Project Title	Control of problem weeds in Hardy Nursery Stock
Project number:	HNS 139
Project leader:	John Atwood, ADAS UK Ltd
Report:	Final report, March 2009
Previous report	September 2007
Key staff:	John Atwood, ADAS, Project leader Sarah Cook, Weed scientist, ADAS (screening experiments) Kerry Maulden, ADAS Senior Scientific Officer (field experiments)
Location of project:	ADAS Boxworth, Cambridge ADAS Terrington, Norfolk Nursery site not disclosed, Norfolk Goregate Ltd., Dereham, Norfolk, NR19 2AW Frank P Matthews, Tenbury Wells, Worcs WR15 8TH
Project coordinator:	Alastair Hazel, Darby Nursery Stock Ltd. Methwold, Norfolk, IP26 4PW. Nick Dunn, Frank P Matthews Ltd. Tenbury Wells, Worcs, WR15 8TH
Date project commenced:	1 July 2005
Date completion due:	31 March 2009

Key words:
2,4-D amine, 212 H, 213H, A9950A, adjuvant, Agroxone, amitrol, Aramo, Artist, Atlantis WG, BAS 635H, ,*Berberis darwinii,* bindweed, *Buddleja davidii* 'Royal Red', Butisan S, *Calistegia sepia, Cardamine corymbosa, Cardamine flexuosa, Cardamine hirsuta,* carfentrazone-ethyl, Casoron G, *Cerastium fontanum,* Centium, Challenge, *Chamaecyparis lawsoniana* 'Elwoods Gold', chlorotoluron, Cleancrop Unival, clomazone, cockspur grass, creeping yellow cress, Crystal, cycloxydim, dicamba, dichlobenil, dichlorprop-p,dimethenamid-p, dimethachlor, Dual Gold, *Echinochloa crus-galli, Epilobium ciliatum, Equisetum arvense,* Falcon, fallow, false hedge bindweed, flazasulfuron, Flexidor 125, flexuous bittercress, florasulam, fluazifop p butyl, flufenacet, fluroxypyr, Fusilade Max, glufosinate ammonium, Glyfos, glyphosate, Goal, goat willow, Goltix WG, grey willow, groundsel, hairy bittercress, hardy nursery stock,Headland Link, Headland Fortune, Headland Guard 2000, Headland Tolerate, *Hebe* 'Margaret', herbicides, Herboxone, horsetail, I.T. Dicamba, Iodosulfuron-methyl-sodium, isoxaben, Kerb Flo, Laser, *Lavandula* 'Princess Blue', lenacil, *Lonicera* 'Halliana', *Malus domestica* 'Reverend W Wilks', *Malus domestica* 'Grenadier', marestail, MCPA, metamitron, metazachlor, metosulam, metribuzin, metsulfuron-methyl, common mouse-ear, New Zealand bittercress, nicosulfuron, ornamentals, oxadiazon, oxyfluorfen, pearlwort, pendimethalin, *Philadelphus* 'Manteau d'hermine', *Potentilla fruticosa* 'Summer Sorbet', propaquizafop, propyzamide, Prospect, *Prunus* 'Amanagowa', *Prunus insititia* 'Merryweather Damson' *Pyracantha* 'Red Column', *Pyrus communis* 'Concorde', Ronstar 2G, Ronstar Liquid, *Rorippa sylvestris, Rosmarinus* 'Miss Jessop', s – metolachlor, *Sagina procumbens, Salix caprea, Salix cinerea,* Samson, *Senecio vulgaris,* Shark, Skirmish, *Sorbus intermedia, Spiraea* 'Snowmound', Starane 2, Starane XL, Stomp 400 SC, Springbok, tepraloxydim, Terano, Teridox, terbuthylazine, thifensulfuron-methyl, triclopyr, Venzar Flowable, *Veronica* 'Ulster Dwarf Blue', weed control, Weedazol-TL, willowherb

The results and conclusions in this report are based on an investigation conducted over a four 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 FOR HNS 139

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

John Atwood
Senior Horticultural Consultant
ADAS UK Ltd

Signature ..... Date .....

Report authorised by:

Dr W E Parker
Horticulture Research & Consultancy Manager
ADAS UK Ltd

Signature ..... Date .....

TABLE OF CONTENTS

GROWER SUMMARY

Headline

A range of herbicide products have been assessed for their efficacy in controlling persistent and perennial weeds in hardy nursery stock and the most successful have been identified.

Background and expected deliverables

A number of weed species have proved difficult to control in container-grown nursery stock crops in recent years. In this project, herbicides were assessed for efficacy against New Zealand, flexuous and hairy bittercress, and pearlwort, groundsel, common mouse-ear, willowherb and sallows. The most promising new herbicides were assessed for crop safety on a range on container-grown hardy nursery stock either as summer or winter treatments.

Cockspur grass (*Echinochloa crus-galli*) is a non-indigenous species causing problems in field-grown nursery stock in southern counties. This project identified some effective residual herbicide treatments for summer applications and selective contact treatments for use in field grown tree crops.

Deep-rooted perennial weeds such as creeping yellow cress, false hedge bindweed and field horsetails are long-standing problems in perennial nursery crops. For these perennial weeds the best combination of treatments for control were established for use either in a pre-planting fallow or as 'directed' treatments within a tree crop. Some of the more promising treatments have been tested for crop safety in different cropping situations.

Summary of the project and main conclusions

Seedling weeds of container-grown nursery stock

Weed control efficacy tests

A range of new herbicides were tested (Table 1). In the initial phase of the project (Study 1), new herbicides were tested alongside existing standards on broad-leaved weeds grown in peat-based media. Herbicides were applied at pre-emergence, 1-2 true leaf and 3-4 true leaf stages in tests carried out at ADAS Boxworth in summer and autumn 2006. For studies two and three, the most promising herbicides were selected for further testing in a nursery

situation with a natural weed infestation in 2007 as either summer or winter treatments, depending on known contact activity. Two new herbicides, New Code A and Springbok (metazachlor + dimethenamid-p) became available at this stage and were also included. For studies four and five, herbicides were again tested in summer and winter in a nursery situation but with weed seeded pots included in the summer experiment. One new herbicide, Teridox (dimethachlor) was included at this stage. The results of the weed control efficacy tests are summarised in Table 2.

Table 1. New herbicides tested against seedling weeds of container-grown nursery stock

Product	**Active ingredient**	**Product application rate**	**Approval status**	**Study**
Chikara	flazasulfuron (25 % w/w)	0.2 kg/ha	Approved for non crop areas	1,3,5
Dual Gold	s-metolachlor 960 (g/L)	1.6 L/ha	Not in UK	1,2,4
Goltix WG	metamitron (70 % w/w)	3.0 kg/ha	LTA*	1
New Code A	not disclosed	2.6 kg/ha	Not in UK	2,4
New Code B	not disclosed	64.0 kg/ha	Not in UK	1
Skirmish	terbuthylazine + isoxaben (420 : 75 g/L)	1.0 L/ha	LTA	1,3,5
Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	LTA	2,4
Sumimax 50WP	flumioxazin (25 % w/w)	0.2 kg/ha	SOLA**	1,3
Sumimax	flumioxazin (300 g/L)	0.1 L/ha	SOLA	5
Terano	flufenacet + metosulam (60 : 2.5 % w/w)	0.75 kg/ha	Not in UK	1,2,4
Teridox	dimethachlor (500 g/L)	3.0 L/ha	Not in UK	4

*LTA = Long-Term Arrangements for Extension of Use.

