mean it is unacceptable for narcissus.

Although there had been some willowherb in this field in the past, numbers on the trial area were negligible and it is likely that Sencorex had prevented a problem. Jouster, Ronstar, Sumimax and Chikara control willowherbs but only Jouster is safe and available.

Flower Quality

Open flowers were assessed for quality. The flower abnormalities due to adverse weather described in Trial A were also visible in Trial B in untreated and treated plots, and with similar frequency. None of the herbicide treatments affected flower quality and there were no differences between herbicide-treated and untreated narcissus. There were no signs of perianth fusing or cup malformations, anthers were fully formed. Scores for quality showed that there were no other abnormalities or flower deformities attributable to the herbicide treatments.

The only visible herbicide damage was severe leaf scorching from Ronstar (treatment 2, and 2x2), and this significantly reduced the effective leaf area and may possibly reduce bulb yield.Leaves protected the emerging bud from herbicide damage. Although flower quality was not affected, flowering was delayed.

Financial Benefits

Herbicides have been lost as a result of pesticide legislation. Hand-weeding costs would be too high to consider as an option. Without suitable herbicides, narcissus production costs could be prohibitive. If weed cover prevents picking narcissus flower buds, or if it is impossible to lift bulbs because weeds clog machinery, then the worst case is a crop loss of 100%. Weeds have the greatest effect if they are not controlled during the period after flowering when narcissus bulbs begin floral initiation (Lawson, 1976), and Lawson showed that in the following year there were 22-25% fewer flowers and a 13% reduction in bulb yield (at current prices, losses of £2,000/ha for flowers, £2,248 for bulbs).

This project has identified potential crop-safe, effective herbicide alternatives:

Applied post-cropping of flowers: Stomp Aqua + Kerb Flo (which would need the addition of a herbicide for groundsel control), Wing-P + Barton, Stomp Aqua + Butryflow.

Applied in the dormant period: Intruder etc. + Sencorex and the cost is similar to the standard, Intruder + Linurex. Jouster has a narrow weed spectrum and is twice the cost but controls willowherbs.

These herbicides appeared safe to narcissus and flower quality was not affected. A wider range of herbicides for a 3-year down crop will enable a weed control strategy using different herbicides at different timings and years, and this could prevent build-up of certain weed species and also avoid herbicide resistance.

Action Points

Results from this project show that there are potential herbicides that appear safe to narcissus when applied post-cropping or at dormant stage. The results are from only one trial and only one early variety Tamsyn. When available, potential treatments should be tested on a small area of crop first. Kerb should not be applied if a sensitive crop is sown the following autumn (e.g. cereals).

EAMUs will be needed for post-cropping Kerb Flo, Wing-P and Butryflow. None will be needed for herbicides for the dormant stage because they are already available for narcissus, with the exception of Chikara, which currently is NOT permitted in the presence of a crop. Although Barton (new, WG formulation of florasulam) was in trial, the company have decided to continue manufacture of Boxer (SC florasulam) as a specialist product for narcissus. Boxer is safe (BOF 52) at all timings and has an EAMU.

It may be possible to omit herbicide applications early post-emergence (leaves 5-10 cm tall), where options are limited because of risk to pickers from dislodgeable residues, and where timing is difficult to judge because of the variability of emergence across a field, where late application may damage buds.

Herbicides used in this project: Current Approval Status (1 April 2012)

Approved on or off-label for ornamental plant production (OPP) or under LTAEU – check the LTAEU LIAISON pages on the HDC website in order to update approvals status of products listed (www.hdc.org.uk) – note only visible to users who are logged in to the site.

SOLAs are now EAMUs (Extension of Authorisation for Minor Use).

Herbicide a.s.	*Product & formulation*	*Company*	*Authorised for OPP?*
Post-cropping trial A			
HDC H1	confidential	confidential	No UK approval yet
pendimethalin/ dimethenamid-p	Wing-P 250/212.5 g/L SC	BASF	EAMU OPP needed not yet requested
Phase 1 conversion			
mesotrione	Callisto 100 g/L SC	Syngenta	No EAMU OPP, not requested
bromoxynil	Butryflow 401.58g/L SC	Nufarm	No EAMU OPP,not yet requested; LTAEU until 1June 2011
pendimethalin	Stomp Aqua 455g/L CS	BASF	EAMU OPP
florasulam	Boxer 50g/L SC	Dow	EAMU narcissus will still be available
	Barton WG25% w/w	Dow	No EAMU OPP not needed
flumioxazin	Sumimax 300g/L SC	Interfarm	EAMU OPP
flufenacet/isoxaflutole	Cadou Star WG 480/100g/kg	Bayer	EAMU OPP
propyzamide	Kerb Flo 400g/L SC	Dow	OPP on-label Christmas trees only EAMU needed for narcissus
Phase 2 conversion			
metamitron	GoltixFlowable 700g/L	Makhteshim	LTAEU for OPP; EAMU OPP requested
	Goltix 90 90% w/w WG		LTAEU for OPP; EAMU OPP requested
prosulfocarb	Defy 800g/L EC	Syngenta	LTAEU for OPP; EAMU OPP requested,
metribuzin	Sencorex WG70% w/w	Interfarm	LTAEU for OPP; EAMU OPP requested,
	new Sencorex SC 600g/L	Bayer	New formulation waiting UK approval potatoes; EAMU OPP for SC requested
Pre-emergence trial B			
napropamide	Jouster 450 g/L SC	United Phosphorus	OPP on-label
oxadiazon	Ronstar Liquid 250 g/L	Certis	OPP on-label
chlorpropham	Intruder 400g/L EC	AgrichemBV	Narcissus on label pre- or post-emergence
	Cleancrop Amigo 400g/L		
linuron (Phase 1)	Linurex 50SC500g/L	Mahkteshim	EAMU OPP pre-emergence only
linuron on-label	Datura 500g/L	AgrichemBV	OPP on-label bulbs pre-emergence only
flazasulfuron	Chikara 25% w/w WG	Belchim	**No approval**. **Only for non-crop use**

SCIENCE SECTION

Introduction

The narcissus crop is grown for three or more years and weeds reduce yield and quality of flowers and bulbs, interfere with picking and bulb lifting, may delay maturity and have potential to introduce pests and disease into the crop (e.g. some weeds are hosts of the stem nematode). Frequent use of the limited range of herbicides can lead to a build-up of weed species that may escape control. As with other minor crops there are very few herbicide recommendations for flower-bulbs, because crop protection companies cannot justify the high cost of the development and approval process for a small market.

Changes to herbicide availability:

- Chlorpropham (CIPC) herbicide approvals were revoked but chlorpropham is now authorised again on-label as products Intruder, Cleancrop Amigo and Cleancrop Amigo 2 for use in bulbs but the maximum individual dose is now lower, at 2.0 L/ha, total dose 4.0 L/ha/year. Traditionally used before crop emergence.
- Diuron may approval expected for bulbs, but there is a delay.
- Cyanazine was widely used when narcissus leaves were 7-10cm but it was not supported in the EC Pesticide Review (use lost 31 December 2007).
- There may be further losses in the second phase of conversion from Long Term Arrangements to EAMUs (CRD website) if there are no, or adverse, data for operator exposure at harvest.
- Further losses are likely (e.g. linuron) under the new Regulation 1107/2009 EECwhere criteria will be hazard-based. However, pendimethalin may survive. The Water Framework Directive will also have an impact on herbicide use.
- Dose rates have been reduced (e.g. pendimethalin, linuron and chlorpropham products). Use may also be restricted at re-registration stage for some other actives and this too will reduce efficacy.
- In the past growers could use metazachlor every year post-flower cropping and it was safe to the crop. The restriction from early 2010 on dose rate of metazachlor to 1000 g a.i./ha (equivalent to Butisan S 2.0 L/ha) was interpreted in the UK to be applied ‘only one year in three’ but in a perennial crop an application may be needed every year. Although this changed (March 2012) to 1000 g a.i./ha ‘over three years’, a reduced dose rate used every year will be inadequate.

Herbicide treatments for narcissus are traditionally applied at three timings:
1. dormant period: glyphosate and a pre-crop-emergence residual herbicide applied as late as possible before shoot emergence.
2. early-post-emergence herbicides: leaf height of 5-10cm;
3. post-flowering.

Lawson, 1976 showed that weeds have the greatest effect if they are not controlled during the period after flowering (timing 3) when narcissus bulbs begin floral initiation - in the following year there were 22-25% fewer flowers and a 13% reduction in bulb yield. Hanks and Briggs (BOF 35, 1994-1997) reported that on untreated plots, weeds germinated after soil disturbance by pickers and weed cover was over 90% by the time of crop senescence. Effective weed control should therefore aim to remove weeds post-cropping so that narcissus are weed-free during the period of flower initiation and bulb increase.

It also seems unlikely that herbicides will be authorised for application pre-cropping because of operator exposure to 'dislodgeable residues' when flowers are cropped and in previous trials (BOF 52) there were very few weeds at this stage. This trial therefore concentrated on herbicide alternatives to Butisan applied at post-cropping stage (trial A).

There are some foliar (e.g. glyphosate) and residual (chlorpropham) herbicide options for use during the dormant period, but growers requested an evaluation of alternative herbicides applied pre-emergence in November 2011 in an attempt to widen the range of treatments available. These were to be applied separately in an adjacent area (trial B) and not as part of a programme with the post-cropping treatments, so that the effect of individual treatments could be assessed.

The aims and objective of the work were therefore to:-

Find safe herbicides post-cropping so that the crop was weed-free during the period of flower initiation and bulb increase.

Find persistent residual herbicides trial B to be applied in the dormant period that might avoid the need for a pre-cropping treatment.

Inform HDC of trial outcomes with a view to obtaining EAMUs, for suitable candidates, but data will be based on only one trial.

Materials and methods

The experimental areas were grown according to standard commercial practice in the first year down (2010) of the crop. The crop was not irrigated at any stage.

In the first year of the trial (i.e. second year of the commercial crop) when trial A, post cropping treatments were examined, the standard commercial regime continued as normal other than the herbicide treatments post emergence which were as described below.

In the second year (2011) of the commercial crop the standard commercial regime continued, but on trial area A only the trial treatments A shown below were applied post cropping. Trial B (adjacent to A) was on an area of the commercial crop which had been produced as normal up until the second year dormant period i.e. a standard post-cropping treatment was applied overall but no residual herbicide was applied overall in the dormant period Trial B treatments were applied in the dormant period as detailed below.

Flower buds were picked as normal on trial areas A and B in 2011, the second year of the crop (i.e. before applying the trial A treatments), but in 2012, the third year of the crop, flowers were left to open in the field in order to assess any possible phytotoxic effects of the treatments on flowering.

Details of herbicide sprays applied overall to trial areas A and B are shown in the diary in table 2.

