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OUTDOOR FLOWERS: AN EVALUATION OF HERBICIDES

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CONTENTS Page no.

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

Grower Summary

BOF 51 Outdoor flowers: An evaluation of herbicides

Headlines

So far, effective and safe herbicide programmes have been found for several of the crops studied:

Direct-drilled crops:

- **China aster**: Stomp* tank-mix with Centium, followed by Betanal Expert or Goltix tank-mix with Betanal applied to cotyledon weeds.
- **Cornflower**: Stomp tank-mix with Flexidor or aclonifen tank-mix with Stomp.
- **Zinnia**: Stomp tank-mix with Centium followed by Betanal at 1.8 L/ha, or Stomp tank-mix with Flexidor.
- **Larkspur**: Stomp tank-mix with Centium pre-emergence. A safe post-emergence treatment is still needed.
- **Bupleurum**: Stomp tank-mix with Flexidor followed by Goltix tank-mix with Betanal.

Transplanted crops:

- **Ronstar Liquid** was useful as a pre-transplanting soil treatment for several flower crops (but it was not safe on delphinium in the 2003 trial).
- **China aster**: Ronstar Liquid (applied before transplanting) followed by Betanal Expert.
- **Stock**: Ronstar Liquid (applied before transplanting) followed by Dacthal tank-mix with Butisan pre-weed-emergence, or Dacthal tank-mix with Butisan followed by Goltix early post weed-emergence.
- **Snapdragon**: Ronstar Liquid (applied before transplanting) or Venzar. Post-weed-emergence treatments need to be tested further.
- **Delphinium**: pre-weed-emergence Stomp tank-mix with Centium followed by Goltix early post-weed-emergence.
- **Phlox**: Ronstar Liquid was effective as a pre-transplanting treatment. Safe herbicides are still needed for later use.

Nigella appeared to be more sensitive than larkspur to all herbicides tested.

* For the names of active ingredients in the products, see Table 5 in Science Section of report.

Background and expected deliverables

Discussions with flower growers almost invariably highlight a need for advice on herbicides. There are very few herbicide recommendations for outdoor flower crops, since agrochemical companies do not consider the relatively small economic value of such specialist crops sufficient to justify the cost of the development and approval process. As a consequence, growers rely heavily on off-label usage, and herbicide applications are often made on the basis of *ad hoc* trials. The aim of this project is to identify herbicides suitable for use on a range of annual, seed-raised cut-flower species grown in the field.

Summary of the project and main conclusions

In the first trial, conducted in 2003, post-emergence Betanal Flow was found to be safe on some flowers, but it is seldom used alone and is ineffective on mayweed species. In short-season cut-flower crops there is insufficient time for more than one post-emergence application. Early removal of weeds avoids crop competition, while later applications, closer to flower initiation, are likely to cause more damage. In 2004, it was decided to evaluate early application of the post-emergence mixture Betanal Expert or a tank-mix of Goltix WG + Betanal Flow.

Drilled China aster

- Pre-emergence residual herbicides containing pendimethalin: Crystal, Stomp and Stomp + Centium were safe to drilled asters, but Stomp + aclonifen caused chlorosis and stunting. Weed control with Crystal at 2.0 L/ha was poor. Groundsel escaped control with all these herbicides, but Stomp + Centium was slightly more effective on this weed.
- Post-emergence follow-up with Betanal (at 2.5 L/ha) was very safe to asters, though it did not control all the remaining weeds. Betanal Expert caused scorch and slight stunting, and so did Goltix + Betanal, but the damage was at an acceptable level and the asters appeared to tolerate the low dose of Goltix used in this tank-mix. Both these programmes gave excellent weed control.

The best programmes were Stomp + Centium (3.3 + 0.2 L/ha) followed by Betanal Expert (1.5 L/ha) or Goltix + Betanal (1.0 kg/ha + 1.8 L/ha) applied to cotyledon weeds.

Drilled cornflower

Cornflowers emerged before the other flowers and their vigorous growth quickly suppressed weeds.

- Flexidor was very effective on nettle, and though it caused slight leaf distortion and curling, it was considered safe. Pre-emergence Stomp + Flexidor (3.3 + 1.0 L/ha) alone was ineffective on groundsel, while Kerb + Flexidor (2.0 + 1.0 L/ha) left groundsel, mayweeds and pale persicaria. Both these tank-mixes were safe to the crop. Crystal did not cause any crop damage, but its control of groundsel and nettle was poor. Aclonifen + Stomp (2.0 + 2.0 L/ha) caused slight chlorosis and stunting, but the crop recovered; it controlled nettle and, with the exception of a few groundsel, weed control was good.
- Programmes of Stomp + Flexidor followed by early post-emergence Betanal Expert or Goltix + Betanal gave excellent weed control, but lacked crop safety.

The best treatments were Stomp + Flexidor (3.3 + 1.0 L/ha) or aclonifen + Stomp (2.0 + 2.0 L/ha). A follow-up early post-emergence with a low dose of Goltix might be safer.

Drilled zinnia

Temperatures were high after drilling and germination was very rapid this year. Although the crop was tall it did not provide a dense leaf canopy, so is a poor competitor for weeds, particularly at the early growth stages.

- Pre-emergence Crystal was safe but weed control was poor, while aclonifen + Stomp caused severe damage. Stomp + Flexidor (3.3 + 1.0 L/ha) was safe to Zinnia, and nettle and most other

species were controlled, though groundsel remained and a post-emergence treatment was needed. Stomp + Centium was less effective on nettle in this instance, while some groundsel remained.

- Post-emergence Betanal Expert caused chlorosis followed by crop death. Betanal (1.8 L/ha) post-emergence controlled nettle, and safety to zinnia was just acceptable.

The best treatment was with Stomp + Centium (3.3 + 1.0 L/ha) followed by Betanal (1.8 L/ha). Stomp + Flexidor is another pre-emergence option, but a more effective, safe post-emergence treatment is needed.

Drilled larkspur

Emergence of larkspur this year was poor, and only one replicate was assessed. This data must therefore be treated with caution.

- Aclonifen + Stomp was too damaging. Pre-emergence Crystal caused no crop effects, but weed control was inadequate. Stomp + Centium was also safe and weed control was better.
- Early post-emergence applications of Betanal Expert (1.5 L/ha) or Goltix + Betanal (1.7 kg/ha +1.8 L/ha) both caused unacceptable damage (severe stunting and some plant death), although weed control was excellent.

The best treatment was with Stomp + Centium (3.3 + 0.25 L/ha). A safe post-emergence treatment is needed.

Drilled nigella

Nigella produces less leaf cover and is not as competitive as larkspur. It was included in this year's trial to assess whether herbicide programmes for larkspur could be extrapolated to nigella. However, it appeared to be more sensitive than larkspur to all herbicides tested. Nigella was completely killed by aclonifen + Stomp, damage from Stomp + Centium was unacceptable, and only Crystal at 2.0 L/ha appeared to be reasonably safe.

Nigella was also completely killed by post-emergence Betanal Expert or Goltix + Betanal applied at an early growth stage.

The only safe herbicide for nigella was Crystal (or possibly Stomp alone, not yet tested), while post-emergence Betanal is a possibility to try next year.

Drilled bupleurum

Bupleurum emerged quickly and its vigorous growth soon smothers weeds, such that in dry summers like 2003 a pre-emergence wide-spectrum herbicide may be all that is required. In the 2004 season there was frequent, and sometimes heavy, rainfall.

- Pre-emergence CIPC + linuron caused initial delay in emergence and a few plants died, but the rest soon recovered. Effects were more severe where there was excess water, but these plots were not included in the assessments. This mixture controlled most weeds, but a few groundsel emerged later. Before recovery a follow-up with Betanal Expert completely killed the crop, while Goltix + Betanal also caused severe damage. Both Stomp + Flexidor and Crystal were very safe, but weed control was inferior to aclonifen + Stomp (also safe).
- Post-emergence Betanal Expert applied after Stomp + Flexidor caused severe stunting, but there was negligible damage from Goltix + Betanal and weed control was excellent.

The best treatment was with Stomp +Flexidor (3.3 + 1.0 L/ha) followed by Goltix + Betanal (1.7 + 1.8 L/ha).

Transplanted crops

- Ronstar Liquid (4.0 L/ha) pre-planting provided a good start. It had a wide margin of crop safety for transplants of China aster, stock, snapdragon and phlox, and controlled most weed species, except chickweed.

Transplanted China aster

- After Ronstar Liquid (applied before transplanting) the follow-up pre-weed emergence with Butisan caused severe stunting.
- Post-emergence Goltix + Betanal (1.25 kg/ha + 1.7 L/ha) caused slight stunting initially, although plants recovered later. Betanal Expert (1.5 L/ha) was safer. All programmes completely controlled weeds.

The best programme was Ronstar Liquid (applied before transplanting) followed by Betanal Expert.

Transplanted stock

- Stomp + aclonifen (2.0 + 2.0 L/ha) caused severe damage initially, and although there was some recovery later, the plants remained stunted and the flowers were short stemmed. Ronstar Liquid (applied before transplanting) followed by Dacthal + Butisan (9kg/ha + 1.5 L/ha) caused slight chlorosis and a growth check initially, but was safe to the crop, although there was some delay in flowering compared with the hand-weeded plots.
- Stocks treated with Dacthal + Butisan pre-weed-emergence and followed by Goltix applied to small weeds (cotyledon - 1 true leaf (TL) stage) suffered more stunting and a longer flowering delay. All programmes completely controlled weeds.

The best programme was with Ronstar Liquid (applied before transplanting) followed by Dacthal + Butisan (9kg/ha + 1.5 L/ha).

Transplanted snapdragon

- Ronstar Liquid (applied before transplanting) was safe to snapdragons, but Goltix (3 kg/ha) applied pre-weed-emergence resulted in a thin, stunted crop. Although these plants recovered later to some extent, the flowers were short and very late. In a programme following Ronstar Liquid (applied before transplanting) or Venzar (4.0 L/ha), Goltix applied later at post-weed-emergence at a lower dose (1.5 kg/ha) caused less stunting and only a slight delay.
- The programmes beginning with Venzar + propachlor (4 + 9 L/ha) or Stomp (3.3 L/ha) caused severe stunting, and there was some plant loss following Stomp. All programmes completely controlled weeds, but caused some delay in flowering compared with the hand-weeded plots.
- Nortron (2.0 L/ha) post-emergence caused negligible damage (slight leaf distortion) and had no effect on flowering, but weed control was poor.

The best programme was Ronstar Liquid (applied before transplanting) or Venzar (4.0 L/ha) followed by Goltix applied at 1.5 kg/ha post-weed-emergence.

Transplanted delphinium

Ronstar Liquid was not used because it had a low margin of crop safety in the previous trial in 2003.

- Stomp + aclonifen (2.0 + 2.0 L/ha) killed the crop. Stomp (3.3 L/ha) alone, or with Centium (0.25 L/ha) or propachlor (9.0 L/ha) caused only slight stunting and appeared to be safe, though some weed species escaped control. Flexidor + Goltix (1.0 L/ha + 3.0 kg/ha) applied pre-weed-emergence was only just acceptable in terms of crop safety, but gave the best weed control.
- Where there were following treatments applied to small weeds (cotyledon - 1 TL stage), Betanal Expert was very damaging initially (with scorch and severe stunting), and Goltix + Betanal (1.7 kg/ha + 1.8 L/ha) caused development of stunting later but also marginally improved weed control. Goltix alone (1.5 kg/ha), applied after Stomp + Centium, was safer.

There were no clear differences between treatments, but the best appeared to be Stomp + Centium followed by a low dose of Goltix (1.5 kg/ha early post-weed-emergence).

Transplanted phlox

Ronstar Liquid applied pre-transplanting alone was safe. The other herbicides tested were too damaging to phlox.

- In terms of weed control, Ronstar Liquid (applied before transplanting) followed by Goltix either pre-weed-emergence (at 3.0 kg/ha) or early post-weed-emergence (at 1.7 kg/ha) performed best. Stomp on its own (3.3 L/ha) was poor.

Phlox appeared to be a difficult species to treat, and further investigations are needed.
The best treatment was Ronstar Liquid (applied before transplanting) (4.0 L/ha).

Financial benefits and action points for growers

Several of the herbicide programmes tested gave excellent weed control, although a few caused adverse crop effects. These programmes have the potential to ease weed problems in cut-flower crops, reducing the costs of hand-weeding.

Some of the better crop/herbicide combinations, given in italics in the summary above, could be tested, at the grower's risk, on small areas of commercial flower crops.

INTRODUCTION

The UK demand for cut-flowers is growing rapidly, and the production of flowers under low-cost polythene tunnels provides a real opportunity for UK growers. However, the lack of technical information for the wide diversity of traditional and novel species being grown is a major factor limiting expansion of the sector. Discussions with flower growers almost invariably highlight a need for advice on herbicides. There are very few herbicide recommendations for outdoor flower crops, since agrochemical companies do not consider the relatively small economic value of such specialist crops sufficient to justify the cost of the development and approval process. As a consequence, growers rely heavily on off-label usage, and herbicide applications are often made on the basis of *ad hoc* trials.

The aim of this project is to identify herbicides free of phytotoxic effects (including height and yield reduction) and otherwise suitable for use on a range of annual, seed-raised cut-flower species grown in the field. In the first year's trial in 2003, a number of potentially useful herbicides and tank-mixes were suggested for cut-flowers. In the second years' trial in 2004, some of these treatments were developed further into herbicide programmes, and some new materials were also tested.

MATERIALS AND METHODS

Plant material and husbandry

Seed of the following were purchased from Hamer Flower Seeds Ltd, Swavesey, UK:

- China aster (*Callistephus chinensis*; Compositae) cv. Matsumoto Purple-rose (D, T)
- Cornflower (*Centaurea cyanus*; Compositae) cv. Boy Blue (D)
- Zinnia (*Zinnia elegans*; Compositae) cv. California Giants (D)
- Larkspur (*Delphinium consolida*; Ranunculaceae) cv. Sydney Purple (D)
- Nigella (*Nigella damascena*; Ranunculaceae) cv. Miss Jekyll Dark Blue (D)
- Bupleurum (*Bupleurum griffitti*; Umbelliferae) (D)
- Snapdragon (*Antirrhinum majus*; Scrophulariaceae) cv. Tatoo Carmine (T)
- Stock (*Matthiola incana*; Cruciferae) cv. Lucinda Lilac-rose (T)
- Delphinium (*Delphinium* hybrids; Ranunculaceae) cv. Pacific Giant Blue Bird (T)
- Phlox (*Phlox drummondi*; Polemoniaceae) cv. Dolly Purple (T)

The flowers marked (D) were direct-drilled in the field, and those marked (T) were raised in cellular trays and transplanted to the field later.

As in the previous year, the trial site was on a medium silty marine alluvial soil at Warwick HRI, Kirton, Boston, Lincolnshire, typical of the South Lincolnshire agricultural area where outdoor cut-flower crops are widely grown. The site had previously supported brassica crops grown with minimal herbicide use, and previous cultivation in two directions was expected to give a reasonably uniform weed population typical of the area. Prior to setting up the trial the site was deep-ploughed, ploughed, cultivated and treated with a contact herbicide (diquat + paraquat) when needed. Standard soil sampling (0-15cm depth) across the site gave the following analysis: pH 7.5, nitrate index 0, P index 4, K index 2+, Mg index 3 and conductivity index 0. According to MAFF fertiliser recommendations, 100kgN/ha and 100 kgK_20/ha (as 290kg ammonium nitrate (34.5%N)/ha and 200kg sulphate of potash (50%K_20)/ha) were applied and ploughed in.