**SOLA = specific off-label approval

Study codes

1 Weed seeded pot initial screening 2006

2 Nursery experiment summer treatment 2007

3 Nursery experiment winter treatment 2007

4 Nursery experiment summer treatment 2008

5 Nursery experiment winter treatment 2008

Table 2. Summary of herbicide efficacy by weed and growth stage

Weed species & growth stage	**Butisan**	**Chikara**	**Dual Gold**	**Flexidor**	**Goltix**	**New Code A**	**New Code B**	**Ronstar 2G**	**Skirmish**	**Springbok**	**Stomp**	**Sumimax**	**Terano**	**Teridox**	**Venzar**
Bittercress, flexuous															
Pre em	****	****	**	****	*	-	****	****	****	***	***	****	****	*	****
1-2 leaf	-	****	-	-	-		-	*	***		-	****	***		-
3-4 leaf	-	***	-	-	-		-	-	***		-	-	***		-
Bittercress, hairy															
Pre em	**	***	*	****	*	-	****	****	****	***	***	****	****	-	****
1-2 leaf	*	****	*	****	-		*	****	****		-	****	**		*
3-4 leaf	*	***	*	***	-		*	**	-		-	****	***		*
Bittercress, New Zealand															
Pre em	****	****	**	****	**	-	****	****	****	***	***	****	****	-	****
1-2 leaf	-	***	*	*	*		*	**	****		*	****	****		*
3-4 leaf	-	***	-	-	-		-	-	***		-	-	***		-
Groundsel															
Pre em	***	****	**	-	****	-	*	****	-	***	-	****	****	***	****
1-2 leaf	*	**	*	-	-		-	**	-		*	**	-		**
3-4 leaf	*	*	*	*	-		-	-	*		*	**	*		*
Mouse ear, common															
Pre em	****	****	*	****	-		***	-	****		***	****	****		****
1-2 leaf	*	****	-	****	-		-	-	****		**	****	***		****
3-4 leaf	-	***	-	***	-		****	-	***		-	****	-		***
Pearlwort															
Pre em	****	****	****	****	-	****	****	-	****	****	****	****	****	**	****
1-2 leaf	**	***	-	*	-		-	-	****		-	****	***		-
3-4 leaf	*	*	-	-	-		-	-	***		-	*	-		-
Willowherb															
Pre em	****	****	****	-	**	**	****	****	***	****	*	****	***	**	****
1-2 leaf	*	**	*	*	-		**	***	***		**	****	***		*
3-4 leaf	*	*	*	*	-		****	*	***		*	****	*		***

Weed species & growth stage	Butisan	Chikara	Dual Gold	Flexidor	Goltix	New Code A	New Code B	Ronstar 2G	Skirmish	Springbok	Stomp	Sumimax	Terano	Teridox	Venzar
Willows															
Pre em	****	****	****	****	****		****	****	****		**	****	****		****
1-2 leaf	*	****	*	**	*		****	****	****		*	****	****		****
3-4 leaf	*	***	*	*	**		***	*	****		*	****	**		****

Key to Table 2

Rating	Notes
Blank	Not tested
-	No control
*	Slight check to germination or slight scorch
**	Moderate check to germination or moderate scorch, partial control
***	Generally good control but could be slow acting and/or inconsistent
****	Full or almost full control

Summary of results of weed species control

All three **bittercress** species were controlled pre-emergence by industry standards Ronstar 2G (oxadiazon) and Flexidor 125 (isoxaben). Unlike hairy bittercress, the non-indigenous species were not controlled post emergence by the industry standards. The only summer treatment to have good activity was Terano (flufenacet + metosulam). For winter treatments Skirmish (terbuthyalazine + isoxaben), Sumimax (flumioxazin) and Chikara (flazasulfuron) were particularly effective against all three species.

Common mouse-ear is not controlled by Ronstar 2G, but most other treatments were effective for pre-emergence control. For post emergence control only Flexidor 125 and Terano would be suitable for summer use but Venzar Flowable (lenacil), Skirmish, Terano, Chikara and Sumimax are all possible winter treatments.

Willowherb was well controlled pre-emergence industry standards, except Flexidor 125. Of the new treatments suitable for growing season use, Dual Gold appears to have the most potential for willowherb control. For winter use, the newer treatments, Skirmish, Sumimax and Chikara all have good potential, including post emergence control.

For growing season control of **pearlwort**, Flexidor 125 is still one of the best treatments, however newer treatments, Terano and Dual Gold (s-metolachlor) have potential and Terano could take out 1-2 leaf seedlings. For winter use, Skirmish, Terano, Chikara and Sumimax all have potential with Skirmish having the best post emergence activity.

For **groundsel**, the most effective pre-emergence treatments for summer use are Ronstar 2G, Terano, and Teridox. Dual Gold was partially effective with potential as a growing season treatment. For winter use, Chikara and Sumimax appear to have the best potential including early post emergence 1-2 true leaf control.

Both **willow** species *Salix caprea* and *Salix cinerea* responded similarly to treatments and were relatively easily controlled. As the commonly used herbicides Ronstar 2G and Flexidor 125 gave good pre-emergence control when used just prior to sowing it must be assumed that reported difficulty in control of these species is due to a lack of sufficient persistence of the herbicides.

Summary of results of new herbicide products

Dual Gold has potential for use as a summer spray treatment, as a supplement to Flexidor 125 as the weed spectrum is complementary. Compared with Flexidor 125 the control of willowherb is very good and groundsel is better. Dual Gold appears to have good crop safety apart from slight tip bleaching on *Hebe* 'Margaret'.

Terano has an excellent weed control spectrum including post emergence activity against key weeds. However *Escallonia* was severely damaged with shoot death and *Hebe* and *Veronica* was moderately damaged.

Teridox appears relatively safe as a growing season treatment in container grown nursery stock. It failed to control some important weeds such as bittercress and willowherb but the control of groundsel could be particularly useful if it was used in tank mix or sequence with other herbicides.

Springbok and **Butisan S** appeared to have similar efficacy against the weed species tested. Both showed good performance against pearlwort, mouse ear, and willowherb. Control of grounsel and bittercress was more variable although there were indications that New Zealand and flexuous bittercress were better controlled. No damage was noted in these experiments but one of the active ingredients contained in both products, metazachlor, has been known to cause scorch to soft growth in early summer.

Chikara, **Sumimax** and **Skirmish** all have potential for use as winter herbicides in nursery stock as an alternative to the industry standard Butisan S (metazachlor) + Flexidor 125. The main benefit of the newer herbicides would be improved post emergence control of flexuous and New Zealand bittercress (Chikara, Skirmish, Sumimax), groundsel (Sumimax), pearlwort

(Skirimish) and willowherb (Skimish, Sumimax). Sumimax, Chikara and Skirmish caused damage to some evergreen subjects when applied over the foliage to dormant crops (Table 3).