Herbicide Treatments

Trial A post-cropping herbicides were selected that had not been tested previously for crop safety in narcissus (Callisto, Cadou Star, Sumimax), and it was important that there was both residual soil and foliar activity (table 1). Where tank-mixes were needed there was a combination with a partner of known crop safety plus a partner of unknown safety (Wing-P, HDCH1, Defy, Butryflow and Kerb Flo). Although Boxer (florasulam) and Sencorex WG (metribuzin) have been used in the past, new formulations were tested as Barton WG and Sencorex SC respectively. However, the company have now decided (April 2012) to continue manufacture of Boxer (SC florasulam) as a specialist product for narcissus. Boxer was safe (BOF 52) at all timings and has an EAMU.

Trial B herbicides were applied at dormant stage and products chosen had not been tested previously for crop safety in narcissus, had persistent soil residual activity and were expected to be effective on willowherb (table 1). In addition the ‘traditional standard’

chlorpropham + linuron was included. As in commercial practice, Roundup was added as a tank-mix to control emerged weeds on all plots including the untreated plots. The trial B pre-emergence area was adjacent to the trial A post-cropping treatment area.

Table 1. Herbicide treatments

Trial A herbicide treatments applied post-cropping at single and double rates in 200L/ha water volume.

	Herbicide Product	*Active Ingredient*	*Product/ha*
	Post-cropping 4 March 2011		
0.	Untreated	-	-
1.	Callisto	mesotrione	1.5L
1x2.	Callisto	mesotrione	1.5L x2
2.	Wing-P + Barton WG	pendimethalin/dimethenamid-P + florasulam	4.0L + 10g
2x2.	Wing-P + Barton WG	pendimethalin/dimethenamid-P + florasulam	(4.0L + 10g) x2
3.	HDCH1+ Stomp Aqua + Goltix	confidential + pendimethalin + metamitron	2.0L + 2.9L+ 2.8L
3x2.	HDCH1+ Stomp Aqua + Goltix	confidential + pendimethalin + metamitron	(2.0L + 2.9L+ 2.8L) x2
4.	Defy + Sencorex SC	prosulfocarb + metribuzin	2.5L + 0.58L
4x2.	Defy + Sencorex SC	prosulfocarb + metribuzin	(2.5L + 0.58L) x2
5.	Butryflow + Stomp Aqua	bromoxynil + pendimethalin	1.0L + 2.9L
5x2.	Butryflow + Stomp Aqua	bromoxynil + pendimethalin	(1.0L + 2.9L)x2
6.	Cadou Star	flufenacet/isoxaflutole	0.425 kg
6x2.	Cadou Star	flufenacet/isoxaflutole	0.425 kg x 2
7.	Stomp Aqua + Kerb Flo	pendimethalin + propyzamide	2.9L + 3.0L
7x2.	Stomp Aqua + Kerb Flo	pendimethalin + propyzamide	(2.9L + 3.0L) x2
8.	Sumimax	flumioxazin	100ml
8x2.	Sumimax	flumioxazin	100ml x2

+ = tank mix
10g Barton = 50ml Boxer; 0.583L Sencorex SC = 0.5kg Sencorex WG

Trial B herbicide treatments applied pre-emergence at dormant stageat single and double rates in 200L/ha water volume to evaluate mainly residual activity and persistence.

	Herbicide (all + Roundup Ace 3.0L/ha)		*Product/ha*
	Pre-emergence 20 October 2011		
0.	Untreated	-	-
1.	Jouster	napropamide	7.0L
1.x2	Jouster	napropamide	7.0L x 2
2.	Ronstar	oxadiazon	4.0L
2 x2	Ronstar	oxadiazon	4.0L x 2
3.	Chikara	flazasulfuron	0.15kg or 0.1kg
3 x2.	Chikara	flazasulfuron	0.15kg x 2
4.	Cadou Star	flufenacet/isoxaflutole	0.85kg
4x2.	Cadou Star	flufenacet/isoxaflutole	0.85kg x 2
5.	Intruder + Sencorex SC	chlorpropham + metribuzin	2.0L (fb 2.0 L) + 0.88L
5.x2	Intruder + Sencorex SC	chlorpropham + metribuzin	(2.0L (fb 2.0L) + 0.88L) x2
6.	Intruder + Linurex 50SC	chlorpropham + linuron	2.0L (fb 2.0L) + 1.2L
6x2	Intruder + Linurex 50SC	chlorpropham + linuron	(2.0L (fb 2.0L) + 1.2L)x2

+= tank mix fb = followed by
0.88 L Sencorex SC = 0.75kg Sencorex WG

Trials design

The crop was grown in ridges; each plot consisted of two adjacent ridges 6m long, with a guard ridge between each treated plot to give a plot width of 2m, length 6m. In addition there was a 1m long untreated area between treated single and double dose rates to facilitate comparisons of flower quality assessed in 2012. There were two replicate plots of each treatment.

Trial site, soil type

The herbicide screening trial was in a three-year down crop cv. Tamsyn in its' second year in 2011 on a light silt loam soil (light soil ADAS classification) at Fosdyke, South Lincolnshire.

Spray applications

Trial treatments were applied with an Azo precision plot sprayer with a 2 m boom, delivering 200 L/ha water volume through four Lurmark flat fan nozzles 02F110 at 1.9 bar pressure. Fungicides were applied overall plots as standard as detailed in the diary (table 2).

Buds were not cropped on Trial A or Trial Bin 3rd year January/February2012.

Details of herbicide sprays applied overall to trial areas A and B are shown in the diary below.

Table 2. Crop and spray diary**.**

Date & application/operation	Weather; crop growth stage	Weeds Growth Stages
Trial area A overall plots		
Overall 31 October 2010 Rosate36 + Linurex 50SC + Sencorex WG + Shark (3.0L + 1.2L + 0.75kg + 0.3L)/ha	Dormant	
February 2011: buds cropped on 2 occasions	Buds	
Trial A treatments post-cropping	4ºC; RH 58%; cloud cover 80%; soil surface damp; no rain after application, drizzle the following day; narcissus buds splitting;	A few patches of small nettle, a few groundsel and ivy-leaved speedwell all at cotyledon stage
4 March 2011 Treatments as table 1		
Trial area A overall plots		
23 June 2011	Complete senescence	
1 September Rosate 36 3.0L/ha	Dormant	Seedling weeds on all plots
14 October 2011 Rosate 36 + Shark (3.0 + 0.8)L/ha	Dormant	
26 October 2011# Intruder + Afalon + Sencorex + Rosate 36 (2.0L + 1.2L + 0.75kg + 3.0L)/ha	Dormant	
10 January 2012 Stomp Aqua + Goltix Flowable (2.9L + 3.0L)/ha	Emerging	

Trial area B overall plots		
31 October 2010 Roundup + Linurex 50SC + Sencorex WG + Shark (3.0L + 1.2L + 0.75kg + 0.3L)/ha	dormant	
23 January 2011 Stomp Aqua + Goltix Flowable (2.9L + 3.0L)/ha	Narcissus leaves 5 cm tall	
February: Buds cropped 2 occasions	Buds at harvest stage	
No herbicide post-cropping, but 6 July 2011 area flailed to remove weeds and decaying foliage	senesced	Large plant small nettle, fat-hen; groundsel seeding. Several species at cotyledon stage
23 June 2011	Complete senescence	Seedling weeds on all plots
1 September Rosate 36 3.0L/ha	dormant	Seedling weeds on all plots
14 October 2011 Rosate 36 + Shark (3.0 + 0.8)L/ha	dormant	To control any remaining willowherb
Trial B treatments dormant stage		
20 October 12-1.30 pm Treatments as table 1	10ºC; RH 40%; cloud cover 20%; soil surface dry; narcissus no leaves emerged.	All weeds dead including tall fat-hen, black-bindweed
24 October 11-12 am plots 5 & 6 2nd application of Intruder	14ºC; RH 39%; cloud cover 60%; soil surface dry; narcissus no leaves emerged.	All weeds dead.

Area A was not flailed on 6 July to remove weeds, fat-hen grew vigorously and glyphosate was not applied overall until 1 September 2011. On area A, a standard residual treatment was applied overall plots 26 October 2011 so the plots were not suppressed by weed at flowering stage in 2012.

Assessments

The following records and assessments were taken following application of the experimental treatments.

- Weather data at, and following, application
- Crop and weed growth stage recorded at the time of application
- Crop safety (% phytotoxicity) scored: 0 (crop killed) to 10 (no herbicide effects as untreated) as detailed below:

Crop score	*% Phytotoxicity*
0	Complete kill
1	80 – 95% damage
2	70 – 80% damage
3	60 – 70% damage
4	50 – 60% damage
5	40 – 50% damage
6	25 – 40% damage
7	20 – 25% damage (considered unlikely to cause reduction in yield or quality at cropping)
8	10 – 20% damage
9	5 – 10% damage
10	No damage (as untreated controls)

- Counts of numbers of each weed species/m^2 in 3 random quadrats of 0.165 m^2 on untreated control plots and species remaining on herbicide treated plots before, and at an appropriate interval after post-cropping herbicide and pre-emergence applications. Glossary shows common English and Latin weed names.

- Weed control scores: 0 (no control) to 10 (no weeds)
- Percentage weed plot cover was assessed as the percentage of the soil area on and between the two ridges covered by weeds.
- In 2012 effects on the bulb (leaf emergence, flower initiation and development) assessed and damage symptoms were recorded at emergence and flowering stage.
- In 2012 the flowers were not cropped for either trial area A or B but were left to open in the field so that visible effects flower quality could be assessed.

Plots were not yielded for flowers or bulbs, and flower vase-life tests were not conducted.

Weather (source Met Office for E England)

February 2011 was mild with mean temperatures 2.0 °C above the 1971–2000 average and there were very few frosts. March was the driest for 50 years, April was the second successive very dry month in this area and less than 1 mm of rain was recorded. Maximum temperatures and sunshine were well above the long-term average. May was also very dry and there was no rainfall until 30May. Only 2mm was recorded from the end of February until 30 May and by then the crop appeared to suffer drought stress. In late June the weather became more unsettled, with frequent showers, some of them heavy. The crop leaves had senesced by23 June. July was a cool, unsettled, cloudy month, and there were some heavy showers. Rainfall was near normal at the site.The autumn and winter were dry and extremely mild with higher than average temperatures until February. There was snowfall (10cm) at the site on 4 February and more on 9 February. Temperatures were minus 17.0°C on the 11February and the snow did not melt until 13 February.

Results

Crop Tolerance Trial A, herbicides applied post-cropping

Uncropped buds were at ‘split bud stage’ (i.e. showing some yellow petal) when the herbicide treatments were applied on 4 March. These flowers were open on untreated plots by 18 March and by 2 April had begun to die; all had died by 19 April. On 3 May narcissus seed pods had formed and leaves had collapsed. Leaves had begun to senesce at the end of May, senescence was complete by 23 June 2011 and the crop was at dormant stage.

Assessments post cropping: Plots were monitored for herbicide damage effects (Table 3) on narcissus at 2-week intervals from the time of post-cropping application until the untreated narcissus had completely senesced. Comparisons were made with the untreated areas between the two dose rates and with untreated plots.