The crops were grown in beds 1.2m-wide at 1.8m centres. The drilled and transplanted crops were in separate, but adjacent areas of the field. Before drilling or transplanting three beds were allocated randomly for each crop. The beds for China aster (both drilled and transplanted), snapdragon and

stocks only received a top-dressing of fertiliser (2.4kg sulphate of potash and 0.85kg ammonium nitrate per $100m^2$) which was then raked into the soil surface. Plots 4.0m long along the beds, with 1.0m unplanted (guard) areas between plots, were allocated and labelled. Drilled crops were sown by hand in four rows, 30cm apart, along the beds, aiming for a density of about one plant every 5cm along the rows.

The raising of transplanted crops was done in '308' cellular trays using a fine propagation compost (Scotts Levington F1), germinating and growing the trays in a Venlo glasshouse at ambient temperatures and ventilated at 8°C. Standard husbandry was applied. During plant raising, plants were treated with fosetyl-aluminium (as Aliette 80 WG) and tolclofos-methyl (as Basilex) to control damping-off and other fungal diseases. Plants were transplanted by hand into six rows 20cm apart along the bed and with a spacing of 20cm in each row. Sowing and transplanting dates were as shown in Table 1 and 2.

In the field the following preventative spray programme was applied:

- pirimicarb + deltamethrin at 10-14 day intervals against aphids and caterpillars
- iprodione and chlorothalonil alternated at 10-14 day intervals against *Botrytis*, powdery mildew, etc.

All fungicides and insecticides were used at standard rates and according to label or other recommendations.

Crops were irrigated using a standard irrigation boom. Water was applied as required to establish all crops, and thereafter 25mm irrigation was applied as required to maintain soil conditions appropriate for effective herbicide action. Irrigation dates (other than for establishment) are shown in Tables 1 and 2 (and with rainfall data in Figure 2). Meteorological data were obtained from the Kirton weather station, sited *ca.* 50m from the trial site. Pertinent weather data for 2003 and 2004 are given in Figure 1, along with 10-year (1993-2002) averages. Figure 1 shows that 2003 was warmer and sunnier than average, June and July were somewhat wetter than average, and August and September somewhat drier than average. 2004 was also warmer than average (except for July, which was cooler), though there was less sunshine; from July, 2004 was wetter than average.

Herbicide treatments

Herbicide treatments covered pre-emergence and post-crop-emergence timings for direct-drilled crops, and pre-transplanting and post-transplanting (pre- and post-weed-emergence) timings for transplanted crops. The treatment combinations are shown in Table 3 (drilled crops) and Table 4 (transplanted crops), providing a total of 68 herbicide programmes or treatments.

Herbicide treatments were allocated randomly within each bed, and crops were arranged in three replicate blocks in order to eliminate effects due to local variations across the field. Following accepted practice, for each crop in all three replicates additional plots were left untreated with herbicides and either (a) hand-weeded or (b) entirely untreated; this allowed weed control and the effects of herbicides and of competition on crop vigour to be assessed.

Following reaching the appropriate stage of weed and crop development, herbicides were applied as soon as weather conditions permitted. Herbicides were applied using an 'Oxford' precision sprayer along the beds, with a medium spray quality for pre-emergence applications and a fine spray quality for post-emergence (cotyledon) weeds. Herbicides were applied in 200 L water per ha. Tables 1 and 2 give the dates of herbicide applications, the growth stages of crops and weeds, and weather conditions on the days sprays were applied.

Table 1. Diary of operations and sprays for drilled crops in 2004.

Crop	*Operation*	*Date (2004)*		*Weather (temperatures are mean daily values)*	*Growth stage*[1]	
		Date	*Day no.*		*Crop*	*Weeds*
China aster	Sown	26 May	147	-	-	-
	Irrigate	27 May	148	-	-	-
	Pre-emergence sprays	02 June	154	14.5	-	-
	Mean emergence	09 June	161	-	-	-
	Irrigate	09 June	161	-	-	-
	Post-emergence sprays	14 June	166	21.1	2TL	Cot-1TL Nettle 2TL
	Main cropping date	23 Sept.	267	-	-	-
Cornflower	Sown	26 May	147	-	-	-
	Irrigate	27 May	148	-		
	Pre-emergence sprays	02 June	154	14.5	-	-
	Mean emergence	06 June	158	-	-	-
	Irrigate	09 June	161	-		
	Post-emergence sprays	14 June	166	21.1	2 - 4TL	Cot-1TL Nettle 2TL
	Main cropping date	11 Aug	224	-	-	-
Zinnia	Sown	26 May	147	-		
	Irrigate	27 May	148	-		
	Pre-emergence sprays	02 June	154	14.5	-	-
	Mean emergence	06 June	158	-	-	-
	Irrigate	09 June	161	-	-	-
	Post-emergence sprays	14 June	166	21.1	2TL	Cot-1TL Nettle 2TL
	Main cropping date	11 Aug	224	-		
Larkspur	Sown	26 May	147	-		
	Irrigate	27 May	148	-		
	Pre-emergence sprays	02 June	154	14.5		
	Irrigate	09 June	161	-		
	Mean emergence	12 June	164	-		
	Post-emergence sprays	14 June	166	21.1	Cot–1TL	Cot-1TL Nettle 2TL
	Main cropping date	01 Sept.	245	-	-	-
Nigella	Sown	26 May	147	-		
	Irrigate	27 May	148	-		
	Pre-emergence sprays	02 June	154	14.5		
	Mean emergence	09 June	161	-		
	Irrigate	09 June	161	-		
	Post-emergence sprays	14 June	166	21.1	1TL	Cot-1TL Nettle 2TL
	Main cropping date	16 Aug	229	-		
Bupleurum	Sown	26 May	147	-	-	-
	Irrigate	27 May	148	-		
	Pre-emergence sprays	02 June	154	14.5	-	-
	Mean emergence	06 June	158	-	-	-
	Irrigate	09 June	161	-	-	-
	Post-emergence sprays	14 June	166	21.1	1TL	Cot-1TL Nettle 2TL
	Main cropping date	11 Aug	224	-	-	-

[1]Cot, cotyledon stage; TL, true leaves.

Table 2. Diary of operations and sprays for transplanted crops in 2004.

Crop	*Operation*	*Date (2004)*		*Weather (temperatures*	*Growth Stage*[1]	
		Date	*Day no.*	*are mean daily values)*	*Crop*	*Weeds*
China aster	Sown	27 May	148	-	-	-
	Pre-planting sprays	30 June	182	16.9		-
	Transplanted	02 July	184	-		
	Pre-weed-em sprays	12 July	194	14.6		
	Post-emergence sprays	20 July	202	17.5	established	Cot-1TL
	Main cropping date	10 Sept.	254	-		
Snapdragon	Sown	27 May	148	-		
	Pre-planting sprays	02 July	184	14.6		
	Transplanted	05 July	187	-		
	Pre-weed-em sprays	12 July	194	14.6		
	Irrigate	19 July	201	-		
	Post-emergence sprays	20 July	202	17.5	established	Cot-1TL
	Main cropping date	11 Aug	224	-		
Stock	Sown	27 May	148	-		
	Pre-planting sprays	02 July	184	14.6		
	Transplanted	06 July	188	-	-	-
	Pre-weed-em sprays	12 July	194	14.6		
	Post-emergence sprays	20 July	202	17.5	established	Cot-1TL
	Main cropping date	01 Sept.	245	-		
Delphinium	Sown	27 May	148	-		
	Transplanted	15 July	197	-		
	Pre-weed-em sprays	22 July	204	18.1		
	Post-emergence sprays	29 July	211	20.0	established	Cot-2TL
	Main cropping date	-	-	-		
Phlox	Sown	27 May	148	-		
	Irrigate	19 July	201	-		
	Pre-planting sprays	13 July	195	15.3		
	Transplanted	14 July	196	-		
	Pre-weed-em sprays	20 July	202	17.5		
	Post-emergence sprays	29 July	211	20.0	established	Cot-2TL

[1]Cot, cotyledon stage; TL, true leaves.

Figure 1. Monthly weather for 2003 and 2004 and 10-year averages (1993-2002)

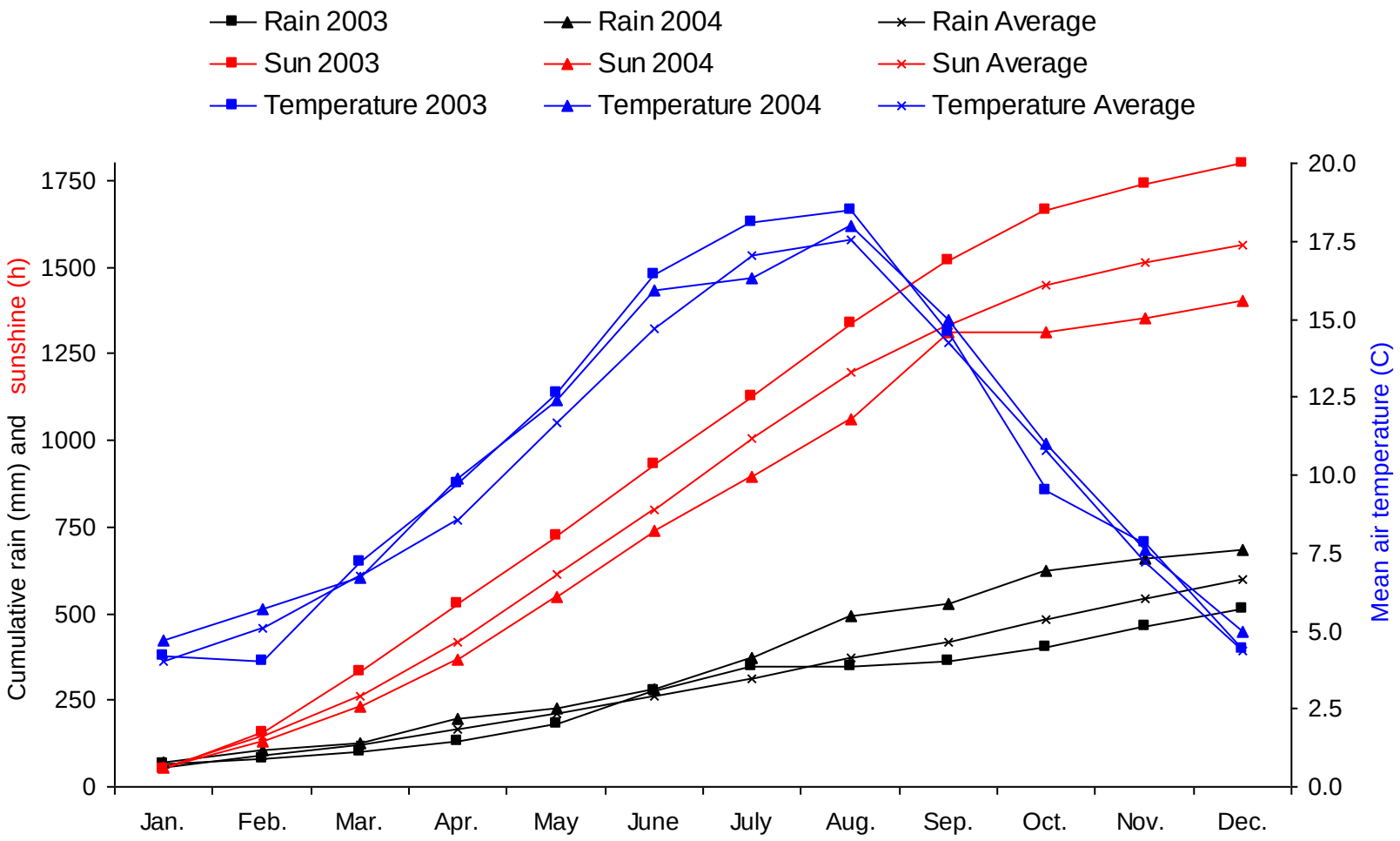


Figure 2. Rainfall and irrigation data for 2004 trial

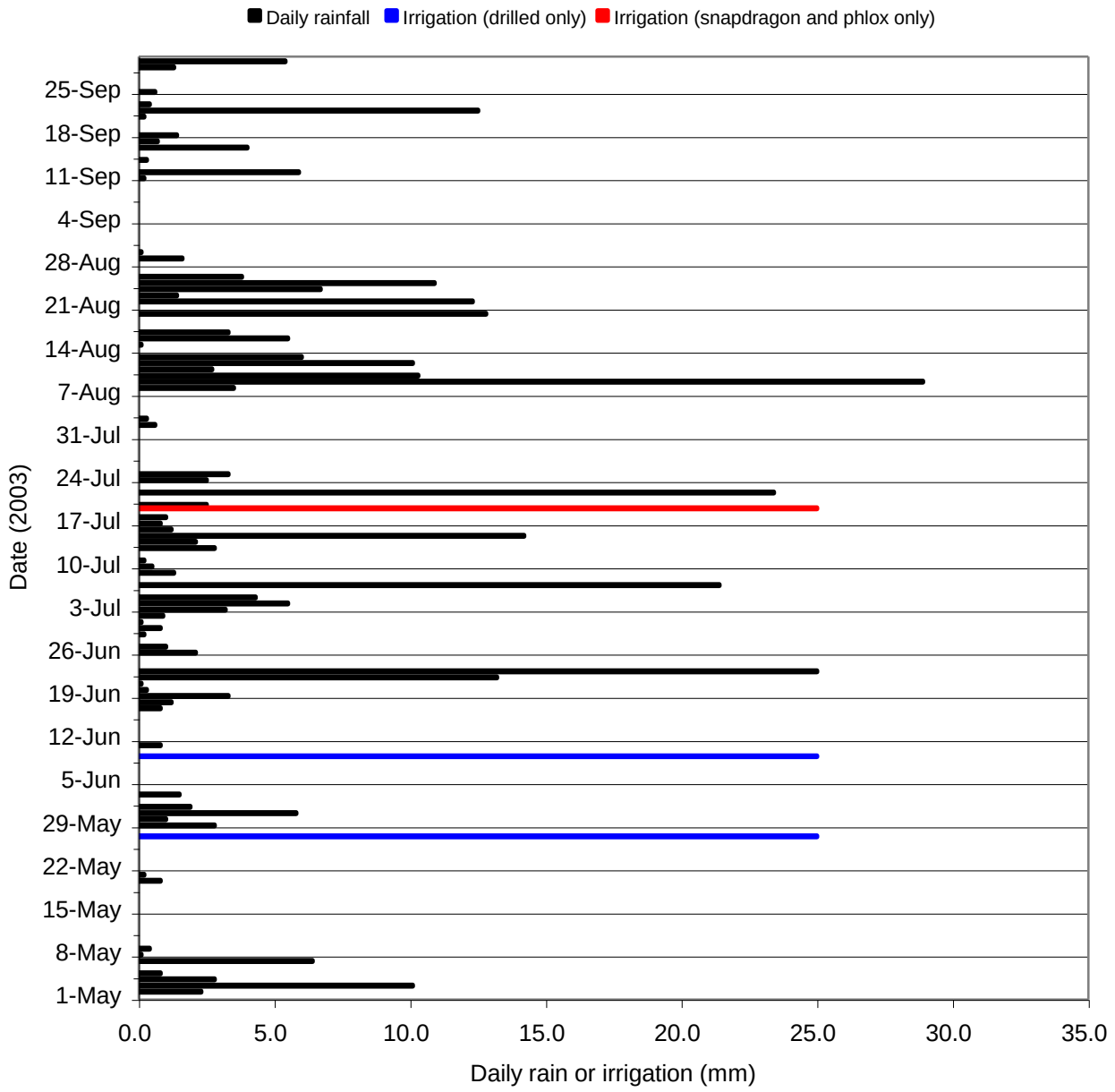


Table 3. Herbicide treatments and dates applied to direct-drilled crops in 2004. Dose rates in L/ha unless stated otherwise.