Table 3. Crop safety for some newer herbicides S = safe, X = not safe, blank = not tested. (* = applied with Butisan S).

	Dual Gold	Springbok	Teridox	Terano	Chikara	Skiirmish*	Sumimax
Subject	**Summer**				**Winter**		
Berberis darwinii	S	S	S	S	S	S	S
Buddleja davidii 'Royal Red'	S	S		S	X	X	S
Choisya ternata	S	S	S	S	S	S	S
Escalonia 'Red Dream'	S	S	S	X	S	X	X
Hebe 'Margaret'	X	S	S	S	S	X	X
Kolkwitzia 'Pink Cloud'	S	S	S	S	S	S	S
Lavandula 'Princess Blue'	S	S		S	S	S	S
Lonicera 'Halliana'	S	S		S	S	S	S
Lonicera 'Lemon Beauty'	S	S	S	S	S	S	S
Philadelphus 'Manteau d'hermine'	S	S		S	S	S	S
Potentilla fruticosa 'Red Ace'	S	S	S	S	S	S	S
Potentilla fruticosa 'Summer Sorbet'	S	S		S	S	S	S
Pyracantha 'Red Column'	S	S		S	S	S	S
Rosmarinus 'Miss Jessop'	S	S		S	S	S	S
Santolina chamycyparisus	S	S	S	S	S	S	S
Sambucus 'Black Lace'	S	S	S	S	S	S	S
Spiraea 'Firelight'	S	S	S	S	S	S	S
Spiraea 'Snowmound'	S	S		S	S	S	S
Chamaecyparis lawsoniana 'Elwoods Gold'	S	S		S	S	S	S
Vinca major 'Maculata'	S	S	S	S	S	S	X
Veronica 'Ulster Dwarf Blue'.	S	S	X	X	S	X	S

Cockspur grass experiment

A range of herbicides were tested on two strains of cockspur grass grown in soil media at pre-emergence, 3 to 4 true leaves, and the 6 to 10 true leaf stage in seeded pot experiments in 2006 (study 1). The herbicides that were effective and likely to be suitable for summer use applied selectively over field grown stock were selected for further field experiments in study 2 in 2007 and 2008 (Table 4).

Table 4. Herbicides used in cockspur control, initial screening and nursery experiments

Product	**Active ingredient**	**Product application rate**	**Approval status (Field grown HNS)**	**Study**
Artist	flufenacet + metribuzin (24+17.5 % w/w)	2.5 kg/ha	LTA*	1,2
Butisan S	metazachlor (500 g/L)	2.5 L/ha	Label	1,2
Crystal	pendimethalin + flufenacet (60 : 300 g/L)	4.0 L/ha	LTA	1,2
Dual Gold	s – metolachlor (960 g/L)	1.6 L/ha	Not in UK	1,2
Laser	cycloxydim (200 g/L)	2.25 L/ha	SOLA	1,2
+ Actipron	adjuvant oil	0.8%		
Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	LTA	2

*LTA = Long-Term Arrangements for Extension of Use

Butisan S, Artist (flufenacet + metribuzin), Crystal (pendimethalin + flufenacet), Springbok and Dual Gold were tested as residual herbicides, and Laser as a selective contact herbicide, in a range of tree crops. Butisan S, Artist and Dual Gold were particularly effective at giving complete residual control of a high population of cockspur grass. Crystal and Springbok were also effective but with a slightly lower level of control. An application of Laser (cycloxydim) + adjuvant oil gave complete post-emergence control of plants, some of which had 10 tillers and were 0.6 m high.

Treatments were further tested by application over foliage in full growth in two sets of experiments over two years. Artist caused a severe scorch to the terminal growth and general growth stunting. Leaves below the terminal shoot were relatively unaffected. All other treatments caused very minor distortion/hardening to the terminal growth. The effect was initially more marked from Springbok and Crystal compared with Butisan S, Dual Gold or the Laser + Dual Gold + Newfarm Oil combination. However these differences were

rapidly outgrown and by the final assessment only the trees treated with Artist were still showing obvious symptoms.

Field horsetail experiment

A range of herbicides and adjuvant combinations were tested on a natural infestation of field horsetail in a fallow situation. Two years of experiments on two sites were carried out (studies 1 and 2). The most effective treatments are listed in Table 5, with a full list of treatments found in the main report.

Weedazol-TL (amitrole) and Agroxone (MCPA) treatments gave effective control in the season of treatment. Weedazol-TL was the only treatment to provide a significant reduction in horsetail re-growth the following year, in both of two years of experiments. Although Agroxone consistently gave a very good initial knockdown, there was variability in the amount of re-growth in the following year. The addition of other hormone herbicides such as dicamba to the Agroxone further reduced re-growth the following season.

The use of different adjuvants in the first study did not give rise to significant differences in control, but there were indications that Headland Fortune was more effective and the use of this combination resulted in the least re-growth the following year.

Table 5. The most effective herbicide treatments used in the field horsetail control experiments

Product	**Active ingredient**	**Product application rate**	**Approval status (field-grown HNS)**	**Study**
Agroxone	MCPA (500 g/L)	6.0 L/ha	LTA*	1,2
I.T. Dicamba	dicamba (480 g/L)	5.0 L/ha	LTA	2
Weedazol-TL	amitrole (225 g/L)	20.0 L/	LTA	1,2

*LTA = Long Term Arrangements for Extension of Use

Creeping yellow cress experiment

A range of herbicides and adjuvant combinations were tested on a natural infestation of creeping yellow cress in a fallow situation. Two years of experiments on two sites were carried out (studies 1 and 2). The most effective treatments used in both experiments are given in Table 6.

Weedazol-TL, Glyfos (glyphosate), and Cleancrop Unival (triclopyr) gave good control of creeping yellow cress in the season of treatment. Cleancrop Unival was the only treatment to consistently reduce the re-growth in the following season although Weedazol-TL also gave a good reduction. Cleancrop Unival (triclopyr) is no longer available but similar formulations of triclopyr are available as Garlon or Timbrel.

Table 6. The most effective herbicides treatments used in creeping yellow cress control experiments

Product	**Active ingredient**	**Product rate**	**Approval status (field-grown HNS)**	**Studies**
Cleancrop Unival	triclopyr (240 g/L)	6.0 L/ha	LTA	1,2
Glyfos	glyphosate (360 g/L)	5.0 L/ha	SOLA***	1
Weedazol-TL	amitrole (225 g/L)	20.0 L/ha	LTA*	1,2

*LTA = Long Term Arrangements for Extension of Use

**SOLA for similar product Depitox

***SOLA for similar glyphosate products

False hedge bindweed experiment

A range of herbicides at different timing (summer and autumn) were tested on a natural infestation of false hedge bindweed in an abandoned *Malus* stoolbed. Two years of control experiments on two sites were carried out (studies 1 and 2). Two experiments were carried out to assess phytotoxicity to field grown rootstocks. The first experiment (study 3) was carried out on newly planted rootstock with treatments applied as directed sprays to the soil adjacent to the stocks. The second experiment (study 4) was carried out in 2008 to assess the phytotoxicity of treatments when used as a directed summer treatment alongside a vigorous *Malus* stoolbed. The most effective treatments used in the four experiments are given in Table 7.