Table 3. Crop tolerance scores, % loss of leaf turgidity and % leaf senescence scores recorded for treatments applied post cropping on 4 March 2011 (Trial A).

	Herbicide	*score*	*score*	*score (% t)*		*score (% s)*	
		18/3	2/4	19/4	3/5	26/5	7/6
0.	Untreated	10	10	10 (10)	10 (0)	10 (10)	10 (30)
1.	Callisto	10	9.5	9.5 (20)	8.5 (3)	8.5 (20)	9.5 (35)
1x2.	Callisto	10	8	8 y (40)	6 (20)	6 (35)	8 (50)
2.	Wing-P + Barton	10	10	10 (10)	10 (0)	10 (10)	10 (30)
2x2.	Wing-P + Barton	10	9.5	9.5 (20)	9 (2)	9 (15)	9.5 (35)
3.	HDCH1+Stomp Aqua+ Goltix	10	9.5	9 (30)	7 (10)	6.5 (30)	8 (40)
3x2.	HDCH1+Stomp Aqua+Goltix	10	8	7.5 p (50)	5 (20)	4 (40)	5 (60)
4.	Defy + Sencorex SC	9.5wt	7.5	8.5 p (35)	4 (30)	4 (40)	5 (60)
4x2.	Defy + Sencorex SC	8wt	5.5	7 p (50)	2 (60)	3 (50)	4 (70)
5.	Butryflow + Stomp Aqua	10	10	10 (10)	10 (0)	10 (10)	10 (30)
5x2.	Butryflow + Stomp Aqua	9.5w	9	9 (30)	9 (5)	9 (15)	9.5 (35)
6.	Cadou Star	10	10	9.5 y (20)	6 y (20)	7.5 y (20)	9.5 (35)
6x2.	Cadou Star	10	9.5	8 y (40)	3 y (60)	5 y (30)	8 (50)
7.	Stomp Aqua + Kerb Flo	10	10	10 (10)	10 (0)	10 (10)	10 (30)
7x2.	Stomp Aqua + Kerb Flo	10	10	10 (10)	9.5 (1)	9 (15)	9.5 (35)
8.	Sumimax	8.5sc	4sc t	3 (70) (10%s)	3 (75)	1 (95)	1 (99)
8x2.	Sumimax	7sc	2sc t	1 (100) (30%s)	1 (95)	0 (100)	0 (100)

Crop score 0=complete kill; 7=acceptable damage; 10= no damage (mean of 2 replicates).
% t = % leaves flopped (i.e. loss of turgidity).
% s = % leaves senesced (Sumimax scores from 9 April and from 3 May for other treatments).
w = reduced leaf wax; sc= scorch; t = loss of turgidity; y=yellowing; p = pale

Visible damage was very slow to develop on the narcissus from most herbicides, except for treatments 4 and 8. On 18 March, 14 days after treatment, Sumimax (treatment 8)had caused severe scorch to leaves and to parts of flowers that were exposed at the time of application(bud split), and these flowers soon died. The tank-mix with Defy (treatment 4) reduced the leaf wax and leaves began to flop by 18 March, and were paler than untreated leaves on 19 April. The double dose of Butryflow + Stomp Aqua also appeared to reduce leaf wax

The most severe damage was from Sumimax (8 and 8x2). Leaves had begun to lose turgidity by 2 April and were completely collapsed (8x2) by 19 April when a percentage of

leaves had also senesced. Sumimax at single and double dose rates caused premature senescence and by the end of May all leaves had senesced and were detachable from the bulb so that the narcissus bulbs could have been lifted.

The main herbicide effects for the following were increased loss of turgidity (i.e. leaves floppy) followed by early leaf senescence compared with untreated narcissus. The tank-mix of Defy + Sencorex caused the most damage, initially reduction of leaf wax and scorch. HDC H1 + Stomp Aqua + Goltix flowable was nearly as phytotoxic. Callisto appeared safe at single but not at double dose where leaves showed some yellowing but not until 19 April; there was no bleaching although it is known to affect several plant species. Cadou Star at 0.425kg/ha and 0.85kg/ha also caused some yellowing of leaves.

Three herbicide treatments appeared safe. Stomp Aqua + Kerb Flo, where there was no damage from the single dose rate and negligible effects from the double dose throughout. Wing-P + Barton, and the tank-mix of Butryflow + Stomp Aqua were also very safe at the single dose rate.

Assessments after dormant period: Effects of herbicides in trial A on the narcissus were assessed on percentage leaf emergence (table 4), total bud numbers, numbers of buds at cropping stage(table 5) with some additional crop score evaluations along with a record of leaf height. Comparisons were made with the untreated areas between the two dose rates and the untreated plots.

Table 4. Percentage leaf emergence* following the dormant period for treatments applied post-cropping (Trial A)

	Herbicide Product	*Product/ha*	*24/11*	*22/12*	*10/1*
			%	*%*	*%*
0.	Untreated	-	<1	90	100
1.	Callisto	1.5 L	<1	90	100
1x2.	Callisto	1.5 L x 2	<1	90	100
2.	Wing-P + Barton	4.0 L+ 10g	1	90	100
2x2.	Wing-P + Barton	(4.0 + 10g) x 2	1	90	100
3.	HDCH1+Stomp Aqua+ Goltix	2.0 L+2.9L+2.8L	1	90	100
3x2.	HDCH1+Stomp Aqua+Goltix	(2.0L+2.9L+2.8L)x2	3	95	100
4.	Defy + Sencorex SC	2.5L+ 0.58L	1	80	95
4x2.	Defy + Sencorex SC	(2.5L+ 0.58L)x2	<1	60	90
5.	Butryflow + Stomp Aqua	1.0L+ 2.9 L	1	90	100
5x2.	Butryflow + Stomp Aqua	(1.0L+ 2.9 L)x2	1	90	100
6.	Cadou Star	0.425 kg	1	80	95
6x2.	Cadou Star	0.425 kg x2	1	80	95
7.	Stomp Aqua + Kerb Flo	2.9 L+ 3.0 L	3	100	100
7x2.	Stomp Aqua + Kerb Flo	(2.9 L+ 3.0 L) x2	5	100	100
8.	Sumimax	100ml	0	3.5	90
8x2.	Sumimax	100ml x2	0	3	85

*mean of 2 replicates

Tamsyn is an early flowering variety and leaves emerged earlier than usual following abnormally mild weather in November, December and January 2011 although there was a frost on a few nights. On 22 December leaves on untreated plots were 3-7 cm tall and no narcissus buds were visible. Delays in leaf emergence associated with treatments 8 and 4 may be explained by herbicide damage which was recorded before the start of the dormant period (table 3) which may then have also affected bulb growth (table 4). Weediness post-cropping may also have delayed emergence on untreated plots, and on plots treated with Cadou Star.

Table 5 shows the effects of herbicide damage and of weed control. Differences between treatments became more obvious as the buds emerged. Some herbicides caused leaf damage and early senescence (table 3) and in the following year the damage was reflected in delays and a reduction in bud numbers (table 5). Lower bulb yields (not recorded) were also likely. Weeds also have an impact but under the dry conditions tall species (fat-hen and small nettle) were not vigorous and they did not shade the crop on untreated plots until late June. Black-bindweed appeared to have an effect, where it was not controlled by Cadou Star. Although groundsel was not controlled by Stomp Aqua + Kerb (treatment 7) it covered the bottom of the ridge and was suppressed by the crop.

Several weeds emerged on trial A in late June during narcissus dormancy, mainly fat-hen, which grew vigorously and may have competed for moisture with developing bulbs. There was no fat-hen on Stomp Aqua +Kerb plots, and the groundsel had senesced. Plots where

HDC H1 + Stomp Aqua + Goltix was sprayed at double dose were also free from fat-hen. There were very few fat-hen on Cadou Star treatments, but black-bindweed smothered the plots. Trial A was not flailed and fat-hen were not controlled until after glyphosate was applied on 1 September over the whole trial A area.

Table 5. Production of flowering stems and associated crop quality following the dormant period for treatments applied post-cropping (Trial A)

	Herbicide Product	*10/1*	*27/1*	*27/1*	*27/1*	*27/1*	*23/2*
		buds at cs / leaf ht cm	*crop score*	*buds at cs /6m*	*total buds/m*	*leaf ht cm*	*crop score*
0.	Untreated	2/22	10	16	73	25	10
1.	Callisto	1/20 d	6 thin d	5	51	25	6
1x2.	Callisto	0/20 st d	4 thin d	1	44	25	4
2.	Wing-P + Barton	2/23	10	17	78	25	10
2x2.	Wing-P + Barton	2/22	9.5	18	78	25	10
3.	HDCH1+Stomp Aqua+Goltix	1/20	7 d	3	56	25	7
3x2.	HDCH1+Stomp Aqua+Goltix	0/20	6thin d	1	32	23	5
4.	Defy + Sencorex SC	0/15 st d	5 thin d	2	35	22	5
4x2.	Defy + Sencorex SC	0/15 st d	4 thin d	1	25	22	3
5.	Butryflow + Stomp Aqua	2/22	10	13	81	25	10
5x2.	Butryflow + Stomp Aqua	2/22	9	9	69	23	9
6.	Cadou Star	2/22	10	13	77	25	10
6x2.	Cadou Star	2/22 thin	7 thin d	4	51	23	6
7.	Stomp Aqua + Kerb Flo	8/25	10	31	86	25	10
7x2.	Stomp Aqua + Kerb Flo	8/25	10	36	89	25	10
8.	Sumimax	0/8 d	2 thin d	0	7	15	4
8x2.	Sumimax	0/4 d	1 thin d	0	0	11	2

All data mean of 2 replicates.
Crop score 0=complete kill; 7=acceptable damage; 10= no damage
number of buds (35cm length) at cropping stage(cs) in 6m ridge;
total number of buds/m ridge
st = stunted; d = delayed compared with untreated; thin = crop thinning

There was clearly variation in bud numbers within plots which is not captured in the formal data (table 5) and hence these data should be treated with caution and give indications only.

Damage was severe on plots treated with Sumimax; emergence was delayed (table 4) and leaves were stunted (table 5) compared with untreated narcissus. On 27 January 2012 there were no buds on the double dose plots and very few at the single dose, although a few more emerged later.

Other treatments also reduced the time for flower initiation because of damage to the foliage and premature senescence. Defy + Sencorex SC had caused a slight delay and reduction in leaf height. There were fewer buds at cropping stage and a large reduction in total bud numbers for single and double dose rates compared with untreated narcissus (table 5). HDCH1+Stomp Aqua+ Goltix did not delay emergence initially, but there was a

reduction in number of buds at cropping stage and on total bud numbers for the single dose. Reduction was severe from the double dose of this tank-mix.

Callisto caused relatively little visual damage earlier, except some yellowing from the double dose. However, after dormancy severe damage from both dose rates was seen: leaf emergence was slightly delayed. Crop thinning was seen and there was a reduction in total bud numbers for single and double dose rates.