Species	*No.*	*Pre-weed-emergence (2 June 2004)*	*Early post-weed-em (cots /one TL) (14 June 2004)*
China aster	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal 2	-
	12	Stomp + Centium 3.3 + 0.25	-
	15	Stomp + Centium 3.3 + 0.25	Betanal Expert 1.5
	16	Stomp + Centium 3.3 + 0.25	Goltix + Betanal 1.0 kg + 1.8
	8	Stomp + Flexidor 3.3 + 1	Betanal Expert 1.5
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal2	-
Cornflower	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	6	Stomp + Flexidor 3.3 + 1	-
	7	Stomp + Flexidor 3.3 + 1	Goltix kg + Betanal 1.7 kg + 1.8
	8	Stomp + Flexidor 3.3 + 1	Betanal Expert 1.5
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal2 l	-
	11	Kerb + Flexidor 2 + 1	-
Zinnia	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	6	Stomp + Flexidor 3.3 + 1	-
	8	Stomp + Flexidor 3.3 + 1	Betanal Expert 1.5
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal 2	-
	12	Stomp + Centium 3.3 + 0.25	
	13	Stomp + Centium 3.3 + 0.25	Betanal 1.8
Larkspur	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal 2	-
	12	Stomp + Centium 3.3 + 0.25	-
	14	Stomp + Centium 3.3 + 0.25	Goltix + Betanal 1.7 kg + 1.8
	15	Stomp + Centium 3.3 + 0.25	Betanal Expert 1.5
Nigella	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal 2	-
	12	Stomp + Centium 3.3 + 0.25	-
	14	Stomp + Centium 3.3 + 0.25	Goltix + Betanal 1.7 kg + 1.8
	15	Stomp + Centium 3.3 + 0.25	Betanal Expert1.5
Bupleurum	1	Control (untreated)	-
	2	Control (hand-weeded)	-
	3	CIPC + Linuron 4.2 + 1.7	-
	4	CIPC + Linuron4.2 + 1.7	Goltix + Betanal 1.7 kg + 1.8
	5	CIPC + Linuron 4.2 + 1.7	Betanal Expert 1.5
	6	Stomp + Flexidor 3.3 + 1	-
	7	Stomp + Flexidor 3.3 + 1	Goltix + Betanal 1.7 kg + 1.8
	8	Stomp + Flexidor 3.3 + 1	Betanal Expert1.5
	9	Aclonifen + Stomp 2 + 2	-
	10	Crystal 2	-

Table 4. Herbicide treatments and dates of application for the five transplanted crops in 2004. Dose rates in L/ha unless stated otherwise.

Species	*No.*	*Pre-transplant (dates below)*	*Pre-weed emergence 2-3d after planting (dates below)*	*Early post-weed-emergence (dates below)*
China Aster		*30 June*	*12 July*	*20 July*
	17	untreated		-
	18	hand-weeded		-
	19	Ronstar Liquid 4	Butisan 2.5	
	20	Ronstar Liquid 4		Betanal Expert 1.5
	21	Ronstar Liquid 4		Goltix + Betanal 1.25 kg +1.7
Stocks		*2 July*	*12 July*	*20 July*
	17	untreated		
	18	hand-weeded		-
	23	Ronstar Liquid 4	Dacthal + Butisan 9 kg + 1.5	-
	24	-	Dacthal + Butisan 9 kg + 1.5	Goltix 1.7 kg
	22	-	Stomp + aclonifen 2 + 2	-
Snapdragons		*2 July*	*12 July*	*20 July*
	17	untreated	-	-
	18	hand-weeded	-	-
	22	-	Stomp + aclonifen 2 + 2	-
	26	Ronstar Liquid 4		Goltix 1.5 kg
	27	-	Venzar 4	Goltix 1.5 kg
	28	-	Venzar + propachlor 4 + 9	Goltix 1.5 kg
	29	Ronstar Liquid 4	Goltix 3 kg	-
	30	-	-	Nortron 2
	31	-	Stomp 3.3	Goltix 1.5 kg
Delphinium		*5 July*	*22 July*	*29 July*
	17	untreated	-	-
	18	hand-weeded	-	-
	22	-	Stomp + aclonifen 2+2	-
	32	-	Stomp 3.3	-
	33	-	Stomp 3.3	Betanal Expert 1.5
	34	-	Stomp 3.3	Goltix + Betanal 1.7 kg + 1.8
	35	-	Stomp + Centium 3.3 + 0.25	Goltix 1.7 kg
	36	-	Stomp + Centium 3.3 + 0.25	Betanal Expert 1.5
	37	-	Stomp + Centium 3.3 + 0.25	Goltix + Betanal 1.7 kg + 1.8
	38	-	Stomp + propachlor 3.3 + 9	-
	39	-	Stomp + propachlor 3.3 + 9	Betanal Expert 1.5
	40	-	Stomp + propachlor 3.3 + 9	Goltix + Betanal 1.7 kg + 1.8
	41	-	Flexidor + Goltix 1+3 kg	-
Phlox		*13 July*	*20 July*	*29 July*
	17	untreated	-	-
	18	hand-weeded	-	-
	20	Ronstar Liquid 4	Goltix 3 kg	-
	29	Ronstar Liquid 4	-	Goltix 1.7 kg
	32	-	Stomp 3.3	-
	42	Ronstar Liquid 4	-	Goltix + Betanal 1.7 kg + 1.8
	43	Ronstar Liquid 4	-	Betanal Expert 1.5
	44	-	Stomp + Centium 3.3 + 0.25	-

The known weed susceptibilities of the herbicides used are given in Appendix B, and the current legal status of the materials are listed in Table 5. The Long-Term Arrangements for Extension of Use (LTAEU) have now been reviewed, and for non-edible crops they will continue (possibly until 2008), but must eventually be replaced by approval as a SOLA for a specific use.

Records

The following assessments were made:

- Crop and weed seedling stage of development at the time of herbicide applications.
- Crop tolerance (i.e. phytotoxic symptoms and crop stand) was assessed on three occasions using the scores given in the table below:

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

- Weed control: overall was scored 0 to 10 (0 no weed control; 7 acceptable control; 10 complete control). Untreated plots weed control score was 0, hand-hoed was 10.
- Weed species present were recorded at intervals.
- Except for treatments where the flowers were overwhelmed by weeds, or the flowers were damaged to a point of non-marketability by the treatment, three bunches of ten stems were cropped from each plot at a commercial cropping stage. Bunch weights and overall bunch length were recorded. Bunches from all cropped treatments were lined up and assessed visually for quality, compared with the hand-weeded controls. The presence of any adverse effects, such as small, damaged or fewer flowers, weak stems or chlorotic foliage, was recorded.

Emergence of larkspur was late this year, and very poor in two replicates, thus only one replicate was assessed. The emergence of aster and nigella was also slow and uneven.

Table 5. Status of the herbicides used in this project, as at February 2005.

Product name	*a.i. and formulation*	*Marketing company*	*EC Review of a.i.*	*Approval status*
Betanal Expert	desmedipham/ ethofumesate/ phenmedipham 25/151/75 g/l EC	Bayer CropScience	phenmedipham ethofumesate Annex 1	UK sugarbeet etc. LTAEU
Betanal Flow	phenmedipham 160g/l SE	Bayer CropScience and others	Annex 1	UK sugarbeet etc. LTAEU
Butisan S	metazachlor 500g/l SC	BASF and others	supported	UK some vegetables LTAEU
Centium 360 CS	clomazone 360g/l encapsulated	Belchim	supported	UK some vegetables LTAEU
CIPC 40	chlorpropham 400g/l SC	Nufarm Whyte and others	Annex 1	UK some vegetables LTAEU
Crystal	flufenacet/pendimethalin 60/300g/l SC	BASF	Both on Annex 1	UK winter wheat LTAEU
Dacthal W 75	chlorthal-dimethyl 75% w/w WP	Certis and other	supported	UK ornamentals, brassicas etc. LTAEU
Flexidor 125	isoxaben 125g/l SC	Landseer and others	supported	UK some vegetables LTAEU
Goltix WG	metamitron 70%w/w WDG	Makhteshim and others	supported	UK sugarbeet etc. LTAEU
Kerb Flo	propyzamide	Dow	Annex 1	UK ornamental plants
Linuron various products	Linuron 500 g/L SC	Makhteshim	Annex 1	UK some vegetables LTAEU
Nortron Flo	ethofumesate 500g/l SC	Bayer CropScience etc.	Annex 1	UK sugarbeet etc. LTAEU
Ramrod Flowable	propachlor 480 g/l SC	Monsanto	supported	UK brassicas and other horticultural crops, LTAEU
Ronstar Liquid	oxadiazon 250g/l EC	Certis	supported	UK ornamentals LTAEU
Stomp 400 SC	pendimethalin 400g/l SC	BASF and others	Annex 1	UK some vegetables LTAEU
Venzar Flowable	lenacil 440g/l SC	Dupont and others	supported	UK ornamentals LTAEU
-	aclonifen 600 g/L SC	Bayer CropScience	supported	UK not available yet. Registered in other EU member states: onions, herbs, carrots

RESULTS AND DISCUSSION

In the 2003 trial post-emergence Betanal Flo was safe on some flowers, but it is seldom used alone and is ineffective on mayweed species. In short-season cut-flower crops, there is insufficient time for more than one post-emergence application. Early weed removal avoids crop competition, and later applications close to flower initiation are likely to cause more damage. In 2004 it was decided to evaluate early applications of post-emergence mixtures: Betanal Expert (phenmedipham/ desmedipham/ ethofumesate 75/25/151 g/L with oil), and a Goltix WG + Betanal tank-mix.

Drilled flowers

Weed populations were very high indeed (624 m^{-2}) and the predominant species were small nettle, chickweed and groundsel (Table 6). Irrigation and rainfall after application on 2 June of pre-emergence herbicides enhanced residual activity and tested crop safety. There was a very early emergence of weeds, including high populations of nettle, before full emergence of larkspur. Nettle cannot be tolerated in a crop that is picked by hand. The post-emergence herbicides were, therefore, all applied early to weeds at the cotyledon to one true-leaf stage and when flowers were at an early growth stage – a stringent test of crop tolerance. The full details of weed species not controlled are tabulated in Appendix A.

Table 6. Assessment of weed species on untreated, drilled plots on 6 July. Figures are weeds/m^{-2} (mean of 13 counts in 0.083 m^2 quadrats). The Latin names of weed species are shown in Appendix B (except green nightshade, *Solanum physalifolium*).

Small nettle	Chickweed	Groundsel	Shepherd's purse	Mayweeds*	Knotgrass	Red dead-nettle	Fat-hen	Redshank	Charlock	Pale persicaria	Green nightshade	TOTAL
273.2	100.6	93.2	36	19.4	19.4	2.8	7.4	49.9	2.8	15.7	2.8	624

* scented and scentless

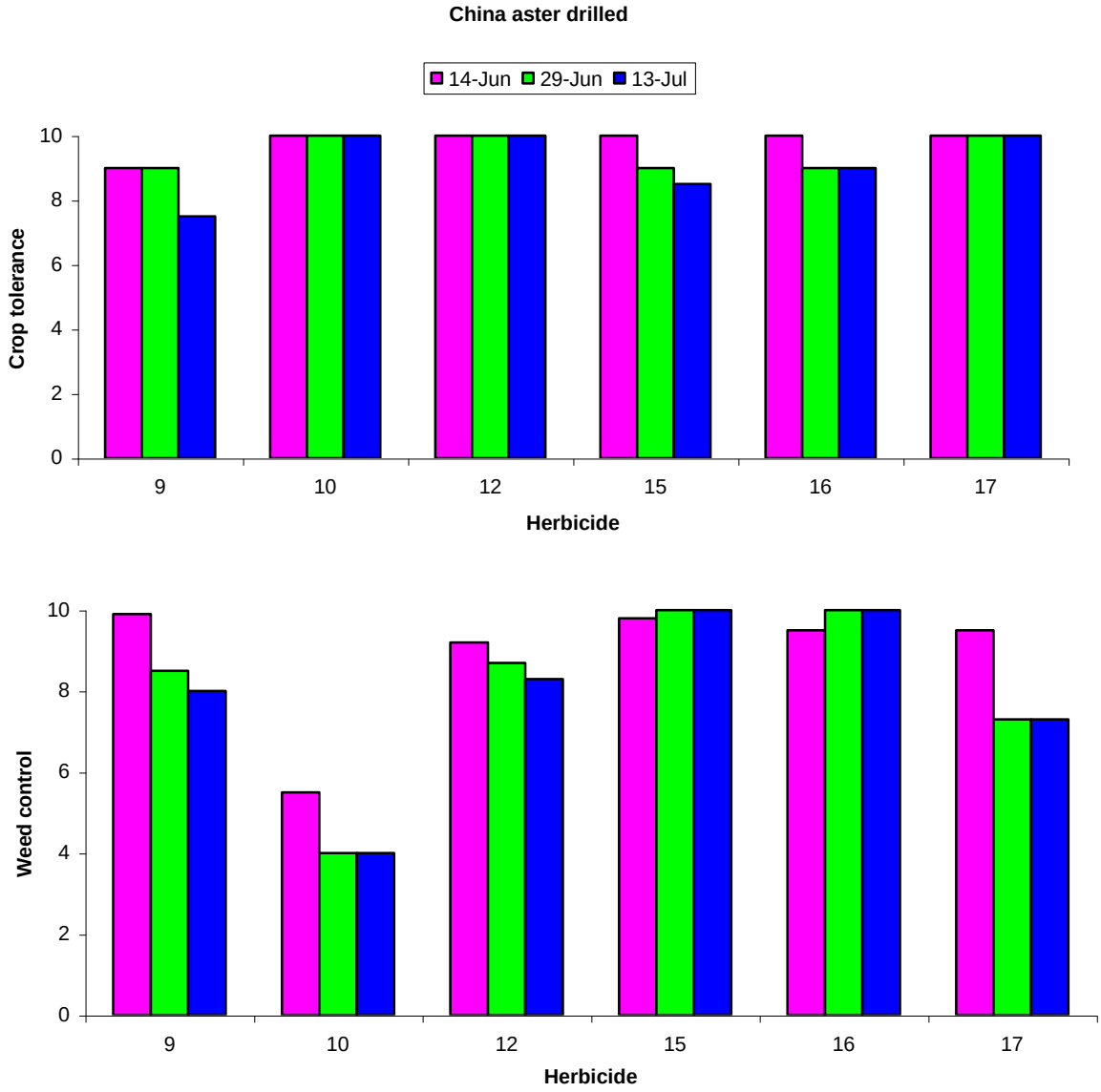
Drilled China asters (Figure 3)

Pre-emergence residual herbicides containing pendimethalin - Crystal, Stomp and Stomp + Centium - were very safe to drilled asters, but Stomp + aclonifen caused damage in the form of chlorosis and stunting. Weed control with Crystal 2.0 L/ha was poor. Groundsel escaped control with all these herbicides, but Stomp + Centium was slightly more effective on this weed.

Post-emergence follow-up with Betanal at 2.5 L/ha was very safe to asters, but it did not control the remaining weeds. Betanal Expert caused scorch and slight stunting and so did Goltix + Betanal, but the damage was at an acceptable level and the asters appeared to tolerate the low dose of Goltix used in this tank-mix. Both programmes gave excellent weed control.

The best programmes were Stomp + Centium (3.3 + 0.25 L/ha) followed by Betanal Expert (1.5 L/ha) or Goltix + Betanal (1.0 + 1.8 L/ha) applied to cotyledon weeds.