Table 7. The most effective herbicides treatments used in false hedge bindweed control experiments

Product	Active ingredient	Product rate	Approval status (Field grown HNS)	Studies
Herboxone	2,4 D amine (500 g/L)	3.3 L/ha	SOLA**	1,2,3
IT.Dicamba	dicamba (480 g/L)	5 L/ha	LTA*	1,2,3,4
Roundup	glyphosate (360 g/L)	5 L/ha	SOLA***	1,2

*LTA = Long term arrangement for the extension of use
**SOLA for similar product Depitox
***SOLA for similar glyphosate products

False hedge bindweed could be controlled for one season but was difficult to eradicate. Whilst Herboxone (2,4-D), or dicamba proved quite effective during the treatment season, it was only the combination of dicamba + Roundup (glyphosate) that significantly reduced the re-growth the following year. The combination of July-applied hormone herbicides in a tank-mix with Roundup proved effective again on a different site in 2007. The re-growth in the following year 2008 was more variable than in 2007 making comparisons difficult, but the combination of dicamba + Roundup appears to be one of the more consistent treatments with good initial knockdown and substantial reduction the following year. It is likely that several years of repeated treatments will be necessary to eradicate this weed.

None of the herbicides tested caused visible phytotoxicity when applied as directed sprays to the soil surface avoiding the tree foliage during July 2007 in plantings of *Malus domestica* 'M9', *Prunus* 'Colt', Quince 'C', and *Sorbus aucuparia*.

In a more stringent phytotoxicity screening trial, a number of treatments were tested for safety when used as a directed spray alongside a *Malus* stoolbed. The vigorous soft growth of a stoolbed is very vulnerable to damage making this a sensitive test. Chikara and Sumimax proved completely safe. Dicamba was initially damaging but the shoot growth recovered. Cleancrop Unival however proved extremely damaging causing shoot death and a reduction in growth.

Financial benefits

Some of the most useful treatments tested are not yet available in the UK market and would also require application for SOLA. Assuming that most container nursery growers would already be using a herbicide programme, the cost of using a different herbicide might range from zero (if one herbicide was substituted for another) to £70/ha for one additional application, an average extra cost of £35/ha. The likely cost of Dual Gold is not known, but the cost of Sumimax is quite low (£27/ha) which compares very favourably with Butisan S + Flexidor 125 at £115/ha.

Taking a conservative estimate that hand-weeding for a whole season would be around £2,500/ha, the cost of removing resistant weeds might be 25% of that (£625/ha).This leads to a saving of around £590/ha. The farm gate value of field grown nursery stock (source Defra Hort. Stats) is £66.7million. If it is assumed that 2% potential lost revenue due to the specific weed problems covered by this project, this would amount to £1.3 million.

Action points for growers

- When available, Dual Gold shows promise as a supplement to Flexidor 125 to improve control of groundsel, grasses and willowherb for general container-grown HNS weed control during the growing season.

- Sumimax could be used as a winter treatment on dormant stock to improve control of flexuous and New Zealand bittercress and groundsel. Similar products Guillotine and Digital also have SOLAs for ornamental plant production.

- Subject to SOLA, Skirmish offers the best available treatment for pearlwort control, but is only for dormant season use.

- For willow control, herbicides such as Flexidor 125 or Ronstar 2G should be freshly applied as soon as the seed is seen on the wind.

- Tree growers with cockspur grass problems should consider using Butisan S or Dual Gold (when available), as summer-applied residual herbicides.

- Butisan S is best applied as directed sprays avoiding the growing point of the trees but a summer application over the foliage can also be acceptably safe for some species.

- When available, Dual Gold will provide very good control of cockspur grass with potential for safe use when applied overall.

- Existing infestations of cockspur grass can be controlled with Laser. This product is selective in many broad-leaved tree crops.

- Weedazol-TL or MCPA remains the best control measure for field horsetail. Headland Fortune was the most effective adjuvant tested.

- MCPA gave the most rapid initial knockdown of field horsetail, but did not eradicate it.

- Cleancrop Unival (triclopyr) was the most effective control agent for creeping yellow cress. Triclopyr is now available as Garlon 4 or Timbrel.

- Dicamba + glyphosate combinations appeared to offer the best control of false hedge bindweed. I.T, Dicamba is no longer available but other products are available that contain dicamba in formulation with 2,4-D or 2,4-D + triclopyr.

SCIENCE SECTION

Introduction

A number of weed species have proved difficult to control in either container-grown or field-grown nursery stock crops in recent years. The problem weeds include non-indigenous, recent introductions such as New Zealand bittercress (*Cardamine corymbosa*) and flexuous bittercress (*Cardamine flexuosa)* in container-grown crops. Pearlwort (*Sagina procumbens*) is an increasing problem in container-grown nursery stock with growers reporting more difficulty in control with existing herbicides. Other annual weeds such as groundsel (*Senecio vulgaris*), common mouse-ear (*Cerastium fontanum*), willowherb (*Epilobium* spp.) and sallows (*Salix caprea, S. cinerea*) are still commonly found in container-grown stock because of resistance to commonly used herbicides or herbicide application timing difficulties.

Although there has been a past programme of weed control research on container grown nursery stock carried out for the HDC, certain weed species in this study have not been investigated previously in detail. It had been intended to include New Zealand bittercress in HNS 111 but it was not possible to obtain seed at the time. Seed is now available. A study in Belgium (Eelden & Bulcke, 1998) showed that flexuous bittercress was less susceptible to isoxaben than hairy bittercress when applied post emergence, but the response to other herbicides was not studied and no further work has been carried out. The sallows (*S. caprea*, *S. cinerea*) have not previously been studied as a nursery stock weed. Pearlwort, common mouse-ear, willowherb and groundsel were studied in HNS 35f, HNS 70 or HNS 111. Although some useful control measures came out of these studies, timing restrictions, phytotoxicity to certain crops, and possible resistance in pearlwort, mean that a further range of treatments would be beneficial. Further herbicides have become available since these studies were carried out, requiring testing, alongside existing herbicides to check whether resistance has developed.

Cockspur grass (*Echinochloa crus-galli*) is another non-indigenous species causing problems in field-grown nursery stock in the southern counties. It can rapidly out-shade field crops leading to loss of quality and difficulty in lifting. Once established it is difficult to remove by hoeing or mechanical cultivations. Cockspur grass has been much studied in tropical crops (Kahn & Kahn, 2003) and some control measures could be adapted for use in nursery stock. Populations are known to differ in susceptibility to herbicides and the mechanism has been studied (Hoagland & Hirase, 2003) but little is known about the resistance status of populations recently introduced to southern counties of the UK.