The dose rate of Cadou Star at 0.425kg/ha was low compared with the normal cereal dose (0.85kg/ha). The 0.425kg/ha single dose appeared safe but there was stunting, delay and fewer buds on plots treated with the double dose, although this may have been caused partly by earlier crop suppression from the black bindweed(by chance there were higher numbers on the double dose plots).

The most advanced narcissus (table 5) were on the Stomp + Kerb plots (treatments 7 and 7x2), where no damage occurred post-cropping and plots were free from fat-hen during early dormancy. On 27 January, compared with untreated narcissus they were more advanced with more buds at cropping stage and total bud numbers were higher at both doses.

Wing-P + Barton also appeared safe at single and double dose rates.Compared with untreated plots cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced.

The single dose rate of Butryflow+ Stomp Aqua (1.0 + 2.9 L/ha) appeared safe. Cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced compared with untreated narcissus.

Flower Quality Trial A, herbicides applied post-cropping

In 2012 on trial area A, flower buds were not cropped and were left to open in the field so that flower development and quality could be assessed.

Cropping on the commercial narcissus surrounding the trial began 27 January 2012, but was interrupted and growth was halted when temperatures dropped and there was snowfall of 10cm at the site on 4 February and more on 9 February. Temperatures were -17°C on the 11February and the snow did not melt until 13 February. Cropping resumed 15 February and finished on 25 February.

The cold weather caused damage to leaf tips, and some buds subsequently failed to open, but on Trial A there were no differences between herbicide treatments and untreated narcissus.

There were a few (less than 1%) slightly deformed flowers throughout the trial, showing slight greening and shortening of the petals - physiological deformities caused during flower formation in 2011, and were found to some extent in virtually all commercial varieties in 2012. There were no differences between herbicide-treated and untreated narcissus.

Whilst there were some abnormalities as described above, none of the herbicide treatments affected flower quality (table 6). There were no signs of perianth-fusing or cup malformations, and anthers were fully formed.

Assessments of open flowers on 13 March (table 6) when 50% of flowers were open on untreated plots showed there were some differences in relative growth stages between treatments and these were also seen at the beginning of cropping on 27 January (Table 3). There were delays in flower opening as a result of herbicide damage particularly evident from treatments Sumimax (8and 8x2), Defy + Sencorex (4and 4x2), Callisto (1and1x2) and Cadou Star (0.45kg x 2).

Scores for vigour (table 6) appear to reflect early senescence of foliage caused by herbicide damage post cropping the previous year (table 3). Where there was a marked early senescence at that time, there was a reduction in vigour, flower numbers and foliage density. This would be expected to have a subsequent effect on bulb yield although yields were not recorded in this trial.

Table 6. Assessment of flowering date,flower quality and crop vigour on plots treated with herbicides applied post cropping (trial A).

		Date:	*13/3/12*	*13/3/12*	*13/3/12*
	Herbicide Product	*Dose rate/ha*	*Open flower date**	*Quality score*	*Crop vigour*
0.	Untreated	-	5	5	5
1.	Callisto	1.5 L	4	5	4
1x2.	Callisto	1.5 L x 2	3	5	3
2.	Wing-P + Barton	4.0 L+ 10g	5	5	5
2x2.	Wing-P + Barton	(4.0 + 10g) x 2	5	5	5
3.	HDCH1+Stomp Aqua+ Goltix	2.0 L+2.9L+2.8L	4	5	5
3x2.	HDCH1+Stomp Aqua+Goltix	(2.0L+2.9L+2.8L)x2	3	5	4
4.	Defy + Sencorex SC	2.5L+ 0.58L	4	5	4
4x2.	Defy + Sencorex SC	(2.5L+ 0.58L)x2	3	5	3
5.	Butryflow + Stomp Aqua	1.0L+ 2.9 L	4	5	5
5x2.	Butryflow + Stomp Aqua	(1.0L+ 2.9 L)x2	4	5	5
6.	Cadou Star	0.425 kg	4	5	5
6x2.	Cadou Star	0.425 kg x2	3	5	4
7.	Stomp Aqua + Kerb Flo	2.9 L+ 3.0 L	5	5	5
7x2.	Stomp Aqua + Kerb Flo	(2.9 L+ 3.0 L) x2	5	5	5
8.	Sumimax	100ml	2	5	3
8x2.	Sumimax	100ml x2	1	5	2

Flowering date score: 1 = very late, 5 = as untreated.
Flower quality (i.e. abnormality, malformation, size) where score 1=unacceptable and 5=no herbicide damage, as untreated.
Crop vigour score: 1 = poor; 5 = normal.
All data are means of 2 replicates.
*Untreated 50% open flower.

Weed Control Trial A herbicides applied post-cropping

Common and Latin weed names are shown in the Glossary.

No herbicide was applied in January to the trial area A at early post-emergence stage, when narcissus leaves were 5-10 cm tall, and no weeds had emerged at this stage. Post-cropping treatments were applied on 4 March when there was a high population of small nettle in patches, groundsel and a few ivy-leaved speedwells,all at cotyledon stage, on untreated plots. Black-bindweed and chickweed emerged later (table 7). A high population of fat-hen emerged on untreated plots by 13 May (table 8). Weed distribution was uneven which is a characteristic of perennial crops. Black-bindweed and fat-hen populations were particularly variable. Although there had been some willowherb in this field in the past only two plants (broad-leaved willowherb) emerged on the trial area.

There was very little rainfall in March, April or May but moisture under the dense crop foliage appeared adequate for good efficacy of residual soil-acting herbicides. Some treatments at single dose rates (1, 2, 5 and 7) initially stunted the nettle and it died later; treatments 3, 4 and 6 had a quicker effect.

Weed counts 29 days after treatment (table 7) showed all herbicide treatments had excellent efficacy on small nettle. Plots treated with Wing-P + Barton, Defy + Sencorex SC and HDCH1+Stomp Aqua+ Goltix at both dose rates were weed free. Groundsel was not controlled by Stomp Aqua or Kerb Flo, but the tank-mix of Stomp Aqua + Kerb Flo was effective on other species present. Although Butryflow, a contact-acting herbicide, killed groundsel present at the time of application, more emerged later. Only a few ivy-leaved speedwell remained after application of Callisto. Cadou Star killed groundsel but had a weakness on black-bindweed and there were high numbers on the double dose plots. Sumimax was effective on most weed species.

Table 7. Number of weeds recorded on plots on 2 April 2011 (29 days after treatment) following post cropping treatments on 4 March 2011 (trial A).

	Herbicide	*Product/ha*	*Small nettle*	*Groundsel*	*Ivy-leaved speedwell*	*Black-bindweed*	*Chickweed*	*Fool's parsley*	*TOTAL*
0.	Untreated	-	131	45	2	20	5	3	206
1.	Callisto	1.5 L	0	0	4st	0	0	0	4st
1x2.	Callisto	1.5 L x 2	0	0	6st	0	0	0	6st
2.	Wing-P + Barton	4.0 L + 10g	0	0	0	0	0	0	0
2x2.	Wing-P + Barton	(4.0 L + 10g) x 2	0	0	0	0	0	0	0
3.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L	0	0	0	0	0	0	0
3x2.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L x2	0	0	0	0	0	0	0
4.	Defy + Sencorex SC	2.5 L + 0.58 L	0	0	0	0	0	0	0
4x2.	Defy + Sencorex SC	(2.5 L + 0.58 Lx2	0	0	0	0	0	0	0
5.	Butryflow + Stomp Aqua	1.0 L + 2.9 L	0	12cot	0	4st	0	1	17
5x2.	Butryflow + Stomp Aqua	(1.0 L + 2.9 L)x2	0	2cot	0	2st	0	0	4
6.	Cadou Star	0.425 kg	0	0	0	17	0	0	17
6x2.	Cadou Star	0.425 kg x 2	0	0	0	22	0	0	22
7.	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	0	35	0	0	0	0	35
7x2.	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	0	21	0	0	0	0	21
8.	Sumimax	100 ml	2	2	0	1	0	2	7
8x2.	Sumimax	100 ml x2	0	2	0	1	0	0	3

Numbers of weed species/m^2(mean of 3 counts in 1/6 m^2 quadrats for 2 replicate plots).
st = stunted; cot = cotyledon

Table 8 shows weed counts on 13 May (70 day after treatment). On untreated plots some weeds may have died as a result of competition, drought, or the severe frost on 4 May, but there was a flush of fat-hen which appeared from mid-April on untreated plots, and more groundsel on some treatments. Growth stages for groundsel were from cotyledon to flowering, and for nettle from 4 true leaves (TL) to large plant stage. Persistence of most residual herbicides could not be expected to last more than 60 days and thus far fat-hen was controlled on most plots.

Weed control scores are shown in Table 9. In the absence of soil disturbance, and negligible rainfall from 4 March until late June, in this trial single doses of Wing-P + Barton, Defy + Sencorex,HDCH1+Stomp Aqua + Goltix and Butryflow + Stomp Aqua(treatments 2–5) kept the narcissus plots virtually weed-free until the 23 June when the foliage had completely senesced on untreated plots. Sumimax plots became weedy earlier than other treatments; this is possibly because it is less persistent, or perhaps because the damaged crop foliage senesced early and did not suppress weeds.

Table 8. Number of weeds recorded on plots on 13 May 2011 (70 days after treatment) following post cropping treatments on 4 March 2011 (trial A).

	Herbicide	*Product/ha*	*Small nettle*	*Groundsel*	*Ivy-leaved speedwell*	*Black-bindweed*	*Chickweed*	*Fat-hen*	*TOTAL*
0.	Untreated	-	112	37	2	19	5	54	229
1.	Callisto	1.5 L	4	7	2	0	0	2	15
1x2.	Callisto	1.5 L x 2	1	2	2	0	0	0	5
2.	Wing-P + Barton	4.0 L + 10g	0	0	0	0	0	0	0
2x2.	Wing-P + Barton	(4.0 L + 10g) x 2	0	0	0	0	0	0	0
3.	HDCH1+Stomp Aqua+Goltix	2.0 L+2.9 L+2.8 L	0	8	0	0	0	0	8
3x2.	HDCH1+Stomp Aqua+Goltix	2.0 L+2.9 L+2.8 Lx2	0	2	0	0	0	0	2
4.	Defy + Sencorex SC	2.5L + 0.58L	0	0	0	0	0	0	0
4x2.	Defy + Sencorex SC	(2.5L + 0.58Lx2	7cot	1	0	0	0	0	8
5.	Butryflow + Stomp Aqua	1.0L + 2.9 L	0	7	0	0	0	0	8
5x2.	Butryflow + Stomp Aqua	(1.0L + 2.9 L)x2	0	7	0	1	0	0	8
6.	Cadou Star	0.425 kg	0	1	0	13	0	0	14
6x2.	Cadou Star	(0.425 kg	0	0	0	30	0	0	30
7.	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	0	40	0	0	0	0	40
7x2.	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	0	11	0	0	0	0	11
8.	Sumimax	100ml	2	9	0	0	0	5	16
8x2.	Sumimax	100ml x2	0	12cot	0	2	1	0	15

Numbers of weed species/m^2(mean of 3 counts in 1/6 m^2 quadrats for 2 replicate plots).
cot = cotyledon stage

Table 9. Weed control scores for herbicides applied post-cropping on 4 March 2011 (Trial A).