Figure 3. Crop and weed profile for **drilled China aster** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-weed-emergence	*Early post-weed-emergence weeds: cot-1T 14 June*	*Crop damage 2TL 14 June*	*Crop damage 4TL 29 June*	*Crop damage 5-6TL 13 July*
9	Aclonifen + Stomp (2.0 + 2.0)		chlorosis	chlorosis, stunt	chlorosis, stunt
10	Crystal (2.0)		-	-	-
12	Stomp + Centium (3.3 + 0.25)		-	-	-
15	Stomp + Centium (3.3 + 0.25)	Betanal Expert (1.5)	-	necrosis, stunt	stunt
16	Stomp + Centium (3.3 + 0.25)	Goltix+Betanal (1.0 + 1.8)	-	scorch	chlorosis, stunt, some death
17	Stomp + Centium (3.3 + 0.25)	Betanal (2.5)	-	-	-

Drilled cornflowers (Figure 4)

Cornflowers emerged before the other flowers, and their vigorous growth quickly suppressed weeds. Flexidor was very effective on nettle and causes slight leaf distortion or curling, but was safe to cornflower. Pre-emergence Stomp + Flexidor (3.3 + 1.0 L/ha) alone was ineffective on groundsel, and Kerb + Flexidor (2.0 + 1.0 L/ha) left groundsel, mayweeds and pale persicaria, but both tank-mixes were safe to the crop. Crystal did not cause any crop effects, but weed control of groundsel and nettle was poor. Aclonifen + Stomp (2.0 + 2.0 L/ha) caused slight chlorosis and stunting, but the crop recovered. It controlled nettle, and with the exception of a few groundsel, weed control was good.

Programmes of Stomp + Flexidor followed by early post-emergence Betanal Expert or Goltix + Betanal gave excellent weed control, but lacked crop safety, and the latter killed some plants though others recovered from damage later.

The best treatments were Stomp + Flexidor or aclonifen + Stomp. A follow-up early post-emergence with a low dose of Goltix might have been safer.

Drilled zinnias (Figure 5)

Temperatures were high after drilling, and the zinnias emerged quickly this year. Although the crop is tall, it does not provide a dense leaf canopy, thus it is a poor competitor with weeds, particularly at early growth stages. Pre-emergence Crystal was safe but weed control was poor, while aclonifen + Stomp caused severe damage. Stomp + Flexidor (3.3 + 1.0 L/ha) was safe to zinnia; nettle and most other weeds being controlled, though groundsel remained and a post-emergence programme was needed. However, Betanal Expert caused chlorosis followed by plant death. Stomp + Centium was less effective on nettle in this area and some groundsel remained, while Betanal (1.8 L/ha) post-emergence controlled nettle and its safety to zinnia was just acceptable.

The best treatment was Stomp + Centium followed by Betanal (1.8 L/ha). Stomp + Flexidor is another pre-emergence option, but a more effective and safe post-emergence treatment is needed.

Drilled larkspur (Figure 6)

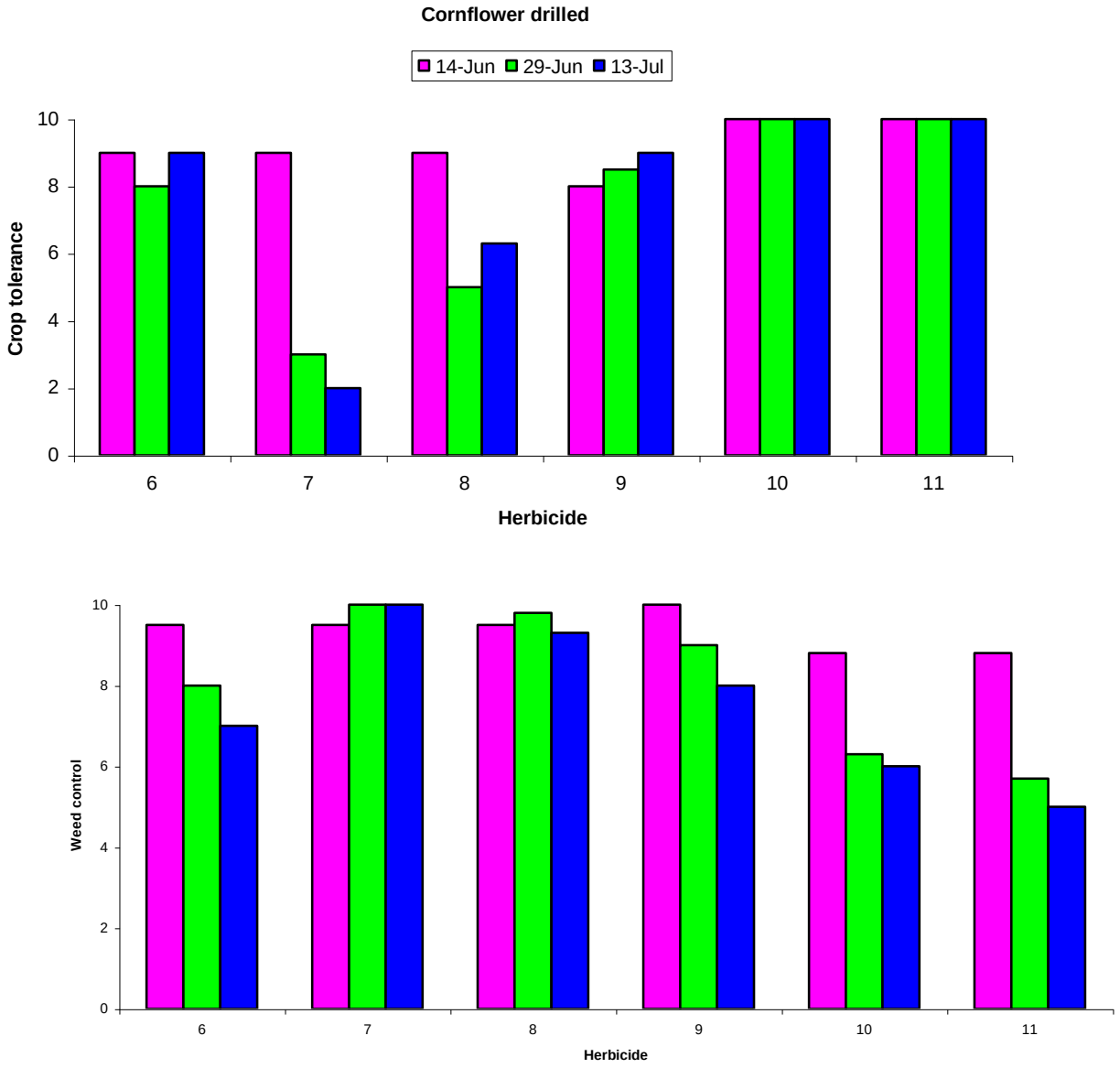
Emergence was poor and only one replicate was assessed, therefore all results should be treated with caution. Aclonifen + Stomp was too damaging, while pre-emergence Crystal caused no crop effects but its weed control was inadequate. Stomp + Centium was also safe, and weed control was better. Early post-emergence applications of Betanal Expert (1.5 L/ha) or Goltix + Betanal (1.7 kg/ha +1.8 L/ha) both caused unacceptable damage - severe stunting and some plant death, but weed control was excellent.

The best treatment was Stomp + Centium. A safe post-emergence treatment is needed.

Drilled nigella (Figure 7)

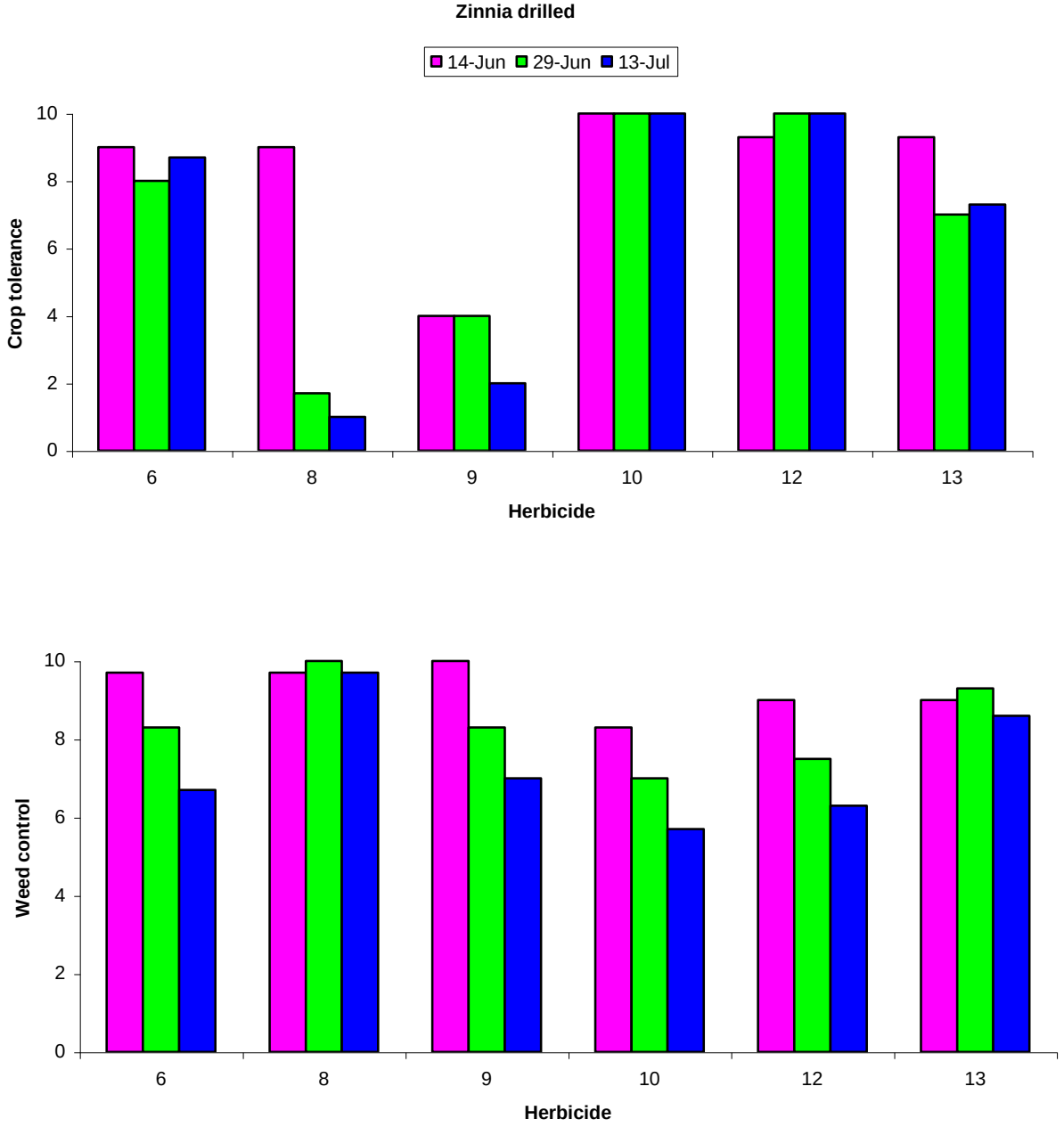
Nigella has less leaf cover and is less competitive than larkspur. It was included in this year's trial to assess whether herbicide programmes for larkspur could be extrapolated to nigella. However, it appeared to be more sensitive than larkspur to all herbicides tested. It was completely killed by aclonifen + Stomp, damage from Stomp + Centium was unacceptable and only Crystal at 2.0 L/ha appeared to be reasonably safe.

Figure 4. Crop and weed profile for **drilled cornflower** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



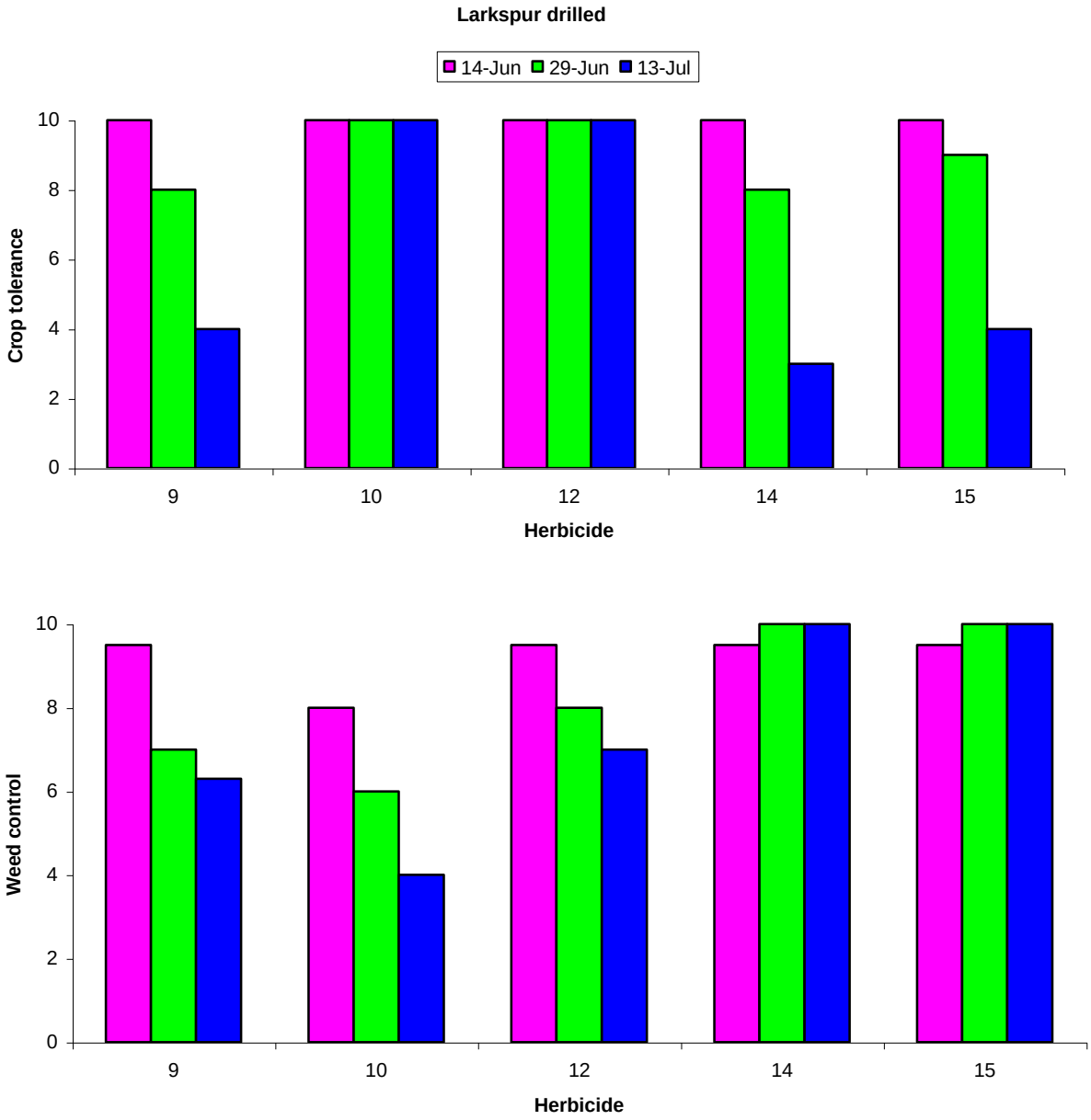
	Pre-weed-emergence 2 June	*Early post-weed-emergence Weeds: cot-1TL 14 June*	*Crop damage 4TL 14June*	*Crop damage 7TL 29June*	*Crop damage Buds 13 July*
6	Stomp+Flexidor (3.3 + 1)	-	chlorosis, distortion,	stunt	slight stunt
7	Stomp+Flexidor (3.3 + 1)	Goltix+Betanal (1.7 + 1.8)	chlorosis, distortion	death	death
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	chlorosis, distortion	necrosis, stunt	stunt
9	Aclonifen+Stomp (2 + 2)	-	chlorosis	stunt	slight stunt
10	Crystal (2)	-	-	-	-
11	Kerb+Flexidor (2 + 1)	-	-	-	-