Deep rooted perennial weeds such as creeping yellow cress (*Rorippa sylvestris*) and horsetail (*Equisetum arvense*) are long-standing problems in perennial nursery crops and can also cause problems in container standing beds and a wide range of other horticultural crops.

Creeping yellow cress and horsetail are competitive with crops, and the rhizomes can be spread with planting stock. The presence of such weeds on nurseries limits the availability of land for planting, forcing growers to seek alternative land or to limit rotation length.

Of the two deep-rooted perennial weeds *E. arvense* and *R. sylvestris*, the former has been studied more extensively with traditional treatments such as MCPA (Merbach, 1993; Marshall, 1984), amitrole (Vezina, 1990; Coupland & Peabody, 1981, Marshall, 1984), dichlobenil (Marshall, 1984) and glyphosate (Hallgren, 1996) all reported as giving partial control. Other recent work has included fluroxypyr, glufosinate-ammonium and chlorsulfuron (Nilsson & Hallgren, 1991). Chlorsulfuron was particularly effective, but is no longer available in the UK. Other sulfonyl urea herbicides have potential, when used in a fallow situation the year before planting. There has been little work carried out on *R. sylvestris*, although there is anecdotal evidence of control from certain sulfonyl urea herbicides such as thifensulfuron-methyl on other *Rorippa* species (DuPont, pers. com).

Materials and Methods

A. Container plant nursery experiments

In the initial phase of the project a range of herbicides were tested on selected broad-leaved weeds grown in peat-based media at pre-emergence, 1-2 true leaf and 3-4 true leaf stages in tests carried out at ADAS Boxworth in summer and autumn 2006. For studies two and three, the most promising herbicides were taken forward for testing in a nursery situation with a natural weed infestation in 2007 as either summer or winter treatments depending on known contact activity. Two new herbicides (New Code A and Springbok) became available at this stage and were also included. Full details of studies 1 - 3 are given in the 2006 and 2007 annual reports.

In 2008, two experiments were set up to investigate the efficacy and phytotoxicity of ten herbicide treatments on a range of container-grown ornamental species in a commercial nursery situation. A summer experiment (study 4) was set up to test seven of the treatments applied immediately after potting and again in full leaf. This experiment included weed-seeded pots. One new herbicide (Teridox) was included at this stage. A winter

experiment (study 5) was set up to test three treatments previously identified as being more suitable for dormant season application.

Eleven shrubs and one herbaceous species were used (Table 8). All plants were supplied from Darby Nursery Stock Ltd. Plants were supplied as 9 cm liner pots potted into 3 litre pots on 21 May. The same plants were used for both summer and winter experiments.

Table 8. Plant species used in container plant nursery experiments 2008

Figure 1. Plants at time of first treatment

Plant species

Berberis darwinii
Choisya ternata
Escalonia 'Red Dream'
Hebe 'Margaret'
Kolkwitzia 'Pink Cloud'
Lonicera 'Lemon Beauty'
Potentilla 'Red Ace'
Santolina chamycyparisus
Sambucus 'Black Lace'
Spiraea 'Firelight'
Vinca major 'Maculata'
Veronica 'Ulster Dwarf Blue'.

Potting Mix:

70% Medium grade peat

30% Pine bark

5.0 kg/m^3 Osmocote Exact Standard 12-14 month

1.8 kg/m^3 Magnesian limestone

0.5 kg/m^3 12:12:12 Compound fertiliser

Summer experiment

Experimental design

The experiment was a split plot design (Appendix 1). There were 8 treatments (including one control) replicated three times (24 main plots for herbicide treatments, 12 HNS species sub-plots x 3 plants). Each plot also included a set of 12 unplanted pots for seeding with four weed species x three sowing dates. The pots were placed on sub-irrigated "Efford" style sandbeds outdoors after potting. Overhead irrigation was used to settle the plants in.

Herbicide treatments

The herbicide treatments used are given in Table 9. Treatments were applied on 21 May 2008 and re-applied 27 August 2008.

Table 9. Treatments used in summer container plant nursery experiments

Treatment	**Product**	**Active ingredient**	**Product application rate**	**Approval status**
1.	Untreated control	-	-	-
2.	Teridox	dimethachlor (500 g/L)	3.0 L/ha	Not in UK
3.	Flexidor 125	isoxaben (125 g/L)	1.0 L/ha	Label
4.	Butisan S	metazachlor (500 g/L)	2.5 L/ha	LTA*
5.	Springbok	metazachlor (200 g/L) + dimethenamid-p (200 g/L)	2.5 L/ha	LTA
6.	Dual Gold	s – metolachlor (960 g/L)	1.6 L/ha	Not in UK
7.	Terano	flufenacet + metosulam (60 : 2.5 % w/w)	0.75 kg/ha	Not in UK
8.	New Code A	not disclosed	2.6 kg/ha	Not in UK

*LTA = Long-Term Arrangements for Extension of Use.

All treatments were applied in 1000 L/ha water at 2 bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 1 m boom and F03-110 spray nozzles.

Weed seeding

The unplanted pots were seeded with groundsel (*Senecio vulgaris*), pearlwort (*Sagina subulata* sowings 1 and 2 or *S*. *procumbens* sowing 3), willowherb (*Epilobium ciliatum*) and flexuous bittercress (*Cardamine flexuosa*). Seeds were purchased from Herbiseed, The Nurseries, Billingbear Park, Wokingham, RG11 5RY, except for *Sagina procumbens* (field collected) and *S. subulata* (Moles Seeds, Stanway, Colchester, CO3 8PD)

Seed was applied to the pot surface 2, 34 and 58 days after herbicide treatment, one pot per plot for each weed timing. Seed was mixed with silver sand applying 1g mix per pot with the aim of achieving up to 50 seedlings per pot assuming 33% potential viability.

Assessments

An assessment of weed number or a score for biomass (weed number x size) on a 1-10 scale compared with the untreated control was made for each species and sowing date on 9 June, 20 June, 2 July, 16 July, 30 July and 13 August 2008. An assessment of unsown weed cover in the species plots was also made on 2 October 2008. Results were all converted to percentage control compared with the untreated.

Observations on phytotoxicity symptoms were made on 9 June, 20 June, 2 July, 13 August, 11 September and 2 October 2008. Where significant damage was noted the symptoms were assessed on the following scale:

Table 10a. Phytotoxicity scores.

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 a significant reduction in quality at marketing)
8	10 – 20% damage
9	5 – 10% damage
10	No damage (as untreated controls)

Winter experiment

Experimental design

The experiment was a split plot design (Appendix 1). There were four treatments (including one control) replicated six times (24 main plots for herbicide treatments, 12 HNS species

sub-plots x 3 plants). The pots were grown on sub-irrigated “Efford” style sandbeds outdoors after potting. There were no weed seeded pots.

Herbicide treatments

The herbicide treatments used are given in Table 10b. Treatments were applied on 28 November 2008. The stage of growth at the time of treatment for each species is listed in Table 11.