	Herbicide	Product/ha	2 /4	3/5	13/5	25/5	8 /6	*23/6*
0.	Untreated	-	0	0	0	0	0	0
1.	Callisto	1.5 L	9.8	9.8	9.5	10	10	8
1x2.	Callisto	1.5 L x 2	9.8	9.8	9.5	10	10	9.9
2.	Wing-P + Barton	4.0 L + 10g	10	10	10	10	10	10
2x2.	Wing-P + Barton	(4.0 L + 10g) x 2	10	10	10	10	10	10
3.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L	10	10	9.5	10	10	8
3x2.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L x2	10	10	10	10	10	9.5
4.	Defy + Sencorex SC	2.5L + 0.58L	10	10	10	10	10	9.5
4x2.	Defy + Sencorex SC	(2.5L + 0.58L) x2	10	10	9.5	10	10	10
5.	Butryflow + Stomp Aqua	1.0L + 2.9 L	9	9.5	9.5	9.5	9	9
5x2.	Butryflow + Stomp Aqua	(1.0L + 2.9 L)x2	10	9.5	9.5	9.5	9	9
6.	Cadou Star	0.425 kg	9	6	6	6	6	5.5
6x2.	Cadou Star	(0.425 kg	9	6	6	5	5	5
7.	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	6	6	6	6	6	4.5
7x2.	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	8	8	8	9	9	8.5
8.	Sumimax	100ml	9.5	9.5	9	9	7	7
8x2.	Sumimax	100ml x2	10	9.5	9	9	8	8

Score 0=no control; 7= acceptable; 10=complete control
All data are means of 2 replicates

The % plot cover by the main weed species on 25 May is shown in Table 10. On untreated plots, % weed cover was 97%. In the dry conditions weed growth was not vigorous and tall species did not shade the crop (fat-hen was 20cm tall)and black-bindweed had not yet begun to spread over the ridges The highest % weed cover was with groundsel (which did not shade the crop) on plots treated with Stomp Aqua + Kerb Flo at the single dose-rate and black-bindweed on Cadou Star plots at single and double rates.

On 23 June after the narcissus foliage had died and was detachable from the bulb (bulb lifting stage), the weed cover on untreated plots was 100% (Table 10). The lowest % plot weed cover for single dose rates was for Wing-P + Barton and Defy + Sencorex. At this stage additional weed cover was mainly due to fat-hen on plots treated with Callisto, and fat-hen and small nettle on Sumimax plots. Where herbicides failed to control groundsel (treatments 7 and 5) the established plants were seeding and had begun to senesce. There were very few fat-hen on plots treated with Cadou Star but black-bindweed had spread over the ridges.

Table 10. Percentage plot cover on 25 May for the main weed species and percentage total weed cover (mean of two replicates)on 25 May (82 days after treatment) and 23 June (111 days after treatment)for herbicides applied post-cropping on 4 March 2011 (Trial A).

	Herbicide	*Product/ha*	*Small nettle*	*Groundsel*	*Black-bindweed*	*Fat-hen*	*TOTAL 25 May*	*TOTAL 23 June*
0.	Untreated	-	35	40	2	20	97	100
1.	Callisto	1.5 L	0	0	0	0	0	10
1x2.	Callisto	1.5 L x 2	0	0	0	0	0	0.5
2.	Wing-P + Barton	4.0 L + 10g	0	0	0	0	0	0
2x2.	Wing-P + Barton	(4.0 L + 10g) x 2	0	0	0	0	0	0
3.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L	0	0	0	0	0	2
3x2.	HDCH1+Stomp Aqua+Goltix	2.0 L + 2.9 L+ 2.8 L x2	0	0	0	0	0	0.5
4.	Defy + Sencorex SC	2.5L + 0.58L	0	0	0	0	0	0.5
4x2.	Defy + Sencorex SC	(2.5L + 0.58Lx2	0	0	0	0	0	0
5.	Butryflow + Stomp Aqua	1.0L + 2.9 L	0	0.3	0	0	0.3	3
5x2.	Butryflow + Stomp Aqua	(1.0L + 2.9 L)x2	0	0.3	0	0	0.3	3
6.	Cadou Star	0.425 kg	0	0	2.5	0	2.5	10
6x2.	Cadou Star	(0.425 kg	0	0	11	0	11	26
7.	Stomp Aqua + Kerb Flo	2.9 L + 3.0 L	0	40	0	0	40	70
7x2.	Stomp Aqua + Kerb Flo	(2.9 L + 3.0 L) x2	0	2	0	0	2	2
8.	Sumimax	100ml	1	1	0	0	2	14
8x2.	Sumimax	100ml x2	0	0.5	0	0.5	1	10

The weather became unsettled at the end of June after the narcissus dormant period had begun and there were some frequent heavy showers in July when several weeds emerged on Trial A. There was a flush of groundsel on most plots, although there were fewer on treatments 4 and 6. By 10 July several seedling fat-hen had emerged on most plots and grew very tall (c.1m). The exceptions were Stomp + Kerb (7 and 7x2) due to the persistence of Kerb, and HDCH1 + Stomp Aqua + Goltix at double dose (3x2).

A commercial crop is normally flailed after senescence but Trial A was not flailed and the fat-hen was not controlled until Rosate (glyphosate) was applied on 1 September over the whole trial area A. Intruder + Afalon + Sencorex + Rosate applied overall area A on 26 October 2011 kept the area weed-free and no weeds had emerged when plots were assessed on 24 November and 22 December.

Crop Tolerance Trial B: herbicides applied at dormant stage

Trial B herbicide treatments were applied on 20 October 2011 during the narcissus dormant stage. Plots were monitored for herbicide effects in 2011/12 (leaf emergence, bud cropping stage, numbers of buds, flower development and quality).Comparisons were made with the untreated areas between the two dose rates and with untreated plots. The flowers were not

cropped on trial area B in 2012.Trial area B had been flailed and narcissus emergence on untreated plots was slightly more advanced than Trial A which was not flailed.

On 15 November a few narcissus leaves (c. 1%) had emerged on all plots. Ronstar caused yellowing of the whole leaf area and emergence was delayed (24 November, table 11).

The weather was unusually mild and there was 100% emergence on untreated and other plots by 22 December, narcissus leaves were 5-10cm tall but no flower buds were visible. Ronstar treatments were the exception, emergence was delayed, leaves were shorter and damaged by herbicide which was picked up from the soil. Leaf tips were scorched (80% of the number of leaves for the single dose rate, 100% for the double dose) and all were yellow. Narcissus leaves treated with Cadou Star also suffered temporary yellowing.

Table 11. Percentage leaf emergence, crop tolerance score, total number of buds/m ridge and number of buds at cropping stage (cs) on 30 January 2012 (72 days after treatment) for herbicides applied at dormant timing on 20 October 2011 (Trial B).

	Date:	24/11	*22/12*	*10/1*	*30/1*	*30/1*	*30/1*	*23/2*
	Herbicide (all + Roundup Biactive 3.75L/ha)	*Product/ha*	% leaf em	*score*	*score*	*score*	*buds cs/6m*	*total buds/m*	*score*
0.	Untreated	-	30	10	10	10	25	88	10
1.	Jouster	7.0L	30	10	10	10	26	90	10
1x2	Jouster	7.0L x 2	30	10	10	10	25	86	10
2.	Ronstar	4.0L	30y	4sc	4st	5st d	21	78	6d
2x2	Ronstar	4.0L x 2	15y	2sc	2st	3st d	10	70	4d
3.	Chikara	0.15kg	30	10	10	10	27	87	10
3x2.	Chikara	0.15kg x 2	30	10	10	10	25	88	10
4.	Cadou Star	0.85kg	30	9.5y	10	10	22	85	10
4x2.	Cadou Star	0.85kg x 2	27	9y	10	10	21	88	10
5.	Intruder+Sencorex	2.0L (fb 2.0L) + 0.88L	30	10	10	10	23	90	10
5x2	Intruder+Sencorex	(2.0L (fb 2.0L) + 0.88L)x2	30	10	10	10	24	93	10
6.	Intruder+Linurex	2.0L (fb 2.0L) + 1.2L	30	10	10	10	24	92	10
6x2	Intruder+Linurex	(2.0L (fb 2.0L) + 1.2L)x2	30	10	10	10	25	90	10

crop tolerance score; 0=complete kill; 7=acceptable damage; 10=no damage.
cropping stage (cs) = buds 35cm tall in 6m ridge
All data mean of 2 replicates
Em = emergence; y = yellowing; sc = scorch; st = stunted, d= delay

The mild weather continued and on 10 January 2012 there was 100% emergence of narcissus on all plots. There were no differences in mean leaf height 22cm between treatments 1, 3, 4, 5, 6 and untreated plots (not shown), most buds had emerged and c. 2 per plot were above leaf height. All narcissus on Ronstar treated plots had emerged but leaves were stunted and scorched: leaves 14cm tall with 10% of the leaf area scorched by the 4.0 L/ha dose rate; leaves 10cm tall with 30% scorch on the 4.0 L/ha x2 dose rate. A

few buds had emerged on the 4.0 L/ha treatment and these showed no scorch, no buds had emerged on the 4.0 L/ha x2 treatment.

On 30 January there were no differences in mean leaf height (25 cm) between treated and untreated plots, except for Ronstar where leaf height was 21 cm for the 4.0 L/ha dose and 16cm for the 4.0 x 2 L/ha dose. All leaf tips were severely scorched and about 7% of the leaf area for the single dose and 19% for the double dose was affected. Several leaves were malformed. The flower buds were enclosed within the leaves and were not damaged. Ronstar caused a delay, and the number of flower buds at cropping stage, and total bud numbers were reduced (table 11). There was a wide variation in bud numbers in untreated plots and these data give indications only. The harvest delay would be unacceptable in a commercial crop.

Flower Quality Trial B: herbicides applied at dormant stage

The flower buds were not cropped in 2012 on trial area B but were left to open in the field and flowering date, flower quality were assessed (table 12).The flower abnormalities caused by adverse weather described in Trial A were also visible in Trial B in untreated and treated plots, and with similar frequency.

Scores for quality showed that there were no abnormalities or flower deformities attributable to the herbicide treatments in Trial B. There were no signs of perianth fusing or cup malformations and anthers were fully formed. There were no differences between herbicide treated and untreated narcissus.

The only visible effect was that of serious leaf scorching from Ronstar (treatment 2, and 2x2), and this significantly reduced the effective leaf area and could possibly reduce bulb yield (not recorded). Although flower quality was not affected, flowering was delayed.

Table 12. Assessment of flowering date from herbicides applied dormant timing on 20 October 2011 (trial B).