Figure 5. Crop and weed profile for **drilled zinnia** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



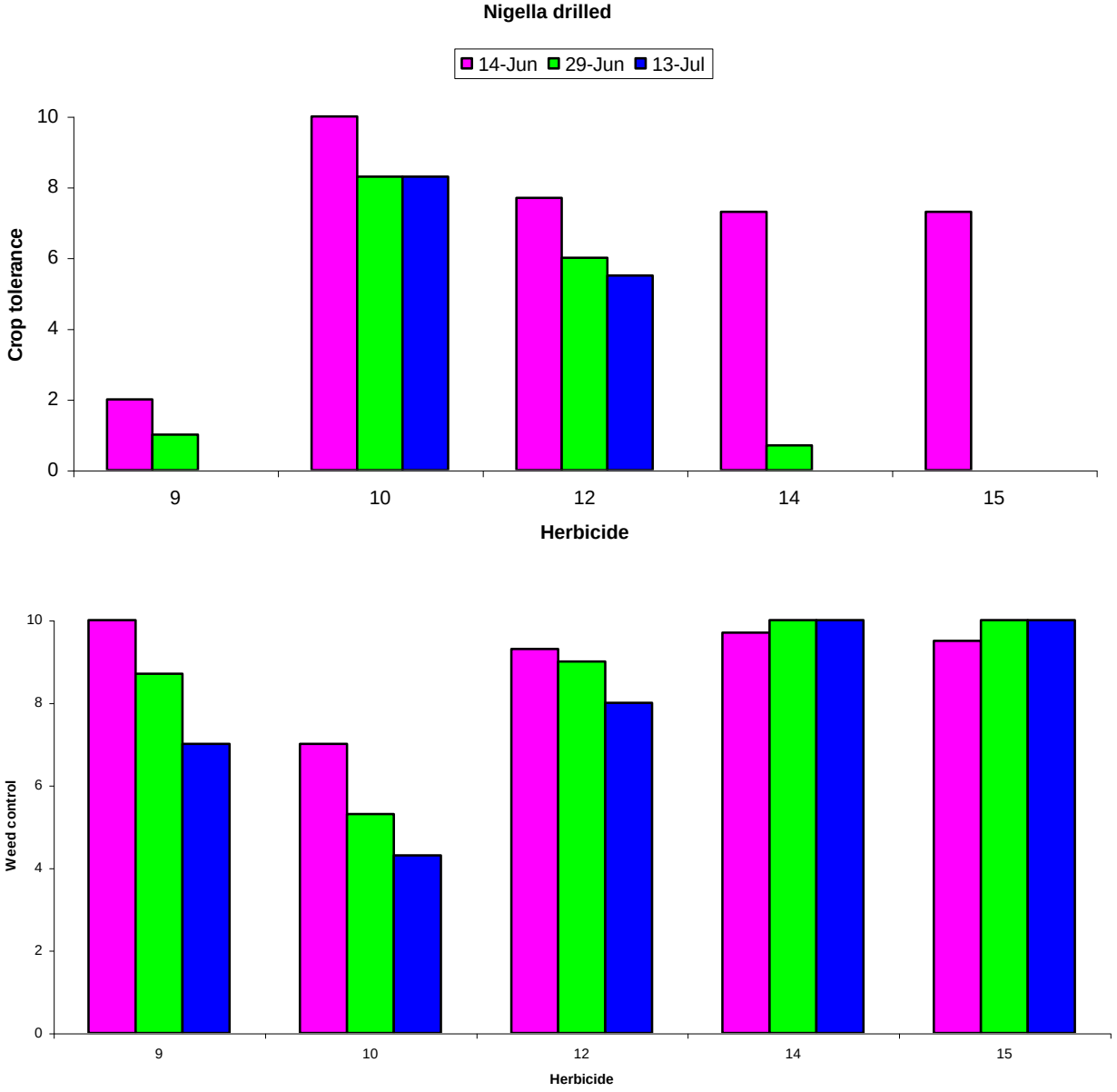
	Pre-weed-emergence 2 June	*Early post-weed-emergence Weeds: cot-1TL 14 June*	*Crop damage 2TL 14 June*	*Crop damage 4TL 29 June*	*Crop damage 6TL 13July*
6	Stomp+Flexidor (3.3 + 1)	-	chlorosis distortion	-	-
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	chlorosis, distortion	scorch death	death
9	Aclonifen+Stomp (2 + 2)	-	chlorosis, death	death	death
10	Crystal (2)	-	-	-	-
12	Stomp+Centium (3.3 + 0.25)	-	slight bleaching	-	-
13	Stomp+Centium (3.3 + 0.25)	Betanal (1.8)	slight bleaching	scorch	scorch

Figure 6. Crop and weed profile for **drilled larkspur** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-weed-emergence 2 June	*Early post-weed-emergence 14 June Cot-1TL*	*Crop damage Cot-1TL 14 June*	*Crop damage 2TL 29 June*	*Crop damage 4.5TL 13 July*
9	Aclonifen+Stomp (2 + 2)		-	chlorosis, death	chlorosis, death
10	Crystal (2)		-	-	-
12	Stomp+Centium (3.3 + 0.25)	-	-	-	-
14	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7 + 1.8)	-	chlorosis, stunt	stunt, death
15	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	-	chlorosis, stunt	stunt, death

Figure 7. Crop and weed profile for **drilled nigella** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-weed-emergence 2 June	*Early post-weed-emergence Cot-1TL 14 June*	*Crop damage 1TL 14 June*	*Crop damage 1-2TL 29 June*	*Crop damage 4-5TL 13 July*
9	Aclonifen+Stomp (2 + 2)		death	death	death
10	Crystal (2)		-	stunt	stunt delay
12	Stomp+Centium (3.3 + 0.25)	-	bleaching	chlorosis, stunt, death	chlorosis, stunt, death
14	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7 + 1.8)	bleaching	death	death
15	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	bleaching	death	death

Nigella was also completely killed by post-emergence Betanal Expert or Goltix + Betanal applied at an early growth stage.

The only safe herbicide was Crystal (or Stomp alone), and post-emergence Betanal is a possibility to try next year.

Drilled bupleurum (Figure 8)

Bupleurum emerged quickly, and its vigorous growth soon smothered weeds and in dry summers, for example 2003, a pre-emergence wide-spectrum herbicide may be all that is required. In the 2004 season there was frequent, and sometimes heavy, rainfall. Pre-emergence CIPC + linuron caused initial delay in emergence and a few plants died, but the rest soon recovered from their damage. Effects were more severe where there was excess water, but these plots were not included in the assessments. CIPC + linuron controlled most weeds, but a few groundsel emerged later. Before recovery a follow-up with Betanal Expert completely killed the crop, and Goltix + Betanal also caused severe damage. Both Stomp + Flexidor and Crystal were very safe, but weed control was only just acceptable and was inferior to aclonifen + Stomp (which was also safe to bupleurum).

Post-emergence Betanal Expert, applied after Stomp + Flexidor, caused severe stunting, but there was negligible damage from Goltix + Betanal and its weed control was excellent.

The best treatment was Stomp +Flexidor followed by Goltix + Betanal.

Transplants

Weed populations were 199 m^{-2} (Table 7), which was not as high as on the drilled crop area. The predominant species were chickweed, mayweeds (on part of the area), shepherd's purse, small nettle and groundsel.

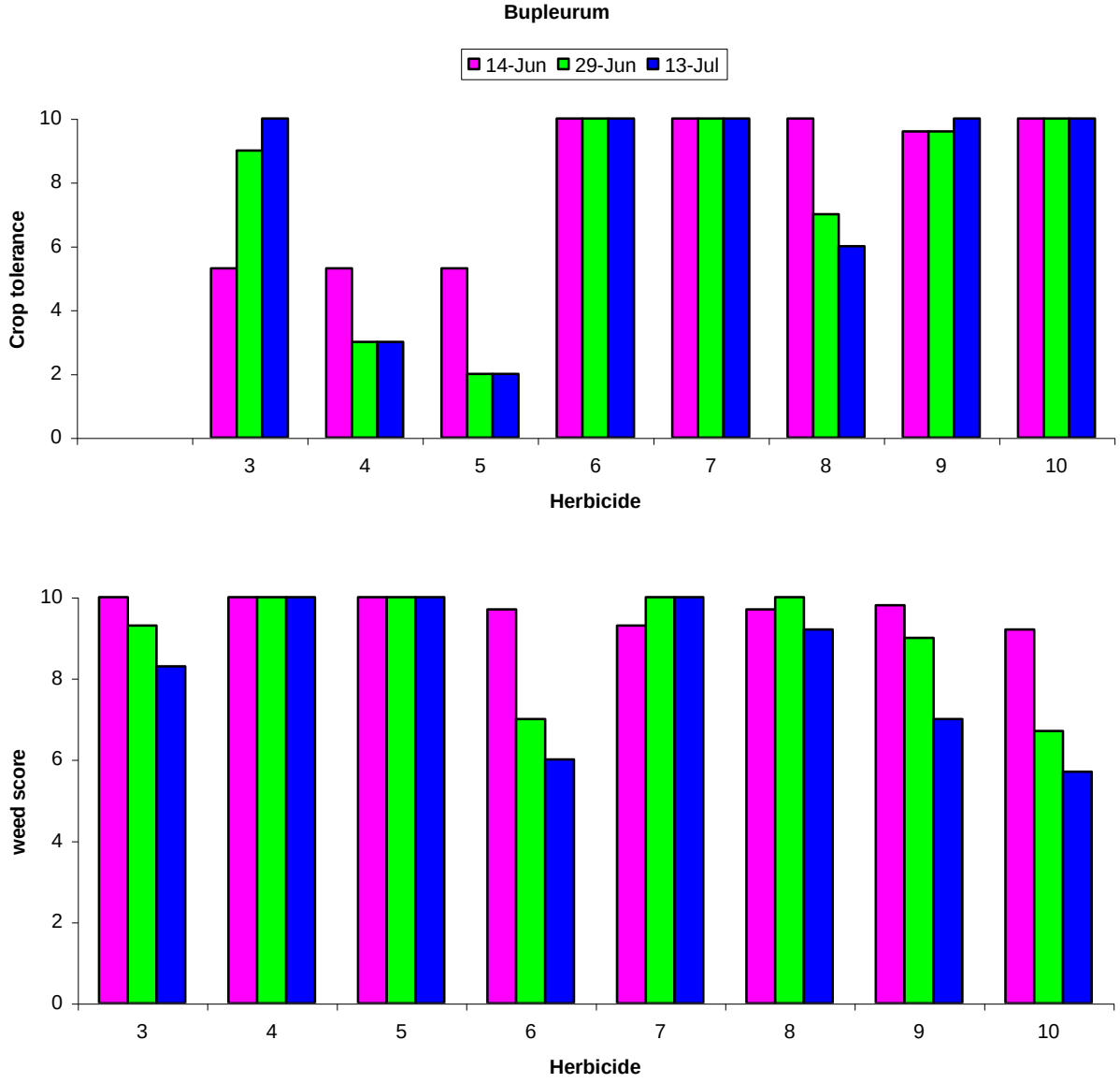
Table 7. Assessment of weed species on untreated, transplanted plots on 26 July. Figures are weeds m^{-2} (mean of 15 counts in 0.33 m^2 quadrats). The Latin names of weed species are shown in Appendix B.

Chickweed	Mayweeds*	Shepherd's purse	Small nettle	Groundsel	Knotgrass	Hedge mustard	Sow thistle	Speedwell	Charlock	Fat-hen	TOTAL
54.2	41.4	34	33.6	26.2	15	0.6	1.2	1.2	0.4	0.4	199.2

* scented, scentless and a few pineappleweed

In general, Ronstar Liquid (4.0 L/ha) pre-planting provided a good start; it had a wide margin of crop safety for transplants of China aster, stocks, snapdragons and phlox, and controlled most weed species except chickweed.

Figure 8. Crop and weed profile for **drilled bupleurum** assessed on three dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-weed-emergence 2 July	*Early post-weed-emergence Cot-1TL 14 June*	*Crop damage 1TL 14 June*	*Crop damage 3TL 29 June*	*Crop damage 6TL 13 July*
3	CIPC+Linuron (4.2 + 1.7)	-	some death, delay	recovering	
4	CIPC+Linuron (4.2 + 1.7)	Goltix+Betanal (1.7 + 1.8)	some death, delay	stunt, scorch, death	stunt, death
5	CIPC+Linuron (4.2 + 1.7)	Betanal Expert (1.5)	some death, delay	death	death
6	Stomp+Flexidor (3.3 + 1)	-	-	-	-
7	Stomp+Flexidor (3.3 + 1)	Goltix+Betanal (1.7 + 1.8)	-	-	-
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	-	stunt	stunt
9	Aclonifen+Stomp (2 + 2)	-	slight chlorosis	slight chlorosis	-
10	Crystal (2)	-	-	-	-

Transplanted China asters (Figure 9)

After Ronstar Liquid (applied before transplanting) the follow-up pre-weed emergence with Butisan caused severe stunting. Post-emergence Goltix + Betanal (1.25 kg/ha + 1.7 L/ha) caused slight crop effects initially, although the asters recovered later; Betanal Expert (1.5 L/ha) was safer. All programmes completely controlled weeds.

The best programme was Ronstar Liquid (applied before transplanting) followed by Betanal Expert.

Transplanted stocks (Figure 10)

Stomp + aclonifen (2.0 + 2.0 L/ha) caused severe damage initially, and although there was some recovery later, the plants were stunted and the flowers short-stemmed. Ronstar Liquid (applied before transplanting) followed by Dacthal + Butisan (9kg/ha + 1.5 L/ha), caused slight chlorosis and a growth check initially, was safe to the crop although there was some delay in flowering compared with the hand-weeded plots.

Stocks treated with Dacthal + Butisan pre-weed-emergence, followed by Goltix applied to small weeds (cotyledon – 1 true-leaf stage) suffered more stunting and a longer flowering delay. All programmes completely controlled weeds.

The best programme was Ronstar Liquid (applied before transplanting) followed by Dacthal + Butisan.

Transplanted snapdragons (Figure 11)

Ronstar Liquid (applied before transplanting) was safe to snapdragons, but Goltix (3 kg/ha) applied pre-weed-emergence resulted in a stunted, thin crop. Although the crop recovered later to some extent, the flowers were short and very late. In a programme following Ronstar Liquid (applied before transplanting) or Venzar (4.0 L/ha), Goltix applied later, post-weed-emergence at a lower dose (1.5 kg/ha) caused less stunting and only a slight delay. The programmes beginning with Venzar + propachlor (4 + 9 L/ha) or Stomp (3.3 L/ha) caused severe stunting, and there was some plant loss due to Stomp. All programmes completely controlled weeds, but also caused some delay in flowering compared with the hand-weeded plots. Nortron (2.0 L/ha) post-emergence caused negligible damage (slight leaf distortion) and there was no effect on flowering, but weed control was poor.