Table 10b. Treatments used in winter container plant nursery experiments

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control	-	-	-
2.	Butisan S	metazachlor (500 g/L) +	2.5 L/ha	LTA*
	+ Skirmish 495SC	isoxaben + terbuthylazine (75 + 420 g/L)	1.0 L/ha	LTA
3.	Chikara	flazasulfuron (25 % w/w)	0.2 kg/ha	Non croped
4.	Sumimax	flumioxazin (300 g/L)	0.1 L/ha	SOLA

*LTA = Long-Term Arrangements for Extension of Use.

Table 11. Crop growth stage at treatment

Species	Growth stage at treatment (28 Nov 08)
Berberis darwinii	In leaf but dormant
Choisya ternata	In leaf but dormant
Escalonia ‘Red Dream’	In leaf but dormant
Hebe ‘Margaret’	In leaf but dormant
Kolkwitzia ‘Pink Cloud’	No leaf, buds tight
Lonicera ‘Lemon Beauty’	In leaf but dormant
Potentilla ‘Red Ace’	Leaf senescing
Santolina chamycyparisus	In leaf but dormant
Sambucus ‘Black Lace’	No leaf, buds tight
Spiraea ‘Firelight’	No leaf, buds slightly swelling
Vinca major ‘Maculata’	In leaf but dormant
Veronica ‘Ulster Dwarf Blue’.	Small rosette of leaves at base

Assessments

No weed control assessments were made because the natural weed infestation in the plots was insignificant and uneven in distribution.

Observations on phytotoxicity symptoms were made on 17 December 2008 and 9 March 2009. Where significant damage was noted the symptoms were assessed on the scale shown in Table 10a

B. **Echinochloa crus-galli (*Cockspur grass) experiment***

Field nursery experiments

For the 2008 field experiment a range of herbicides identified in 2006 and 2007 as giving good control of *E. crus-galli* control were tested for phytotoxicity on a commercial crop of *Prunus* 'Colt' rootstocks. A plot of land was selected on a nursery site in Hampshire (A E Roberts Ltd). Although the nursery had experienced problems with *E. crus-galli* at various sites it was not known if the current site (Sandy Lane, Curdridge) was infested. However the main focus for the 2008 trial was phytotoxicity testing as efficacy of the herbicides had already been established in the 2006 and 2007 experiments. Plots were marked out in early June 2008. The previous crop (2007) on the experimental site was grass pasture. The soil type was fine sandy loam.

Crop during experiment

Rootstocks *Prunus* 'Colt' were planted on 4 June 2008 direct from cold store, all supplied by A E Roberts Ltd. Planted was delayed by wet weather during May. Further wet weather during June enabled the crop to establish well

Site maintenance

The crop was planted into clean cultivated soil. No herbicides were applied after planting and subsequently a few seedling weeds developed. These weeds were sprayed off with a directed application of Harvest (glufosinate ammonium 150 g/L) 5 L/ha, on 21 August 2008.

Experimental design

Experiments were laid out in a randomized plot design with three replicate blocks. Each plot was 1.5m x 3m with a single row of trees planted 0.2m within the row (Appendix 2). A full treatment list is given in Table 12.

Table 12. Herbicides treatments used in *E. crus-galli* field experiments

Treatment	Product	Active ingredient	Product rate	Approval status (Field grown HNS)
1.	Untreated control	-	-	-
2.	Butisan S	metazachlor (500 g/L)	2.5 L/ha	Approved
3.	Springbok	metazachlor + dimethenamid-p (200 : 200 g/L)	2.5 L/ha	LTA*
4.	Crystal	pendimethalin + flufenacet (60 : 300 g/L)	4.0 L/ha	LTA
5.	Dual Gold	s – metolachlor (960 g/L)	1.6 L/ha	Not in the UK
6.	Artist	flufenacet + metribuzin (24 : 17.5 % w/w)	2.5 kg/ha	LTA
7.	Laser + Dual Gold + Nufarm Cropoil	cycloxydim (200 g/L) + s-metolachlor (960 g/L) + adjuvant oil	2.25 L/ha + 1.6 L/ha 0.8%	LTA

*LTA = Long Term Arrangements for Extension of Use

All treatments were applied in 1000 L/ha water using a Cooper-Pegler CP-15 Knapsack Sprayer with a single (green) fan jet spray nozzle. The applications were made on 1 August over the top of the rootstocks in full leaf and active growth.

Assessments

Phytotoxicity to the crop was assessed on 8, 13 and 29 August 2008 by scoring for severity of damage (see Table 10a) with individual symptoms noted and photographed. Crop height was assessed on 13 August 2008 by measuring 6 trees randomly selected within the centre of each plot.

No cockspur grass germinated on this site in 2008 so no weed control assessments were made.

C. Equisetum arvense (Field horsetail) experiment

A range of herbicides and adjuvant combinations were tested on a natural infestation of *E. arvense* in a fallow situation. Two years of experiments on two sites were carried out. The first year's results were reported in the first annual report (2006) and the second year's results were reported in the second annual report (2007). The results on re-growth in 2008 are reported here.

Second year efficacy experiment (2007-08)

For the second year (2007 treated) experiment a plot of land with a uniform natural infestation of *E. arvense* was selected at ADAS Terrington. Plots were marked out and the initial pre-treatment infestation recorded in June 2007. The previous crop (2006) was winter wheat, but the site was fallow during the experiment. Soil type was silty clay loam.

Site maintenance

Prior to the start of the experiment the site was ploughed and cultivated in early spring. Very little annual weed developed so it was not necessary to apply additional contact herbicides.

Experimental design

The experiment was laid out in a randomised complete block design with seven treatments (Table 13) replicated three times. Plot size was 2 m x 5 m with 0.3 m pathways between plots, 1 m pathways between blocks and 2.5 m pathways around the experimental area (Appendix 3).

Table 13. Treatments used in 2007 field horsetail experiment

Treatment	Product	Active ingredient	Product application rate	Approval status (Field grown HNS)	Timing
1.	Untreated control	-	-	-	-
2.	Weedazol-TL+ Headland Fortune	amitrol (225 g/L) + adjuvant	20.0 L/ha + 2.0 L/ha	LTA*	18/06/07
3.	Agroxone + Headland Fortune	MCPA (500 g/L) + adjuvant	6.0 L/ha + 2.0 L/ha	LTA	18/06/07
4.	I.T. Dicamba + Headland Fortune	dicamba (480 g/L) + adjuvant	5.0 L/ha + 2.0 L/ha	LTA	18/06/07
5.	Headland Link + Headland Fortune	dichlorprop-p (600 g/L) + adjuvant	2.4 L/ha + 2.0 L/ha	LTA	18/06/07
6.	Agroxone + I.T. Dicamba + Headland Fortune	MCPA (500 g/L) + dicamba (480 g/L) + adjuvant	6.0 L/h + 5.0 L/ha + 2.0 L/ha	LTA	18/06/07
7.	Agroxone + I.T. Dicamba + Headland Link + Headland Fortune	MCPA (500 g/L) + dicamba (480 g/L) + dichlorprop-p (600 g/L) + adjuvant	6.0 L/ha + 5.0 L/ha + 2.4 L/ha + 2.0 L/ha	LTA	18/06/07

*LTA = Long Term Arrangements for Extension of Use

All treatments were applied in 400 L/ha water at 2 bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 2 m boom and F03-110 spray nozzles.