		Date:	*5/3/12*	*13/3/12*
	Herbicide (all + Roundup Biactive 3.75L/ha)	*Product/ha*	Relative flowering date	quality score
0.	Untreated	-	5	5
1.	Jouster	7.0L	5	5
1x2	Jouster	7.0L x 2	5	5
2.	Ronstar	4.0L	4	5
2x2	Ronstar	4.0L x 2	3	5
3.	Chikara	0.15kg	5	5
3x2.	Chikara	0.15kg x 2	5	5
4.	Cadou Star	0.85kg	5	5
4x2.	Cadou Star	0.85kg x 2	5	5
5.	Intruder + Sencorex SC	2.0L (fb 2.0L) + 0.88L	5	5
5x2	Intruder + Sencorex SC	(2.0L (fb 2.0L) + 0.88L)x2	5	5
6.	Intruder + Linurex 50SC	2.0L (fb 2.0L) + 1.2L	5	5
6x2	Intruder + Linurex 50SC	(2.0L (fb 2.0L) + 1.2L)x2	5	5

Flowering date score: 1 = very late; 5 = as untreated.
Flowering quality score 1=unacceptable; 5=no herbicide damage, as untreated.
All data mean of 2 replicates.

Weed Control Trial B herbicides applied at dormant stage on 20 October

On 15 November a few weeds were beginning to emerge on untreated plots. On 24 November a few tiny cotyledon groundsel emerged on plots treated with Jouster and Cadou Star. No weeds emerged on other treatments. A severe frost killed most of the groundsel, those remaining on 22 December are shown in table 13. At this stage the narcissus leaves were 5-10 cm tall, the growth stage for herbicide application pre-cropping, but this would not have been needed following any of the trial B treatments.

Table 13. Numbers of weed species/m^2 on 22 December 2011 (62 days after treatment) for herbicides applied dormant timing on 20 October 2011(trial B).

	Herbicide (all + Roundup Biactive 3.75L/ha)	*Product/ha*	*Groundsel*	*Cleavers #*	*Ivy-leaved speedwell*	*TOTAL*
0.	Untreated		26	3	3	32
1.	Jouster	7.0L	6	0	0	6
1.x2	Jouster	7.0L x 2	4	0	8	12
2.	Ronstar	4.0L	0	0	0	0
2 x2	Ronstar	4.0L x 2	0	0	0	0
3.	Chikara	0.15kg	0	0	0	0
3x2.	Chikara	0.15kg x 2	0	0	0	0
4.	Cadou Star	0.85kg	0	0	0	0
4x2.	Cadou Star	0.85kg x 2	0	0	0	0
5.	Intruder + Sencorex SC	2.0L (fb 2.0 L) + 0.88L	0	0	0	0
5.x2	Intruder + Sencorex SC	(2.0L (fb 2.0L) + 0.88L) x2	0	0	0	0
6.	Intruder + Linurex 50SC	2.0L (fb 2.0L) + 1.2L	0	0	0	0
6x2	Intruder + Linurex 50SC	(2.0L (fb 2.0L) + 1.2L) x2	0	0	0	0

All data mean of 2 replicates. Groundsel at cotyledon – 1 TL stage; # uneven distribution.

Table 14. Numbers of weed species/m^2 and weed control score on 27 January 2012 (100 days after treatment) for herbicides applied dormant timing on 20 October 2011 (trial B).

	Herbicide (all + Roundup Biactive 3.75L/ha)	*Product/ha*	*Groundsel #*	*Cleavers*	*Ivy-leaved speedwell*	*TOTAL*	*Weed score*
0.	Untreated		112	2	6	121	0
1.	Jouster	7.0L	81	0	0	81	8
1.x2	Jouster	7.0L x 2	108	0	8	116	8
2.	Ronstar	4.0L	0	0	4	4	9.8
2 x2	Ronstar	4.0L x 2	0	0	0	0	10
3.	Chikara	0.15kg	0	0	0	0	10
3x2.	Chikara	0.15kg x 2	0	0	0	0	10
4.	Cadou Star	0.85kg	86y	0	0	86	8
4x2.	Cadou Star	0.85kg x 2	93y	0	0	93	8
5.	Intruder + Sencorex SC	2.0L (fb 2.0 L) + 0.88L	20	0	0	20	9.5
5.x2	Intruder + Sencorex SC	(2.0L (fb 2.0L) + 0.88L) x2	6	0	2	8	10
6.	Intruder + Linurex 50SC	2.0L (fb 2.0L) + 1.2L	66	0	0	66	8.5
6x2	Intruder + Linurex 50SC	(2.0L (fb 2.0L) + 1.2L) x2	40	0	0	40	9.5

Weed control score: 0=no control; 7= acceptable; 10= complete control.
All data mean of 2 replicates.
groundsel at cotyledon stage died during snow and severe frost in February; y = yellow.

Weed species were counted 100 days after treatment, on 27 January at the beginning of cropping stage (table 14). Most herbicides do not persist for more than 60 days but Chikara is an exception.

Cropping stage for flower buds was earlier than normal. The weeds were too small to affect the flower development or to interfere with picking on any plot and % weed cover per plot was not assessed.

There was a further emergence of groundsel. Growth stages were: groundsel cotyledon to one true-leaf; cleavers 3 to 4 whorls and ivy-leaved speedwell cotyledon to large plant stage. The highest numbers of groundsel were on the Jouster plots. Groundsel on Cadou Star plots was chlorotic and affected by the herbicide. Intruder (chlorpropham) does not control groundsel, and the tank-mix with Sencorex (treatment 5) was more effective than with linuron (treatment 6). However, most of the groundsel was killed during the period of snow and low temperatures in February.

Weed control scores are shown in table 15. The most effective treatment was Chikara, a very persistent residual herbicide thatappeared safe to narcissus. Ronstar was also very effective on weeds on this trial but it will not control chickweed.

Table 15. Weed control scores for herbicides applied in dormant period 20 October 2011 (trial B)

	Herbicide (all + Roundup Biactive 3.75L/ha)	*Date:* *Product/ha*	*24/11/11*	*22/12/11*	*27/1/12*	*23/2/12*
0.	Untreated		0	0	0	0
1.	Jouster	7.0L	8	9	8	9.5
1.x2	Jouster	7.0L x 2	10	10	8	10
2.	Ronstar	4.0L	10	10	9.8	10
2 x2	Ronstar	4.0L x 2	10	10	10	10
3.	Chikara	0.15kg or 0.1kg	10	10	10	10
3x2.	Chikara	0.15kg x 2	10	10	10	10
4.	Cadou Star	0.85kg	9	10	8	8
4x2.	Cadou Star	0.85kg x 2	10	10	8	8
5.	Intruder + Sencorex	2.0L (fb 2.0 L) + 0.88L	10	10	9.5	9.5
5.x2	Intruder + Sencorex	(2.0L (fb 2.0L) + 0.88L) x2	10	10	10	10
6.	Intruder + Linurex	2.0L (fb 2.0L) + 1.2L	9	10	8.5	9
6x2	Intruder + Linurex	(2.0L (fb 2.0L) + 1.2L) x2	10	10	9.5	9.5

Weed control scores: 0=no control; 7= acceptable; 10=complete control.
All data mean of 2 replicates.

Discussion

The project objectives were to select new safe, effective potential herbicides for application post-cropping (trial A) and pre-emergence (trial B) in narcissus in screening trials at one site in one variety.

Trial A Post-cropping herbicide treatments applied 4 March 2011

The weather after application was very dry from March and there was no significant rainfall until the end of June. This reduced the risk of damage resulting from leaching of soil-acting residual herbicides. More damage is anticipated in a wetter season.

Some herbicides caused leaf damage and premature senescence (table 3) and in the following year this resulted in delays in emergence, bud cropping stage and a reduction in bud numbers (table 5); lower bulb yields (not recorded) were also likely. However, there was a wide variation in bud numbers on untreated plotsand reductions on treated plots give indications only. The main effect was from herbicide damage. Weed control had less impact because under dry conditions tall species (fat-hen and small nettle) were not vigorous and did not shade the crop on untreated plots until late June. Black-bindweed, not controlled by Cadou Star, over-ran the ridges and had an effect. Although groundsel was not controlled by Stomp Aqua + Kerb, it covered the bottom of the ridge and was suppressed by the crop.It is possible that fat-hen present later and not controlled until 1 September with glyphosate, competed with the crop and may have affected bulb growth during this period.

None of the herbicide treatments affected flower quality. There were no signs of perianth-fusing or cup malformations, and anthers were fully formed.

Three herbicide tank-mixes appeared safe:

The Stomp Aqua + Kerb Flo (2.9 + 3.0) L/ha tanks mix did not result in damage from as the single dose rate and negligible effects resulted from the double dose. Groundsel was not controlled by Stomp Aqua or Kerb Flo, but the tank-mix was effective on other species present and Kerb, which is persistent, provided long term control of fat-hen. After dormancy the most advanced narcissus were on the Stomp + Kerb plots, which were free from fat-hen during early dormancy and where no damage occurred. By 27 January there were more buds at cropping stage than on untreated plots and greater number of total buds for single and double doses. A tank-mix of these two products with Wing-P, (or if they had already emerged, with foliar acting Barton or Butryflow), would be needed to control groundsel but crop safety of these tank-mixes would need to be tested and these would be high cost treatments, but necessary to prevent a build-up of groundsel becoming a problem in following crops.

Wing-P + Barton (4.0 L + 10g) /ha at single dose was safe and gave the best weed control; plots were weed-free until senescence on 23 June. The dimethenamid-P component of Wing-P gave long-term residual control of groundsel. Barton, which is foliar-acting, controlled weeds that had already emerged. Compared with untreated plots cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced.

Butryflow + Stomp Aqua (1.0 + 2.9) L/ha also appeared very safe at the single dose rate. Butryflow, a contact-acting herbicide, killed groundsel present at the time of application, but more emerged later. Cropping was not delayed and numbers of narcissus buds at cropping stage, and total buds were not reduced.

Four herbicide treatments were not safe:

Sumimax (100ml/ha) caused the most severe damage; scorch to narcissus foliage and flowers, and premature senescence by the end of May, a month earlier than untreated plots. The narcissus bulbs therefore had very little time to initiate new flowers. Emergence after dormancy was delayed, and leaf height reduced. At cropping stage (for the commercial crop) there were very few flower buds on Sumimax plots at single dose and none for the double dose. Sumimax plots became weedy earlier than other treatments.

The following three treatments also reduced the time for flower initiation because of damage to the foliage. The main herbicide effects were loss of turgidity (leaves floppy) followed by early leaf senescence compared with untreated narcissus.

Defy + Sencorex (2.5 + 0.583) L/ha caused the most damage: loss of leaf wax, slight scorch followed by loss of leaf turgour, then early senescence. Defy contains a powerful wetter, and this probably increased the effect of Sencorex. There was delayed emergence after dormancy and on 27 January a considerable reduction in total bud numbers for single and double dose rates, although narcissus was weed-free until the beginning of dormancy.