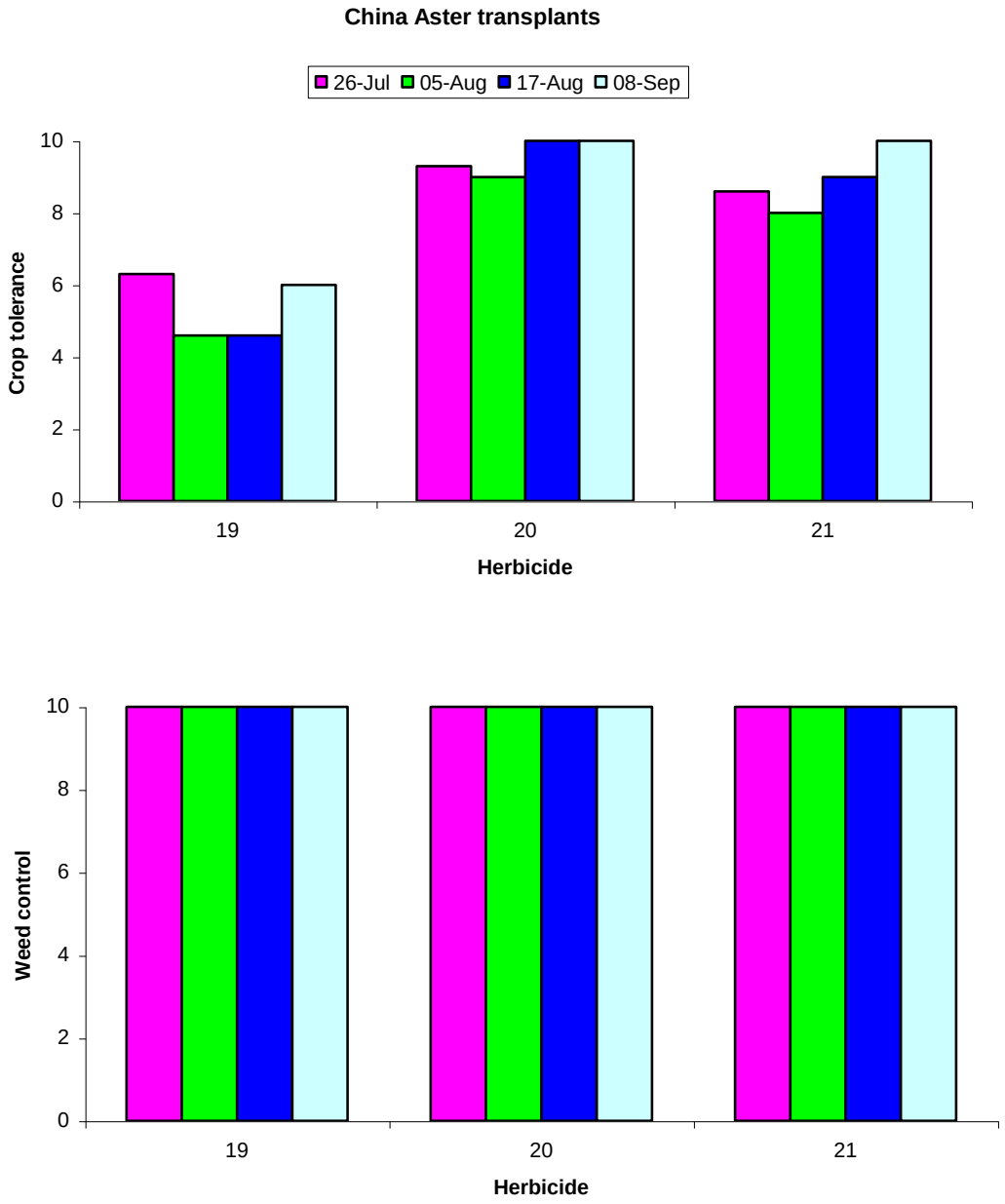
The best programme was Ronstar Liquid (applied before transplanting) or Venzar (4.0 L/ha) followed by Goltix applied at 1.5 L/ha post-weed-emergence.

Transplanted phlox (Figure 12)

Ronstar Liquid applied alone pre-transplanting was safe, but none of the other herbicides tested were safe to phlox. In terms of weed control, Ronstar Liquid (applied before transplanting), followed by Goltix (either pre-weed-emergence at 3.0 kg/ha or early post-weed-emergence at 1.7 kg/ha) performed best. Stomp (3.3 L/ha) on its own was poor.

The best treatment was Ronstar Liquid (applied before transplanting) (4.0 L/ha).

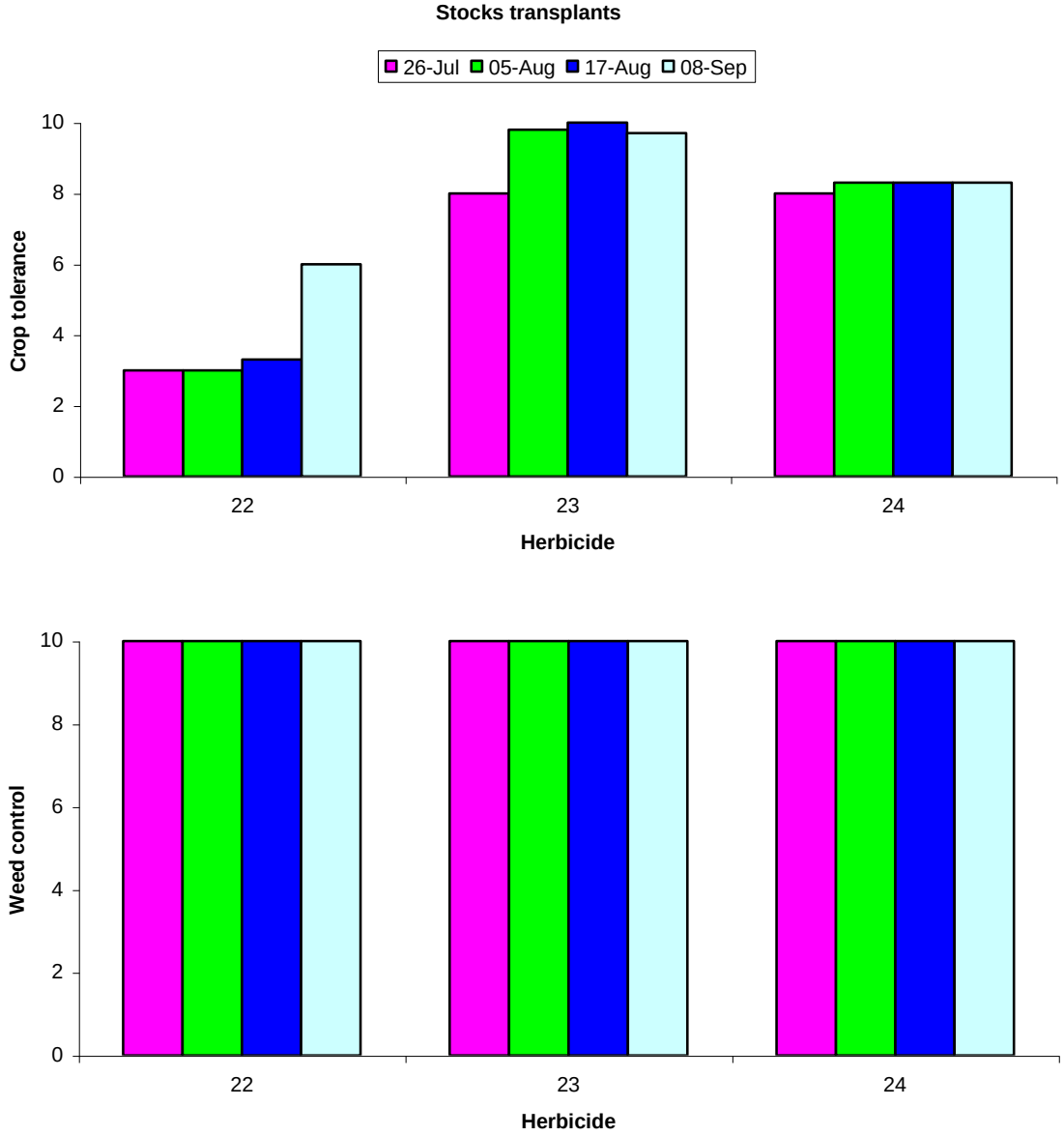
Figure 9. Crop and weed profile for **transplanted China aster** assessed on four dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-transplant 30 June	*Pre-weed-emergence 12 July*	*Early post-weed-emergence 20 July*	*Crop damage 26 July*	*Crop damage 5 August*	*Crop damage 17 August*	*Crop damage 8 Sept.**
19	Ronstar Liquid (4)	Butisan 2.5	-	stunt	stunt, distortion	stunt, distortion	30% height reduction
20	Ronstar Liquid (4)	-	Betanal Expert (1.5)	-	-	-	-
21	Ronstar Liquid (4)	-	Goltix+Betanal (1.25 +1.7)	chlorosis	stunt	slight stunt	-

* Untreated crop 50% open flowers, crop cover 80% on hand-weeded

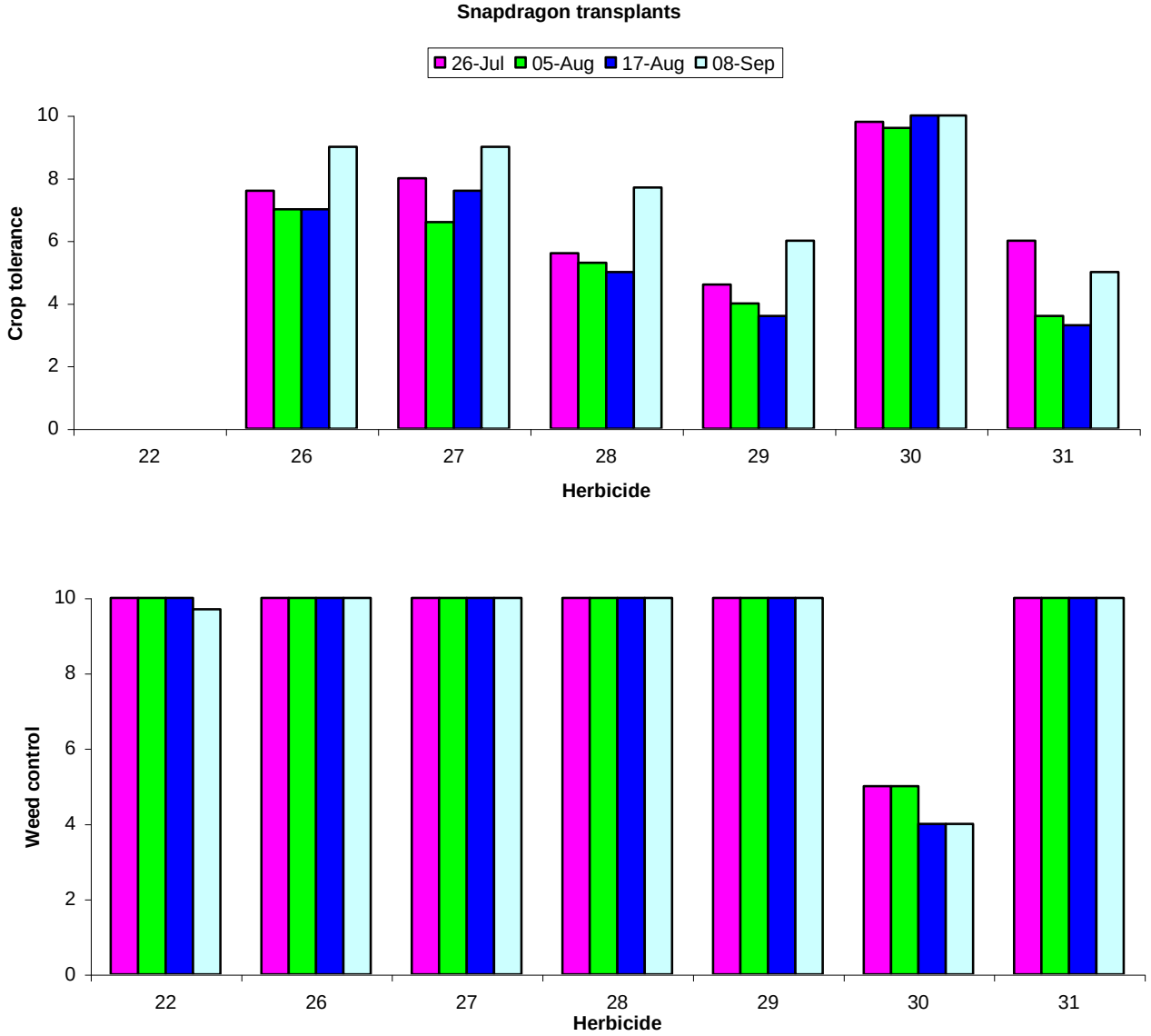
Figure 10. Crop and weed profile for **transplanted stocks** assessed on four dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-transplant 2 July	*Pre-weed-emergence 12 July*	*Early post-weed-emergence 20 July*	*Crop damage 26 July*	*Crop damage 5 August*	*Crop damage 17 August buds*	*Crop damage 8 Sept.**
22	-	Stomp+aclonifen (2+2)	-	chlorosis, death	necrosis, stunt	necrosis, stunt	short
23	Ronstar Liquid (4)	Dacthal + Butisan (9kg+1.5)	-	slight chlorosis	-	-	Delay, 50% flowering
24	-	Dacthal + Butisan (9kg+1.5)	Goltix (1.7)	slight chlorosis	stunt	stunt	Delay, only a few flowering