Assessments

E. arvense frond counts were made using a 0.06 m^2 quadrat, with 5 (12 June assessment) or 10 (all other assessments) quadrats per plot assessed within the central 1 m x 4 m area of the plot. Results were expressed as fronds/m^2.

Assessments were made on 12 June 2007 (pre treatment), 23 July 2007 and 28 August 2007 and reported in the 2007 annual report. A final assessment of re-growth the following season was made on 19 June 2008.

D. Rorippa sylvestris (creeping yellow cress) experiment

A range of herbicides and adjuvant combinations were tested on a natural infestation of creeping yellow cress in a fallow situation. Two years of experiments on two sites were carried out. The first year's results were reported in the first annual report (2006) and the second year's results were reported in the second annual report (2007). The results on re-growth in 2008 are reported here.

Second year efficacy experiment (2007-08)

For the second year experiment on *R. sylvestris* a naturally-infested plot of land was selected on non-cropped land on a fruit farm site in Norfolk. Plots were marked out and the initial pre-treatment infestation recorded 26 May 2006. There was no previous crop. Soil type was a medium sandy loam. Treatments are listed in Table 14.

Table 14. Herbicide treatments used in creeping yellow cress efficacy experiment

Treatment	Product	Active ingredient	Product rate	Approval status (Field grown HNS)	Timing
1.	Untreated control	-	-	-	-
2.	Weedazole	amitrol (225 g/L)	20.0 L/ha	LTA*	2 May
3.	Cleancrop Unival	triclopyr (240 g/L)	6.0 L/ha	LTA	2 May
4.	Herboxone	2,4 D (500 g/L)	3.3 L/ha	LTA	2 May
5.	IT Dicamba	dicamba (480 g/L)	5 L/ha	LTA	2 May
6.	Headland Link	dichlorprop-p (600 g/L)	2.4 L/ha	LTA	2 May
7.	Herboxone + IT Dicamba + Unival	2,4 D (500 g/L) + dicamba (480 g/L) + triclopyr (240 g/L)	3.3 L/ha 5 L/ha 6.0 L/ha	LTA	2 May
8.	Herboxone + I.T.Dicamba Headland Link	2,4 D (500 g/L) + dicamba (480 g/L) + dichlorprop-p (600 g/L)	3.3 L/ha 5 L/ha 2.4 L/ha	LTA	2 May
9.	Cleancrop Unival + I.T.Dicamba + Headland Link	triclopyr (240 g/L) + dicamba (480 g/L) + dichlorprop-p (600 g/L)	6.0 L/ha 5 L/ha 2.4 L/ha	LTA	2 May

*LTA = Long Term Arrangements for Extension of Use

Maintenance

At this site the predominant weed cover was *R. sylvestris* so there was no need to remove other weeds and no herbicides other than the treatments were applied.

Experimental design

The experiment was laid out in a randomized block design with nine treatments (Appendix 4) replicated three times. Plot size was 1.5 m x 2 m. All treatments were applied in 400 L/ha water at 2 bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 1.5 m boom and F03-110 spray nozzles.

Assessments

Percentage ground cover of *R. sylvestris* was assessed, recording only within the central 1 m x 1.5 m of the plot. Assessments were made on 5 June 2007, 3 July 2007 and 30 August 2007 (reported in the 2007 annual report). An assessment of re-growth was made on 2 June 2008.

E. Calistegia sepium (false hedge bindweed) experiment

A range of herbicides at different timing (summer and autumn) were tested on a natural infestation of false hedge bindweed in an abandoned *Malus* stoolbed. Two years of experiments on two sites were carried out. The first year's results were reported in the first annual report (2006) and the second year's results were reported in the second annual report (2007). The results on re-growth in 2008 are reported here.

Second year efficacy experiment (2007-8)

For the second year experiment on *C. sepium* a plot of land with a natural infestation of *C. sepium* was selected at the Frank P Matthews stoolbed site in Worcestershire. Plots with 100% cover were marked out on 6 June 2007. The experimental area was an abandoned *Malus* stoolbed. The soil type was fine sandy clay loam.

Maintenance

Because of the high level of infestation with false hedge bindweed, there was no need to apply pre-treatment herbicides to control annual weeds in 2007.

Experimental design

The experiment was laid out in a randomized block design with 11 treatments (Table 15) replicated three times. Plot size was 1.5 m x 2 m (Appendix 5). All treatments were applied in 400 L/ha water at 2-bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 1.5m boom and F03-110 spray nozzles.

Assessments

Percentage ground cover of *C. sepium* was assessed, recording only within the central 1 m x 1.5 m of the plot. An assessment was made on 21 August 2007 (reported in the 2007 annual report. An assessment of re-growth the following year was made on 23 June 2008.

Table 15. Herbicide treatments used in 2007 false hedge bindweed efficacy experiment

Treatment	Product	Active ingredient	Product rate	Approval status (Field grown HNS)	Timing
1.	Untreated control	-	-	-	-
2.	Centium + Roundup	clomazone (360 g/L)+ glyphosate (360 g/L)	0.33 L/ha 5 L/ha	LTA* Label	19 July
3.	Centium Roundup	clomazone (360 g/L) glyphosate (360 g/L)	0.33 L/ha 5 L/ha	Label LTA	19 July 13 Sept
4.	Herboxone + Roundup	2,4 D amine (500 g/L)+ glyphosate (360 g/L)	3.3 L/ha 5 L/ha	LTA Label	19 July
5.	Herboxone Roundup	2,4 D amine (500 g/L) glyphosate (360 g/L)	3.3 L/ha 5 L/ha	LTA Label	19 July 13 Sept
6.	IT.Dicamba+ Roundup	dicamba (480 g/L) + glyphosate (360 g/L)	5 L/ha 5 L/ha	LTA Label	19 July
7.	IT Dicamba Roundup	dicamba (480 g/L) glyphosate (360 g/L)	5 L/ha 5 L/ha	LTA Label	19 July 13 Sept
8.	Starane 2 + Roundup	fluroxypyr (200 g/L)+ glyphosate (360 g/L)	2 L/ha	LTA Label	19 July
9.	Starane 2 Roundup	fluroxypyr (200 g/L) glyphosate (360 g/L)	2 L/ha 5 L/ha	LTA Label	19 July 13 Sept
10.	Herboxone + IT Dicamba+ Starane 2 +Roundup	2,4 D amine (500 g/L) + dicamba (480 g/L)+ fluroxypyr (200 g/L)+ glyphosate (360 g/L)	6 L/ha + 5 L/ha + 2 L/ha + 5 L/ha	LTA LTA LTA Label	19 July
11.	Herboxone + IT Dicamba+ Starane 2 Roundup	2,4 D amine (500 g/L) + dicamba (480 g/L)+ fluroxypyr (200 g/L) glyphosate (360 g/L)	6 L/ha + 5 L/ha + 2 L/ha 5 L/ha	LTA LTA LTA Label	19 July 13 Sept

*LTA = Long term arrangement for the extension of use

Phytotoxicity studies

Two years of experiments were done to assess phytotoxicity to field grown rootstocks. The first experiment was done in 2007 on newly planted rootstock with treatments applied as directed sprays to the soil adjacent to the stocks. Details are given in the 2007 annual report. The second experiment was carried out in 2008 to assess the phytotoxicity of treatments when used as a directed summer treatment alongside a vigorous *Malus* stoolbed and is described below.