Although the initial effects of HDCH1 + Stomp Aqua + Goltix (2.0 + 2.9 + 2.8 L/ha)were less severe, after dormancy there was a delay and reduction in number of buds at cropping stage and in total bud numbers for both dose rates. Narcissus was almost weed-free until the dormant stage.

Callisto 1.5 L/ha appeared safe at the single dose rate used, but not at double dose where leaves showed some yellowing. However, severe damage from both dose rates was seen after dormancy: leaf emergence was slightly delayed. Crop thinning was seen on 27 January and there was a reduction in total bud numbers for single and double dose rates. A similar effect has been seen in asparagus where Callisto was sprayed on asparagus fern (HDC project FV 372).Callisto performed well on the weed species in this trial but gaps pre-weed-emergence include knotgrass and annual meadow-grass.

These four herbicide treatments applied post-cropping caused damage that reduced vigour, bud numbers and foliage density in the following year. The delays at flower cropping stage would be unacceptable particularly for an early flowering variety. Bulb yield could also be reduced (not recorded). There would be impacts on crop profitability.

Marginal crop safety:

Cadou Star:dose rates of 0.425kg/ha and 0.425kg/ha x 2 were low compared with the normal cereal dose. It caused some yellowing of the foliage. The single dose appeared safe but there was stunting, delay and fewer buds on plots treated with the double dose, although this may have been caused by earlier crop suppression from the black bindweed which overran the crop. Although a relatively inexpensive herbicide for maize, weaknesses on black-bindweed and knotgrass mean it is unsuitable for a spring bulb treatment where these weeds are sometimes problems.

Trial B dormant stage herbicide treatments applied 20 October

Tamsyn is an early variety and after a mild winter emerged earlier than usual. On 22 December the narcissus leaves were 5-10 cm tall, the growth stage for herbicide application pre-cropping, but this would not have been needed following any of the trial B treatments.

The stage for flower bud cropping was from 27 January. At this time the weeds were too small to affect the flower development or to interfere with picking on treated or untreated plots. Weeds could be a greater problem on a later variety. There were flushes of groundsel which were not controlled by some treatments but were killed by frost. The highest numbers were on the Jouster plots.

None of the dormant stage herbicide treatments affected flower quality. There were no signs of perianth-fusing or cup malformations, and anthers were fully formed.

There were no differences in leaf height, number of flower buds at cropping stage, and total bud numbers between the following treatments and untreated plots:

Chikara (0.15 kg/ha)appeared very safe to the crop and was the most persistent herbicide tested, but is unlikely to be available for use in a crop in the near future. It was the most effective on the weeds at this site, but at the dose rate used, has the highest cost c. £215/ha. It does not control fat-hen or annual meadow-grass but would kill willowherb.

Intruder + Sencorex {2.0 (followed by 2.0) + 0.88} L/ha: Intruder (chlorpropham) does not control groundsel, and the tank-mix with Sencorex was more effective than the standard treatment Intruder + Linurex 50SC. The tank-mix would be a similar cost. Sencorex SC (or the WG formulation) could be a useful replacement for linuron.

Although there had been some willowherb in this field in the past, numbers on the trial area were negligible and it is likely that Sencorex had prevented a problem. Jouster appeared safe to narcissus but it has a limited weed spectrum, although it would control willowherb.

Cadou Star at single dose rate 0.85 kg/ha and double dose caused some yellowing of narcissus foliage when it emerged, but otherwise no damage. It was less effective than Intruder + Sencorex SC and is less persistent.

Ronstar 4.0 L/ha was not safe to the crop. It delayed emergence, leaves were stunted and all were damaged. Leaf tips were scorched by herbicide as they emerged but the flower buds enclosed within the leaves were not affected. There was a potential reduction of bulb yield resulting from damage to the leaves. Damage was more severe from the double dose

and total bud numbers were lower than untreated narcissus. Weed control was good and it is effective on willowherb, but it does not control chickweed. The cost is also high £150. Ronstar is therefore unsuitable for narcissus.

There are EAMUs for all these dormant stage treatments except Chikara. The best available treatment was Intruder + Sencorex.

Appendix III gives some information on weed susceptibility to herbicides but the tables are based on limited information from herbicide labels, trials or data from other EU Member States – please treat with caution.

Conclusions

Results from this screening trial show that there are potential herbicides that are effective and appear safe to narcissus. The data is from only one trial, on one variety Tamsyn, and there was no significant rainfall until June and thus no damage as a result of leaching of any soil-acting residual herbicides. When available, potential treatments should be tested on a small area of crop first. Kerb should not be applied if a sensitive crop is sown the following autumn (e.g. cereals).

- A wider range of herbicides for a 3-year down crop will enable a weed control strategy using different herbicides at different timings and years, and this could prevent build-up of certain weed species and also avoid herbicide resistance.
- Herbicide treatments for narcissus are currently applied at three timings. It may be possible to omit the early post-emergence timing (leaves 5-10 cm tall) where options are limited because of risk to pickers from 'dislodgeable residues', and where timing is difficult to judge because of the variability of emergence across a field; late application may damage buds. In this trial there were no weeds at this timing.
- Metazachlor post-flower cropping is also safe to the crop. Growers should note that the restriction on dose rate of metazachlor to 1000 g a.i./ha (equivalent to Butisan S 2.0 L/ha) interpreted in the UK to be applied 'only one year in three has changed and now 'over 3 years' is permitted (EFSA report) – but a dose rate of 0.66L/ha will be inadequate.

Applied post-cropping

- Three herbicide treatments appeared safe. Stomp Aqua + Kerb Flo (2.9 + 3.0) L/ha, where there was no damage from the single dose rate and negligible effects from

twice this dose, Wing-P + Barton (4.0L + 10g) /ha, and the tank-mix of Butryflow + Stomp Aqua (1.0 + 2.9) L/ha were also safe.

- Groundsel was not controlled by Stomp Aqua or Kerb Flo and the addition of Wing-P, or foliar-acting Barton, Butryflow if the weed has emerged, would be needed to control groundsel. Crop safety for these tank-mixes would need to be tested.

Applied in the dormant period

- The following appeared safe to the crop at single (and double) dose rates: Intruder + Sencorex SC (2.0 followed by 2.0 + 0.88) L/ha, was also effective and a similar cost to the standard Intruder + Linurex 50SC.Jouster7.0 L/ha and Cadou Star 0.85 kg/ha were also safe but less effective.
- Although there had been some willowherb in this field in the past, only two plants (broad-leaved willowherb) emerged on the trial area and it is possible that Sencorex had prevented a problem. Jouster controls willow herb but at high cost.

EAMUs

- EAMUs will be needed for post-cropping Kerb-Flo, Wing-P and Butryflow. None will be needed for herbicides for the dormant stage because they are already available for narcissus, with the exception of Chikara, which would NOT be permitted in the presence of a crop.
- Barton WG, a new formulation of florasulam, was in trial, but the company have now decided to continue manufacture of Boxer (SC formulation of florasulam) as a specialist product for narcissus. Boxer is safe (BOF 52) at all timings and has an EAMU for application pre- and post-cropping.

Knowledge and Technology Transfer

Trial visited by agronomists.

Update of preliminary findings at BOF panel meeting 4 April 2011.

An article on BOF 73 preliminary trial results was published in HDC News in 2011 no. 179.

Another article on final results will be submitted in October 2012.

Glossary

Latin and common English names for weeds

Latin name	Common name
Chenopodium album	Fat-hen
Epilobiummontanum	Broad-leaved willowherb
Gallium aparine	Cleavers
Polygonum convolvulus	Black-bindweed
Senecio vulgaris	Groundsel
Stellaria media	Chickweed, common
Urticaurens	Small nettle
Veronica hederifolia	Ivy-leaved speedwell

References

Lawson, H. M.(1976). The effects of spring-germinating weeds on narcissus. Annals of Applied Biology 83, 324-327.

Knott, C. M. and Hanks, G. R. (2006).Narcissus: Seeking replacements for ‘Fortrol’ (cyanazine) and sulphuric acid. Horticultural Development Company Final Report for project BOF 52.

Knott, C. M.(2011).Evaluation of potential alternatives for weed control in asparagus following the loss of herbicides.Horticultural Development Company Final Report for project FV 372.

Appendix I

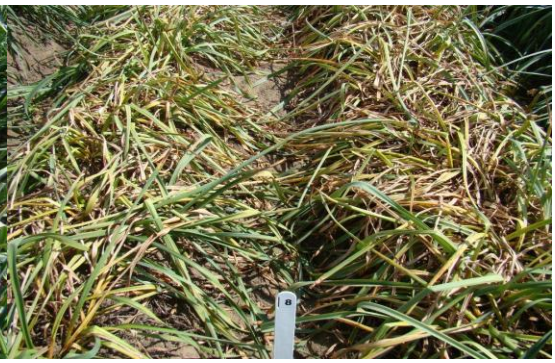
Trial A herbicides applied post-cropping 4 March 2011

Cotyledon weeds before application

13 May 2011 the following caused severe damage:

Defy + Sencorex (2.5 +0.583) L/ha

Sumimax 100ml



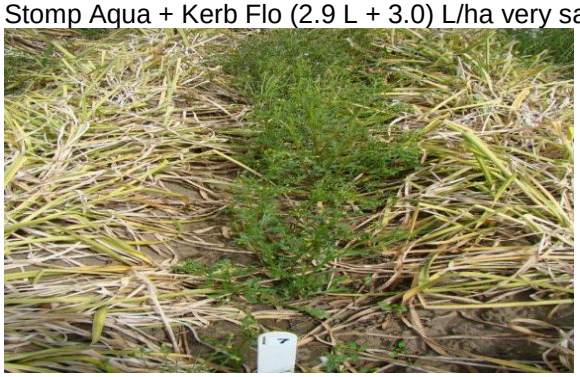
Wing-P + Barton (4.0 L + 10g) /ha appeared safe and effective

At senescence stage 23 June 2011:

Untreated (nettle, fat-hen, groundsel)

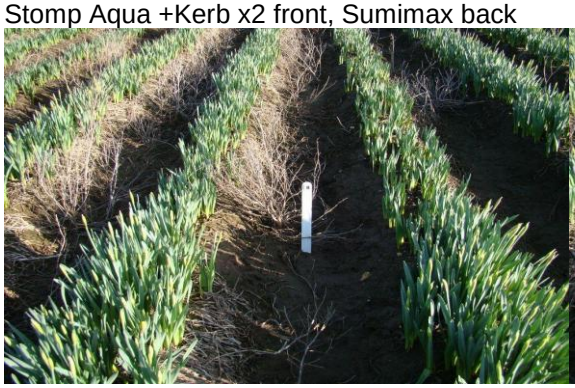
Wing-P + Barton (4.0 L + 10g) /ha weed free