*100% flowering, some finished; crop cover 70% on hand-weeded

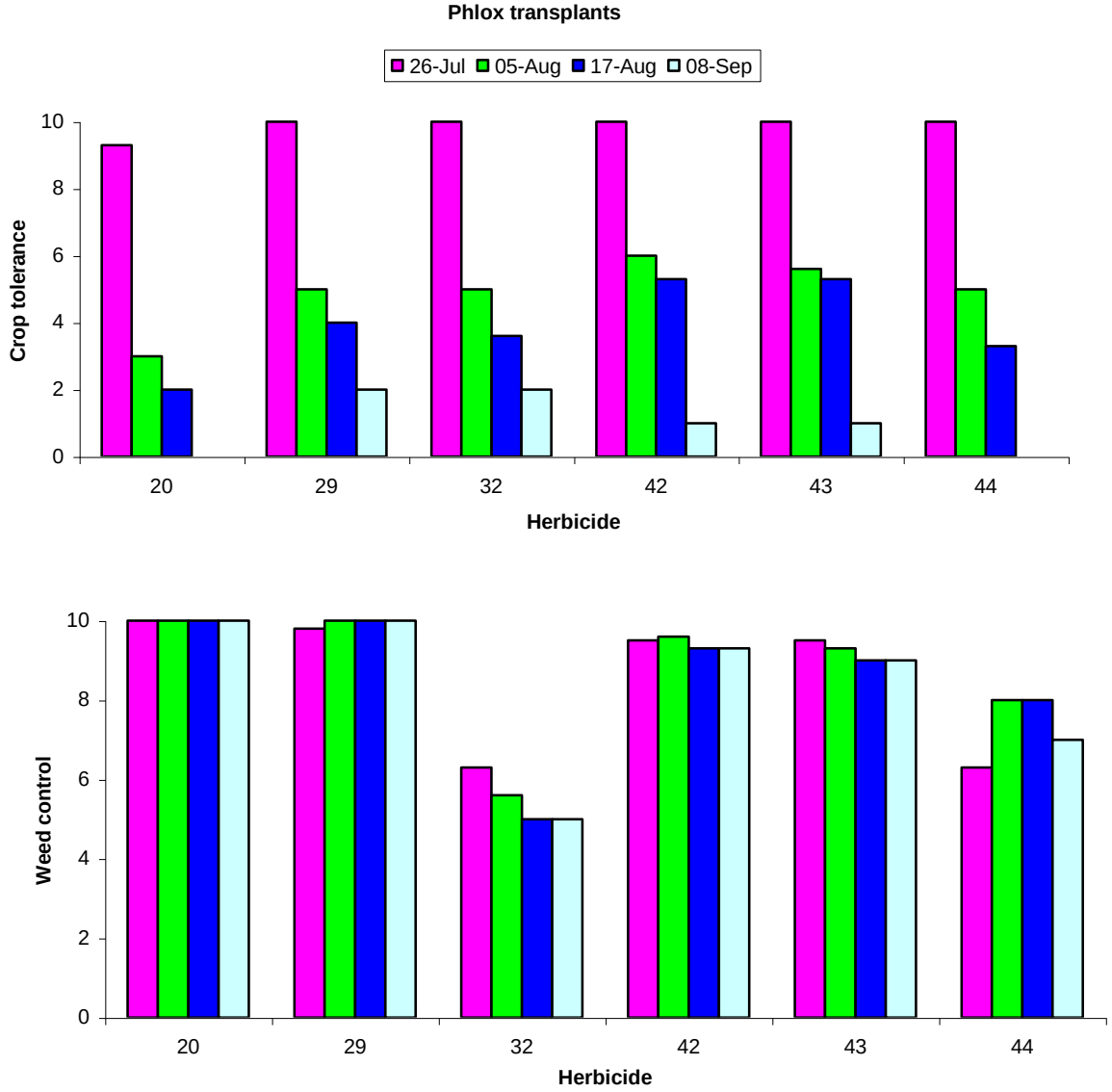
Figure 11. Crop and weed profile for **transplanted snapdragon** assessed on four dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-transplant	*Pre-weed-emergence 12 July*	*Early post-weed-emergence 20 July*	*Crop damage 26 July*	*Crop damage 5 August*	*Crop damage 17 August flowering*	*Crop damage 8 Sept.**
22	-	Stomp+aclonifen (2+2)	-	complete kill	complete kill	complete kill	complete kill
26	Ronstar Liquid (4)	-	Goltix (1.5)	chlorosis	chlorosis, stunt	stunt	90% flower
27	-	Venzar (4)	Goltix (1.5)	chlorosis	chlorosis, stunt	stunt	90% flower
28	-	Venzar + propachlor (4 + 9)	Goltix (1.5)	severe scorch, stunt	severe stunt, scorch	severe stunt	60% flower
29	Ronstar Liquid (4)	Goltix (3)	-	severe scorch	severe scorch, stunt	severe stunt	25% flower
30	-	-	Nortron (2)	-	-	-	100% flower
31	-	Stomp (3.3)	Goltix (1.5)	stunt	severe stunt	severe stunt, no flowers	80% flower, fewer plants

*100% flowering, some finished; crop cover 100% on hand-weeded

Figure 12. Crop and weed profile for **transplanted phlox** assessed on four dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-transplant 13 July	*Pre-weed emergence 20 July*	*Early post-weed emergence 29 July*	*Crop damage 26 July*	*Crop damage 5 August*	*Crop damage 17 Sept.*	*Crop damage 8 Sept.**
20	Ronstar Liquid (4)	Goltix (3)	-	-	scorch stunt	scorch kill	dead
29	Ronstar Liquid (4)	-	Goltix (1.7)	-	scorch stunt	scorch kill	dead
32	-	Stomp (3.3)	-	-	stunt kill flowers	stunt kill flowers	dead
42	Ronstar Liquid (4)	-	Goltix+Betanal (1.7 + 1.8)	-	scorch stunt	scorch kill	dead
43	Ronstar Liquid (4)	-	Betanal Expert (1.5)	-	scorch stunt	scorch kill flowers	dead
44	-	Stomp+Centium (3.3 + 0.25)	-	slight bleach	stunt kill flowers	stunt kill flowers	dead

*Crop cover 2% on hand-weeded, 100% flowering on hand-weeded

Transplanted delphinium (Figure 13)

Ronstar Liquid was not used on delphinium because it had a low margin of crop safety in the 2003 trial. Stomp + aclonifen (2.0 + 2.0 L/ha) killed the crop. Stomp alone (3.3 L/ha) or + Centium (0.25 L/ha) or + propachlor (9.0 kg/ha) caused only slight stunting, but appeared to be safe, though some weed species escaped control. Where the following treatments were applied to small weeds (at the cotyledon - 1TL stage), Betanal Expert was very damaging initially and caused scorch and severe stunting, and Goltix + Betanal (1.7 + 1.8 L/ha) caused stunting which developed later but also gave marginally better weed control. Goltix alone (1.5 L/ha), applied after Stomp + Centium, was safer. Flexidor + Goltix (1.0 + 3.0 L/ha) applied pre-weed-emergence was only just acceptable in terms of crop safety, but gave the best weed control.

There were no clear differences between treatments, but the best appeared to be Stomp + Centium followed by a low dose of Goltix (1.5 L/ha) early post-weed-emergence.

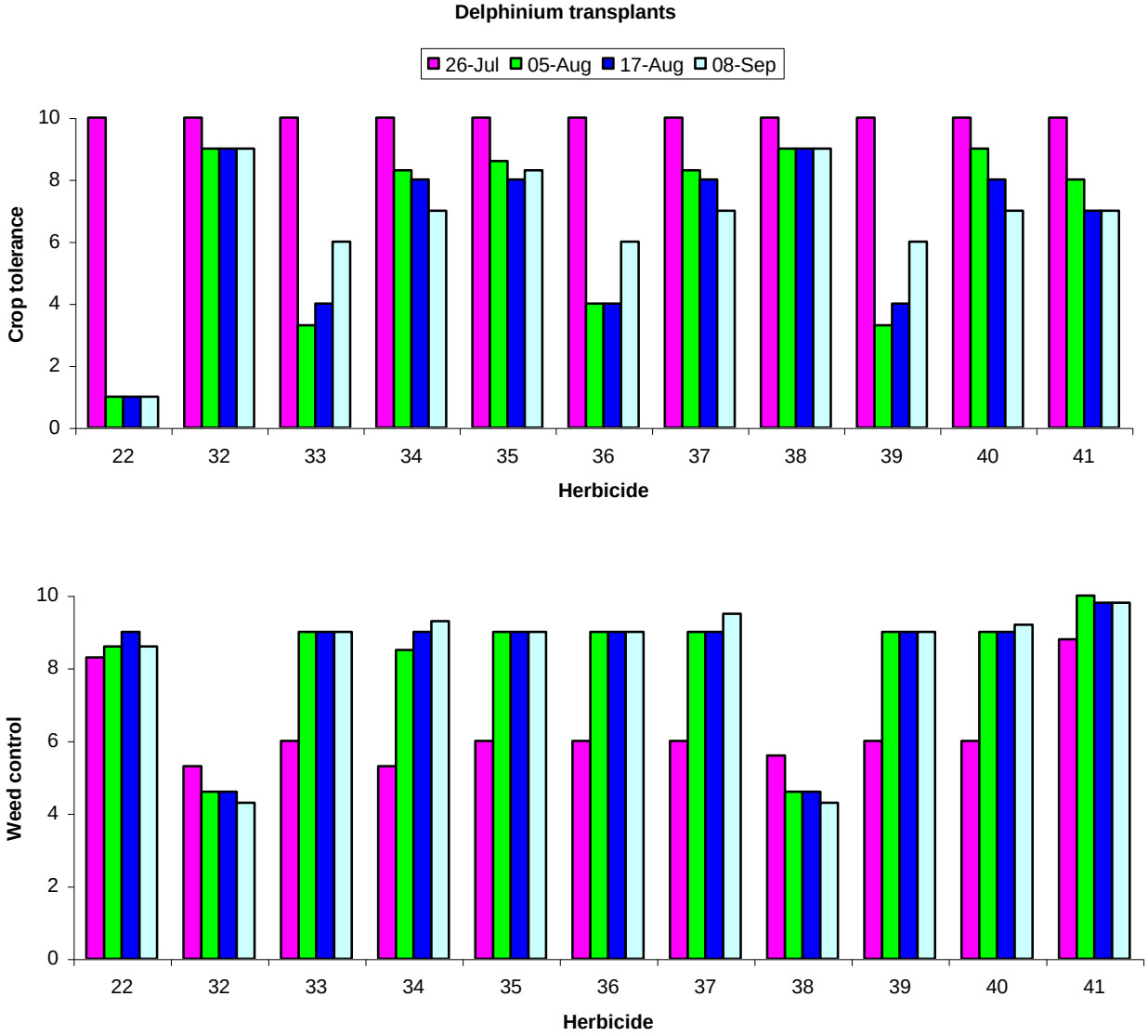
CONCLUSIONS

As a result of these trials, safe and effective herbicide programmes have been suggested for drilled China aster, cornflower, zinnia and bupleurum, and for transplanted China aster, stocks and delphinium. For larkspur (drilled) and snap-dragon (transplanted), there is a need for further trials to find safe post-emergence treatments, while for nigella (drilled) and phlox (transplanted), none of the herbicides tested so far have proved safe. In a trial in 2005, further pre-emergence Stomp tank-mixes and post-emergence applications of Goltix, Betanal and Skirmish (isoxaben + terbutylazine) will be tested on drilled crops, while, on transplanted crops, a number of herbicides will be tested separately and in combination pre-emergence (Decimate, Dacthal, Pyramin and Venzar).

ACKNOWLEDGEMENTS

This project was funded by the Horticultural Development Council. We thank Rod Asher of Warwick HRI, Kirton, for the skilled cultivation of the crops.

Figure 13. Crop and weed profile for **transplanted delphinium** assessed on four dates (2004). Weed control assessed from 0 (no control) to 10 (complete weed control), and crop tolerance scored from 0 (crop dead) to 10 (no damage); **the safest and most effective treatments therefore show as high values in both sets of histograms.** Herbicides, crop damage and growth stages are shown in the table below.



	Pre-weed 22 July	*Early post-weed-emergence 29 July*	*Crop damage 5 August*	*Crop damage 17 August*	*Crop damage 8 Sept**
22	Stomp+aclonifen (2+2)	-	necrosis, death	total kill	killed
32	Stomp (3.3)	-	slight stunt	slight stunt	-
33	Stomp (3.3)	Betanal Expert (1.5)	scorch, stunt	severe stunt	stunt
34	Stomp (3.3)	Goltix+Betanal (1.7 + 1.8)	scorch, chlorosis, stunt	stunt	stunt
35	Stomp+Centium (3.3 + 0.25)	Goltix (1.7)	stunt	slight stunt	stunt
36	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	severe scorch, stunt	severe stunt	stunt
37	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7 + 1.8)	slight scorch, chlorosis, stunt	stunt	stunt
38	Stomp+propachlor(3.3+9)	-	slight stunt	slight stunt	-
39	Stomp+propachlor(3.3+9)	Betanal Expert (1.5)	severe scorch, stunt	severe stunt	stunt
40	Stomp+propachlor(3.3+9)	Goltix+Betanal (1.7 + 1.8)	slight scorch, chlorosis, stunt	stunt	stunt
41	Flexidor+Goltix (1+3)	-	chlorosis	stunt	stunt

*Crop cover50%; several flowering on hand-weeded, a few on treatments 32, 38, 40; all others delayed flowering

Weed species assessments

Herbicides, dose rates (product L/ha unless otherwise specified), dates of application, main weed species on untreated plots, weed species not controlled and % weed cover. Weed species in parentheses present in low numbers.

China aster drilled 26 May 2004

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)	-	nettle chickweed shepherd's purse groundsel pale persicaria (knotgrass)	nettle chickweed shepherd's purse groundsel pale persicaria (knotgrass)	nettle chickweed shepherd's purse groundsel pale persicaria (knotgrass)
9	Aclonifen+Stomp (2 + 2)		groundsel	groundsel	groundsel
10	Crystal (2)		groundsel nettle redshank pale persicaria	groundsel nettle redshank pale persicaria	groundsel nettle redshank pale persicaria
12	Stomp+Centium (3.3 + 0.25)		groundsel nettle	groundsel nettle	groundsel nettle
15	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	groundsel nettle	-	-
16	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1kg + 1.8)	groundsel nettle	-	-
17	Stomp+Centium (3.3 + 0.25)	Betanal (2.5)	groundsel nettle	-	-

Cornflower drilled 26 May 2004

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)	-	nettle chickweed groundsel shepherd's purse redshank	nettle chickweed groundsel shepherd's purse redshank	nettle chickweed groundsel shepherd's purse redshank
6	Stomp+Flexidor (3.3 + 1)	-	groundsel	groundsel	groundsel
7	Stomp+Flexidor (3.3 + 1)	Goltix+Betanal (1.7kg + 1.8)	groundsel	-	-
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	groundsel	(groundsel)	(groundsel)
9	Aclonifen+Stomp (2 + 2)	-	-	groundsel	groundsel
10	Crystal (2)	-	groundsel nettle	groundsel nettle	groundsel nettle
11	Kerb+Flexidor (2 + 1)		groundsel mayweed pale persicaria	groundsel mayweed pale persicaria	groundsel mayweed pale persicaria

Zinnia drilled 26 May 2004

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)		nettle chickweed groundsel shepherd's purse redshank pale persicaria knotgrass	nettle chickweed groundsel shepherd's purse redshank pale persicaria knotgrass	nettle chickweed groundsel shepherd's purse redshank pale persicaria knotgrass
6	Stomp+Flexidor (3.3 + 1)	-	groundsel	groundsel chickweed redshank	groundsel
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	groundsel	-	-
9	aclonifen+Stomp (2 + 2)	-	groundsel	groundsel	groundsel
10	Crystal (2)	-	groundsel nettle	groundsel nettle	groundsel nettle
12	Stomp+Centium (3.3 + 0.25)		nettle	groundsel nettle	groundsel
13	Stomp+Centium (3.3 + 0.25)	Betanal (1.8)	nettle	-	-

Larkspur drilled 26 May 2004

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)	-	nettle chickweed redshank groundsel shepherd's purse	nettle chickweed redshank groundsel shepherd's purse	nettle chickweed redshank groundsel shepherd's purse
9	aclonifen+Stomp (2 + 2)		groundsel knotgrass		groundsel
10	Crystal (2)		groundsel nettle redshank pale persicaria	groundsel nettle redshank pale persicaria	
12	Stomp+Centium (3.3 + 0.25)	-	groundsel nettle (redshank pale persicaria)	groundsel	groundsel
14	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7kg + 1.8)	groundsel nettle	-	-
15	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	groundsel nettle	-	-

Nigella drilled 26 May 2004)

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)	-	nettle chickweed groundsel shepherd's purse	nettle chickweed groundsel shepherd's purse	nettle chickweed groundsel shepherd's purse
9	Aclonifen+Stomp (2 + 2)		groundsel	groundsel	
10	Crystal (2)		groundsel nettle redshank pale persicaria	groundsel nettle redshank pale persicaria	groundsel nettle redshank pale persicaria
12	Stomp+Centium (3.3 + 0.25)	-	nettle	nettle	groundsel nettle
14	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7kg + 1.8)	nettle	-	-
15	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	nettle	-	-

Bupleurum drilled 26 May 2004

	Pre-weed-emergence 2/6	**Early post-weed-em (cots /one TL) 14/6**	**Weeds not controlled* 14/6**	**Weeds s not controlled 29/6**	**Weeds not controlled 13/7**
1	Control (untreated)	-	groundsel nettle mayweed knotgrass chickweed shepherd's purse redshank	groundsel nettle mayweed knotgrass chickweed shepherd's purse redshank	groundsel nettle mayweed knotgrass chickweed shepherd's purse redshank
3	CIPC+Linuron (4.2 + 1.7)	-	-	groundsel	groundsel
4	CIPC+Linuron (4.2 + 1.7)	Goltix+Betanal (1.7kg + 1.8)	-	-	-
5	CIPC+Linuron (4.2 + 1.7)	Betanal Expert (1.5)	-	-	-
6	Stomp+Flexidor (3.3 + 1)	-	groundsel	groundsel	groundsel
7	Stomp+Flexidor (3.3 + 1)	Goltix+Betanal (1.7kg + 1.8)	groundsel	-	-
8	Stomp+Flexidor (3.3 + 1)	Betanal Expert (1.5)	groundsel	-	-
9	Aclonifen+Stomp (2 + 2)	-	groundsel knotgrass	groundsel	groundsel
10	Crystal (2)	-	groundsel redshank	groundsel redshank	groundsel redshank

China Aster transplanted 2 July 2004

	Pre-transplant 30/6	Pre-weed-em 12/7	Early post-weed-em 20/7	Weed species not controlled* 26/7	Weed species not controlled 5/8	Weed species not controlled 17/8	Weed species not controlled 8/9	% weed cover** 8/9
17	Untreated	-	-	Chickweed groundsel nettle shepherd's purse (mayweed)	Chickweed groundsel nettle shepherd's purse (mayweed)	Chickweed groundsel nettle shepherd's purse (mayweed)	Chickweed groundsel nettle shepherd's purse (mayweed)	30
19	Ronstar Liquid (4)	Butisan (2.5)	-	-	-	-	-	0
20	Ronstar Liquid (4)	-	Betanal Expert (1.5)	-	-	-	-	0
21	Ronstar Liquid (4)	-	Goltix+Betanal (1.25kg +1.7)	-	-	-	-	0

* chickweed not controlled by Ronstar Liquid; ** crop cover 80% on hand-hoed

Stocks transplanted 6 July 2004

	Pre-transplant 2/7	Pre-weed-em 12/7	Early post-weed-em 20/7	Weed species not controlled* 26/7	Weed species not controlled 5/8	Weed species not controlled 17/8	Weed species not controlled 8/9	% weed cover** 8/9
17	untreated	-	-	Chickweed groundsel nettle shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	90
22	-	Stomp+aclonifen (2+2)	-	-	-	-	A few groundsel	1
23	Ronstar Liquid 4	Dacthal + Butisan (9kg+1.5)	-	-	-	-	-	0
24	-	Dacthal + Butisan (9kg+1.5)	Goltix 1.7kg	-	-	-	-	0

* chickweed not controlled by Ronstar Liquid; ** crop cover 70% on hand-hoed

Snapdragon transplanted 5 July 2004

	Pre-transplant 2/7	**Pre-weed-em 12/7**	**Early post-weed-em 20/7**	**Weed species not controlled* 26/7**	**Weed species not controlled 5/8**	**Weed species not controlled 17/8**	**Weed species not controlled 8/9**	**% weed cover** 8/9**
17	Untreated	-	-	Chickweed groundsel shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	Chickweed groundsel nettle shepherd's purse mayweed	100
22	-	Stomp+aclonifen (2+2)	-	-	-	A few groundsel	A few groundsel	1
26	Ronstar Liquid (4)		Goltix (1.5kg)	Chickweed	Chickweed	Chickweed	Chickweed	1
27	-	Venzar (4)	Goltix (1.5kg)	-	-	-	-	0
28	-	Venzar+propachlor (4+9)	Goltix (1.5kg)	-	-	-	-	0
29	Ronstar Liquid (4)	Goltix (3kg)	-	-	-	-	-	0
30	-	-	Nortron (2)	shepherd's purse groundsel mayweed	shepherd's purse groundsel mayweed nettle	shepherd's purse groundsel mayweed nettle	shepherd's purse groundsel mayweed nettle	60
31	-	Stomp (3.3)	Goltix (1.5kg)	-	-	-	-	0

* chickweed not controlled by Ronstar Liquid; ** crop cover 100% on hand-hoed

Phlox transplanted 14 July 2004

	Pre-transplant 13/7	**Pre-weed em 20/7**	**Early post-weed-em 29/7**	**Weed species not controlled* 26/7**	**Weed species not controlled 5/8**	**Weed species not controlled 17/8**	**Weed species not controlled 8/9**	**% weed cover** 8/9**
17	untreated	-	-	shepherd's purse groundsel nettle mayweed chickweed	shepherd's purse groundsel nettle mayweed chickweed	shepherd's purse groundsel nettle mayweed chickweed	shepherd's purse groundsel nettle mayweed chickweed	100
20	Ronstar Liquid (4)	Goltix (3kg)	-	chickweed	-	-	-	0
29	Ronstar Liquid (4)	-	Goltix (1.7kg)	chickweed	(chickweed)	(chickweed)	(chickweed)	1
32	-	Stomp (3.3)	-	shepherd's purse groundsel mayweed chickweed	shepherd's purse groundsel (mayweed)	shepherd's purse groundsel (mayweed)	shepherd's purse groundsel (mayweed)	50
42	Ronstar Liquid (4)	-	Goltix+Betanal (1.7kg + 1.8)	chickweed	(chickweed)	(chickweed)	(chickweed)	2
43	Ronstar Liquid (4)	-	Betanal Expert (1.5)	chickweed	(chickweed)	(chickweed)	(chickweed)	8
44	-	Stomp+Centium (3.3 + 0.25)	-	shepherd's purse groundsel mayweed chickweed	shepherd's purse groundsel mayweed	shepherd's purse groundsel (mayweed)	shepherd's purse (groundsel) (mayweed)	30

*chickweed not controlled by Ronstar Liquid; ** crop cover 2% on hand-hoed

Delphinium transplanted 15 July 2004

	Pre-weed 22/7	Early post-weed-em 29/7	Weed species not controlled 26/7	Weed species not controlled 5/8	Weed species not controlled 17/8	Weed species not controlled 8/9	% weed cover** 8/9
17	untreated	-	mayweed groundsel shepherd's purse chickweed	mayweed groundsel shepherd's purse chickweed	mayweed groundsel shepherd's purse chickweed	mayweed groundsel shepherd's purse chickweed	100
22	Stomp+aclonifen (2+2)	-	mayweed groundsel	(mayweed) groundsel	(mayweed) groundsel	(mayweed) groundsel	12
32	Stomp (3.3)	-	groundsel mayweed shepherd's purse	groundsel mayweed shepherd's purse	groundsel mayweed shepherd's purse	groundsel mayweed shepherd's purse	70
33	Stomp (3.3)	Betanal Expert (1.5)	groundsel mayweed shepherd's purse	mayweed groundsel	mayweed	mayweed	12
34	Stomp (3.3)	Goltix+Betanal (1.7kg + 1.8)	groundsel mayweed shepherd's purse	mayweed groundsel	mayweed	mayweed	7
35	Stomp+Centium (3.3 + 0.25)	Goltix (1.7kg)	mayweed shepherd's purse	(mayweed)	(mayweed)	(mayweed)	5
36	Stomp+Centium (3.3 + 0.25)	Betanal Expert (1.5)	mayweed shepherd's purse	mayweed groundsel	mayweed groundsel	mayweed groundsel	37
37	Stomp+Centium (3.3 + 0.25)	Goltix+Betanal (1.7kg + 1.8)	mayweed shepherd's purse	(mayweed)	(mayweed)	(mayweed)	5
38	Stomp+propachlor (3.3+9)	-	shepherd's purse groundsel mayweed	shepherd's purse groundsel mayweed	shepherd's purse groundsel mayweed	shepherd's purse groundsel mayweed	70
39	Stomp+propachlor (3.3+9)	Betanal Expert (1.5)	shepherd's purse groundsel mayweed	shepherd's purse groundsel mayweed	(shepherd's purse groundsel) mayweed	(groundsel) mayweed	8.3
40	Stomp+propachlor (3.3+ 9)	Goltix+Betanal (1.7kg + 1.8)	shepherd's purse groundsel mayweed	(groundsel shepherd's purse mayweed)	(shepherd's purse mayweed)	(shepherd's purse mayweed)	6.7
41	Flexidor+Goltix (1+3kg)	-	mayweed	-	-	-	0

** crop cover 50% on hand-hoed

Weed susceptibilities

Weed susceptibility to the herbicides used in the project, compiled from the registration holders' labels and other information. Raft (oxadiargyl), tested in 2003 and not yet available in the UK, is not listed, but has a similar weed spectrum to Ronstar Liquid. Herbicide rates shown are L/ha unless otherwise stated. Key: S, susceptible; MS, moderately susceptible; R, resistant; MR, moderately resistant; blanks mean no data are available.

Common name	*Latin name*	***Dacthal 9.0 kg***	***Kerb 2***	***Stomp+Centium 2.0 + 0.25***	***Stomp + aclonifen 2.0 + 2.0***	***Stomp 5.0***	***Crystal 2.0***	***Flexidor 2.0***	***CIPC + linuron 4.2+1.7***	***Venzar 4.0***	***Decimate 10.0***	***Butisan 1.5***	***Ronstar Liquid 4.0***
Bindweed, black	*Fallopia convolvulus*	MS	S	S	S	S				S	MS		S
Bugloss	*Anchusa arvensis*												
Charlock	*Sinapis arvensis*	MR	S	MS	S			S	S	S	MR		S
Chickweed, common	*Stellaria media*	S	S	S	S	S	S	S	S	S	S	S	R
Cleavers	*Galium aparine*		MS	S	MS	S		MR	S	S	S	MR	
Corn marigold	*Chrysanthemum segetum*	R				S		S	S	S	S		
Corn spurrey	*Spergula arvensis*							S		S	S		S
Crane's-bill, cut-leaved	*Geranium dissectum*											MR	
Deadnettle, henbit	*Lamium amplexicaule*					S							
Dead-nettle, red	*Lamium purpureum*	MS		S	S	S	S	S	S	MS	S	S	S
Dock(seedling), broad-lved	*Rumex obtusifolius*												
Fat-hen	*Chenopodium album*	S	S	S/MS	S	S	S	S	S	MS	S		S
Fool's parsley	*Aethusa cynapium*			S	R?								
Forget-me-not, field	*Myosotis arvensis*					S		S				S	
Fumitory, common	*Fumaria officinalis*	R	MS	MS	MS	MS			S	S	R	R	
Gallant-soldier	*Galinsoga parviflora*	R									S		
Groundsel	*Senecio vulgaris*	R	R	S	R			MS	S	MS	S	S	S
Hemp-nettle, common	*Galeopsis tetrahit*	S				S			S	R			R
Knotgrass	*Polygonum aviculare*	S	S	MS		S		S	S	S	S	R	S
Mayweed, scented	*Matricaria recutita*	R	R	S/MS	S	MS		S	S	S	S	S	S
Mayweed, scentless	*Tripleurospermum inodorum*	R	R	S/MS	S	MS		S	S	S	S	S	S
Nettle, small	*Urtica urens*	S	S					S	S	MS	S		S
Nightshade, black	*Solanum nigrum*	MS	S	S	MS	S			S	R	S		
Orache, common	*Atriplex patula*	MS						S	S	S			
Pansy, field	*Viola arvensis*	S		MS	MS	S	MS	S		R	S	R	
Parsley piert	*Aphanes arvensis*					S		S				S	
Pennycress, field	*Thlaspi arvense*	R								S	R	R	
Persicaria, pale	*Persicaria lapathifolia*			MS						S			
Pimpernel, scarlet	*Anagalis arvensis*	S				S		S	S	S			R
Pineappleweed	*Matricaria discoidea*		R		S	MS		S	S				S
Poppy, common	*Papaver rhoeas*	S				S	S	S		S		MS	
Redshank	*Persicaria maculosa*	MR	S		S	S		S	S	S	MS		S
Shepherd's-purse	*Capsella bursa-pastoris*	R		S	S	S	MS	S	S	S	S	S	S
Sow-thistle, smooth	*Sonchus oleraceus*			MS	MS	S				S	MS		S
Speedwell, common, field	*Veronica persica*	S	S	MS	S	S	S		S	MS	S		S
Speedwell, ivy-leaved	*Veronica hederifolia*	R				S	S	S	S	R			S
Sun spurge	*Euphorbia helioscopia*												S
Thistle, creeping	*Cirsium arvense*		R	R	R								
Wild radish	*Raphanus raphanistrum*	R		MS	S			S		S	R		S
Annual meadow-grass	*Poa annua*	MS	S	S	S	S			S		S	S	
Black-grass	*Alopecurus myosuroides*		S			S			S	R		S	R
Brome, barren	*Anisantha sterilis*		S										
Wild-oat	*Avena fatua*		S						S				
Volunteer oil-seed rape	*Brassica napus*		R			MS		S					

(Table A continued on next page)

Table A (continued).

Common name	*Latin name*	***Goltix 1.0 kg***	***Betanal Flow 1.5***	***Betanal Expert 1.5***	***Nortron Flo 2.0***
Bindweed, black	*Fallopia convolvulus*	MR	MS	S	S
Bugloss	*Anchusa arvensis*			S cot	S
Charlock	*Sinapis arvensis*	MS		S cot	S
Chickweed, common	*Stellaria media*	S	S	S	S
Cleavers	*Galium aparine*	R	MR	S	S
Corn marigold	*Chrysanthemum segetum*	S		S	S
Corn spurrey	*Spergula arvensis*	S			S
Crane's-bill, cut-leaved	*Geranium dissectum*		R		
Deadnettle, henbit	*Lamium amplexicaule*			S	S
Dead-nettle, red	*Lamium purpureum*	MS	S	S	S
Dock(seedling), broad-lved	*Rumex obtusifolius*	S			
Fat-hen	*Chenopodium album*	S	S	S	S
Fool's parsley	*Aethusa cynapium*	S			
Forget-me-not, field	*Myosotis arvensis*	S	MR		
Fumitory, common	*Fumaria officinalis*	MS	S	S	S
Gallant-soldier	*Galinsoga parviflora*				
Groundsel	*Senecio vulgaris*	S	S	S	S
Hemp-nettle, common	*Galeopsis tetrahit*	S	S		S
Knotgrass	*Polygonum aviculare*	S	S	S	S
Mayweed, scented	*Matricaria recutita*	S		S	S
Mayweed, scentless	*Tripleurospermum inodorum*	S	MS	S	S
Nettle, small	*Urtica urens*	S	S	S	S
Nightshade, black	*Solanum nigrum*	MR		S	S cot
Orache, common	*Atriplex patula*	S	S	S	S
Pansy, field	*Viola arvensis*	S	S	S	S
Parsley piert	*Aphanes arvensis*				
Pennycress, field	*Thlaspi arvense*	S	MS	S	S
Persicaria, pale	*Persicaria lapathifolia*	MS	S	S	S
Pimpernel, scarlet	*Anagalis arvensis*	MR	S	S	S
Pineappleweed	*Matricaria discoidea*	S		S	S
Poppy, common	*Papaver rhoeas*	S	S		S
Redshank	*Persicaria maculosa*	MS	S	S	S
Shepherd's-purse	*Capsella bursa-pastoris*	S	S		S
Sow-thistle, smooth	*Sonchus oleraceus*		R		
Speedwell, common, field	*Veronica persica*	S	S	S	S
Speedwell, ivy-leaved	*Veronica hederifolia*	MS	MS	S	S
Sun spurge	*Euphorbia helioscopia*	S			
Thistle, creeping	*Cirsium arvense*	R			
Wild radish	*Raphanus raphanistrum*	MR	S	S	S
Annual meadow-grass	*Poa annua*	S	R	S	S
Black-grass	*Alopecurus myosuroides*				S
Brome, barren	*Anisantha sterilis*				
Wild-oat	*Avena fatua*				S
Volunteer oil-seed rape	*Brassica napus*				

Gordon Hanks 21 March 2005