Stomp Aqua + Kerb Flo (2.9 L + 3.0) L/ha very safe but no control of groundsel



Trial A cropping stage 27 January 2012

Stomp Aqua +Kerb x2 front, Sumimax back



Untreated front, Defy + Sencorex x2 back

Untreated front, Cadou Star x2 back

Callisto front, untreated, Callisto x2 back

Trial A Cropping stage 23 February 2012

Untreated front, Callisto x2 back

Untreated front, Cadou Star x2 back

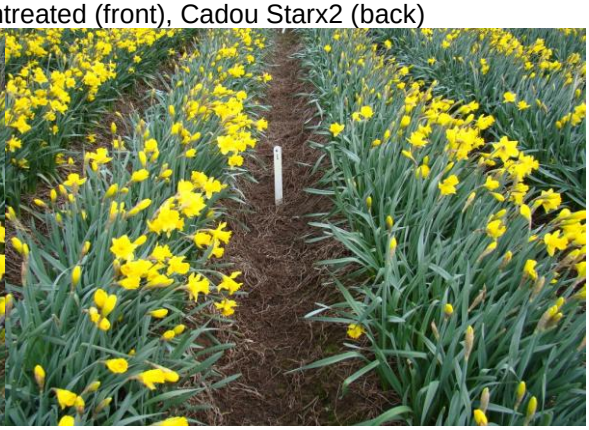
Untreated (L), Sumimax x2 (R)

Trial A 6 March 2012

Wing-P + Barton(front),untreated, Wing-P + Barton 2x2 (back)

Untreated (front), Callistox2 (back)

Untreated (front), Cadou Starx2 (back)



Appendix II

Trial B dormant stage herbicide treatments applied 20 October

27 January 2012

Untreated groundsel and ivy-leaved speedwell

Intruder + Sencorex SC (2.0L (followed by 2.0L)

Chikara 0.15 kg/ha safe no weeds

Ronstar 4.0L/ha not safe**24 Dec 2011**

Ronstar 4.0L/ha not safe no weeds **27 Jan 2012**

Untreated **6 March 2012**

Intruder + Sencorexsafe**6 March 2012**

Ronstar**6 March 2012**, leaf damage

Appendix III

The following tables are based on limited information from labels, trials and data from other EU Member States – please treat with caution.

Weed Susceptibility to herbicides applied post-cropping. Dose rate L or kg/ha **.**Data for Callisto and Sumimax residual activity.HDC H1 is confidential and not available yet
S = susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant

Common name	*Stomp Aqua pendimethalin*	*Kerb propyzamide*	*Butisan metazachlor*	*Butisan metazachlor*	*Goltix flow* metamitron	*Wing-P pendimethalin/ dimethenamid-P*	*Sencorex* metribuzin
	2.9L	*3.0L*	*2.0L*	0.66L	2.8L	4.0L	0.5kg
Amaranth, common							
Bindweed, black		S	MS		MR	S	S
Bugloss							S
Charlock			MR		MS		S
Chickweed, common	S	S	S	S	S	S	S
Cleavers		MS - R	MS		R		R
Corn marigold	S		S		S		MS
Corn spurrey			MS		S		S
Crane's-bill, cut-leaved			MR				
Dead-nettle, henbit	S				MS		S
Dead-nettle, red	S		S	S	MS	S	S
Dock, broad-leaved					S		
Fat-hen	S	S	MS		MS	S	S
Fool's parsley					S		
Forget-me-not, field	S	MS	S		S		S
Fumitory, common	MS	MS - R	R		MS		S
Gallant-soldier		R					
Groundsel	R	R	S	S	MS	S	S
Hemp-nettle, common	S		MR		S		S
Knotgrass	S	S	R		MS	S	MS
Mayweed, scented	MS	R	S	S	S	S	S
Mayweed, scentless	MS	R	S	S	S	S	S
Nettle, small	S	S	MS		S	S	S
Nightshade, black		S			MR	S	R
Orache, common	S				S		S
Pansy, field	S		MR		MS		MS
Parsley piert	S		S				
Pennycress, field			R		S		S
Persicaria, pale					MS	S	S
Pimpernel, scarlet	S	R			MR		S
Pineapple weed	MS	R	S		S		
Poppy, common	S	R	S		S		
Redshank		S	MS		MS	S	S
Shepherd's-purse	MS	MS- R	S	S	S	S	S
Sow-thistle, smooth	S					S	MS
Speedwell, field	S	S	S	S	S	S	S
Speedwell, ivy-leaved	S	S	S	S	MS	S	S
Sun spurge					S		
Thistle, creeping		R			S seedling		
Wild radish					MS	R	S
Annual meadow-grass	S	S	S	S	MS	S	S
Blackgrass	S	S	S		R		MS
Brome, barren		S	MS		R		
Couch, common					R		S
Wild-oat		S	MR		R		S
Volunteer oil-seed rape	MS		R		MS	R	S
Volunteer potatoes							S
Willowherbs			MS				

Weed Susceptibility to post-weed-emergence herbicides. Barton, Basagran and Butryflow are foliar acting and only kill emerged weeds, Weed spectrum below if applied post-weed-emergence. Dose rates/ha;
S = susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant.

Common name	***Latin name***	*Barton florasulam*	*Barton florasulam*	*Basagran SG bentazone*	Butryflow *bromoxynil*
		20g	*10g*	*1.65kg*	*1.0 L*
Amaranth, common	*Amaranthus*				
Bindweed, black	*Fallopia convolvulus*	S		MS	S
Bugloss	*Anchusaarvensis*				
Charlock	*Sinapisarvensis*	S	S	S	
Chickweed, common	*Stellaria media*	S	S	S	MR
Cleavers	*Galiumaparine*	S	S	S	
Corn marigold	*Chrysanthemum segetum*	S		S	
Corn spurrey	*Spergulaarvensis*			S	
Crane's-bill, cut-leaved	*Geranium dissectum*			S	
Deadnettle, henbit	*Lamiumamplexicaule*			MS	
Dead-nettle, red	*Lamiumpurpureum*			MS	
Dock, broad-leaved	*Rumexobtusifolius*				R
Fat-hen	*Chenopodium album*	R		MS	S
Fool's parsley	*Aethusacynapium*			S	
Forget-me-not, field	*Myosotisarvensis*	S		S	
Fumitory, common	*Fumariaofficinalis*			MS	
Gallant-soldier	*Galinsogaparviflora*				
Groundsel	*Senecio vulgaris*	S		MS	S
Hemp-nettle, common	*Galeopsistetrahit*	S		MR	
Knotgrass	*Polygonumaviculare*	MS		MR	S
Mayweed, scented	*Matricariarecutita*	S	S	S	
Mayweed, scentless	*Tripleurospermuminodorum*	S	S	S	
Nettle, small	*Urticaurens*	R		S	MS
Nightshade, black	*Solanumnigrum*	S		S	S
Orache, common	*Atriplexpatula*			MS	S
Pansy, field	*Viola arvensis*			R	
Parsley piert	*Aphanesarvensis*	S		-	
Pennycress, field	*Thlaspiarvense*			S	
Persicaria, pale	*Persicarialapathifolia*			S	
Pimpernel, scarlet	*Anagalisarvensis*			S	
Pineappleweed	*Matricariadiscoidea*	S		S	
Poppy, common	*Papaverrhoeas*	MR		MS	
Redshank	*Persicariamaculosa*			S	MS
Shepherd's-purse	*Capsella bursa-pastoris*			S	S
Sow-thistle, smooth	*Sonchusoleraceus*			MS	
Speedwell, field	*Veronica persica*			MS	
Speedwell, ivy-leaved	*Veronica hederifolia*			MR	
Sun spurge	*Euphorbia helioscopia*			-	
Thistle, creeping	*Cirsiumarvense*			suppr	
Wild radish	*Raphanusraphanistrum*			S	
Annual meadow-grass	*Poaannua*	S		R	
Blackgrass	*Alopecurusmyosuroides*			R	
Brome, barren	*Anisanthasterilis*			R	
Couch, common	*Eltrigiarepens*				
Wild-oat	*Avenafatua*			R	
Volunteer oil-seed rape	*Brassica napus*	S	S	S	
Volunteer potatoes	*Solanumtuberosum*				
Willowherbs	*Epilobium spp.*	R	R	R	

Barton new formulation of florasulam
Boxer *0.05L= 10g Barton*

Weed Susceptibility to herbicides applied pre-crop emergence. They are mainly residual herbicides although Sencorex, linuron and Cadou Star has foliar activity as well. Linuron can only be used pre-emergence. Chikara can only be applied to non-cropped land.Dose rate L or kg/ha; fb = followed by.
S = susceptible; MS = Moderately Susceptible; R = Resistant; MR = Moderately Resistant.

Common name	*Intruder + Linurex 50SC* *chlorpropham + linuron*	*Intruder* *chlorpropham*	*Sencorex* metribuzin	*Devrinol* *napropamide*	*Chikara* *flazasulfuron*	Cadou Star *flufenacet /isoxaflutole*
	2.0 fb 2.0L + 1.2L	*2 .0 L*	0.5kg	*5-9 L*	*150g*	*0.5kg*
Amaranth, common						
Bindweed, black	S	S	S			MR
Bugloss			S			S?
Charlock	S		S	R		S
Chickweed, common	S	S	S	S		S
Cleavers	S	R	R	MS		MR
Corn marigold	S		MS	R		
Corn spurrey			S	S		
Crane's-bill, cut-leaved						MS
Dead-nettle, henbit			S			S
Dead-nettle, red	S		S			S
Dock, broad-leaved						
Fat-hen	S	MS	S	S	R	MS
Fool's parsley						
Forget-me-not, field			S	S		
Fumitory, common	S	MS	S			MR
Gallant-soldier						
Groundsel	S	R	S	S		S
Hemp-nettle, common	S		S			
Knotgrass	S	S	MS	S		MR
Mayweed, scented	S	R	S	S		MS
Mayweed, scentless	S	R	S	S	(S)	MS
Nettle, small	S	S	S	MS		MS
Nightshade, black	S	MS	R	R	R	S
Orache, common	S	MS	S			MR
Pansy, field			MS	MS		MS
Parsley piert				R		
Pennycress, field		S	S	R		
Persicaria, pale		S	S	MS		MS
Pimpernel, scarlet	S		S			MS
Pineapple weed	S	R		S		MS
Poppy, common				S		
Redshank	S	MS	S	MS		MR
Shepherd's-purse	S	MS	S	MS		S
Sow-thistle, smooth		R	MS	MS	R	MR
Speedwell, field	S	S	S	S	R	S
Speedwell, ivy-leaved	S	S	S			S
Sun spurge						
Thistle, creeping					S#	
Wild radish			S			MR
Annual meadow-grass	S	S	S	S	R	S
Blackgrass	S	S	MS	S		MR
Brome, barren						
Couch, common			S			
Wild-oat	S	S	S			MR
Volunteer oil-seed rape			S			S
Volunteer potatoes			S			MR
Willowherb	S			S	S#	

#Chikara + Roundup post gives 3-4 months control, other susceptible weeds up to 5 months