Third year phytotoxicity and efficacy experiment (2008)

In order to test for possible phytotoxicity resulting from the herbicides tested for control of *E. arvense, Rorrippa sylvestris* or *Calystegia sepia,* a further experiment was done using the same site (Frank P Matthews Ltd, Tenbury Wells, Worcs.) as the 2007 efficacy experiment although a different field on the same farm was used. The soil type was fine sandy clay loam. A range of nine herbicide or herbicide combinations (Table 16) was applied as a directed spray alongside rows of *Malus* rootstock stoolbeds. The site was marked out on 23 June 2008. At the time of spraying there was 20-25 cm of soft growth on the stoolbed and 80% cover of false hedge bindweed in the adjacent alleys.

Maintenance

Prior to the start of the experiment, in early Spring 2008, a routine application of Flexidor 125 2 L/ha + Butisan S 2.5 L/ha was made to the entire site. This was effective in controlling annual weeds, allowing the false hedge bindweed to grow without competition.

Experimental design

The experiment was laid out in a randomized block design with 9 treatments (Appendix 5) replicated three times. Plot size was 3.0 m x 2 m. All treatments were applied in 400 L/ha water at 2-bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 1.5 m boom and F03-110 spray nozzles. Two 1.5m strips were applied for each plot with the edge of the spray swath at the edge of the stoolbed growth.

Table 16. Herbicide treatments used in 2008 stoolbed phytotoxicity and efficacy experiment

Treatment	Product	Active ingredient	Product rate	Approval status (Field grown HNS)
1.	Untreated control	-	-	-
2.	IT Dicamba	dicamba (480 g/L)	5 L/ha	LTA*
3.	Cleancrop Unival	triclopyr (240 g/L)	6.0 L/ha	LTA
4.	Sumimax	flumioxazin (300 g/L)	0.1 L/ha	SOLA
5.	Flazasulfuron	flazasulfuron (25 % w/w)	0.2 kg/ha	Not yet available

*LTA = Long Term Arrangements for Extension of Use

Treatments were applied 23-27 June 2008

Assessments

Phytotoxicity to the crop was assessed on 10 July, 27 August and 26 September 2008 by scoring for severity of damage (see Table 10a) with individual symptoms noted. Crop height was assessed on 26 September 2008 by measuring 10 shoots randomly selected within the centre of each plot.

Percentage ground cover of *C. sepium* was assessed, recording only within the central 1 m x 1.5 m of each plot half. Assessments were made on 10 July, 27 August and 26 September 2008.

Results and Discussion

A. Weed seedling container experiments

Container plant nursery experiments – weed seeding

Epilobium ciliatum (American willowherb)

An average of 28 seedlings per control pot germinated from the first sowing, 55 from the second sowing and 17 from the third. The best control was achieved by Butisan S, Springbok and Dual Gold with close to 100% control (Table 17). Although Dual Gold performed less well at the second sowing there was still sufficient persistence to give 90% control at the third sowing, 58 days after treatment. Terano and Teridox gave partial control and Flexidor 125 and New Code A inconsistent control.

Table 17. Percentage control of willowherb sowings made 2, 34 and 58 days after treatment (DAT)

	Sowing 1: 23 May (2 DAT)			**Sowing 2: 24 June (34 DAT)**			**Sowing 3: 18 July (58 DAT)**	
Treatment	**9 Jun**	**20Jun**	**2 Jul**	**16 Jul**	**30 Jul**	**13Aug**	**30 Jul**	**13 Aug**
1. Untreated control	0	0	0	0	0	0	0	0
2. Teridox 3.0 L/ha	66.8	69.8	66.7	18.6	53.3	53.3	48.3	31.1
3.Flexidor 125 1.0 /ha	35.7	36.4	30.0	35.7	0	0	9.4	0
4. Butisan S 2.5 L/ha	68.9	98.4	93.3	100	100	96.7	100.0	100.0
5. Springbok 2.5 L/ha	82.1	97.7	96.7	83.7	73.3	66.7	100.0	100.0
6. Dual Gold 1.6 L/ha	90.4	97.7	93.3	44.9	30.0	6.7	90.6	68.7
7. Terano 0.75 kg/ha	64.3	65.2	66.7	42.9	66.7	66.7	62.8	49.9
8. New Code A	38.2	44.8	10.0	0	0	3.3	55.6	25.0
P (ANOVA)	0.06	ns	0.00	0.01	0.02	0.01	ns	ns
df	14	14	14	14	14	14	14	14
S.E.D	25.89	32.32	23.93	36.80	33.16	27.31	62.11	41.76
L.S.D.	55.57	ns	51.32	99.74	71.12	58.58	ns	ns

ns = not significant

These results confirm the results from pot seeded trials in 2006 where Butisan S and Dual Gold gave good control of willowherb. Terano performed better in the 2006 trials than in

2008. Flexidor 125 gave poor control of willowherb also in 2006. Teridox, Springbok and New Code A were not tested in 2006.

Sagina subulata (pearlwort)

An average of 34 seedlings per control pot germinated from the first sowing and 9 from the second sowing. The best control was achieved with Flexidor 125 with 100% control at the first assessment for both sowing dates (Table 18). Butisan S, Springbok, Terano and New Code A also had good activity although results from Terano and New Code A were more variable. With Terano and New Code A there was some recovery of the weed after a month particularly from the first sowing. Dual Gold gave partial (42.9 – 96.2%) control but Teridox was less effective (21.3 – 76.9% control).

Table 18. Percentage control of pearlwort sowings made 2 and 34 days after treatment (DAT)

	Sowing 1:23 May (2 DAT)			**Sowing 2:24 June (34 DAT)**		
Treatment	**9 Jun**	**20 Jun**	**2 Jul**	**16 Jul**	**30 Jul**	**13 Aug**
1. Untreated control	0	0	0	0	0	0
2. Teridox 3.0 L/ha	21.3	50.7	42.9	76.9	63.0	46.7
3. Flexidor 125 1.0 L/ha	100.0	100.0	100.0	100.0	85.2	90.0
4. Butisan S 2.5 L/ha	93.3	100.0	95.3	100.0	100.0	100.0
5. Springbok 2.5 L/ha	94.2	96.1	85.7	100.0	100.0	100.0
6. Dual Gold 1.6 L/ha	58.3	55.2	42.9	96.2	63.0	73.3
7. Terano 0.75 kg/ha	80.5	69.4	57.1	100.0	92.6	96.7
8. New Code A	87.5	78.0	66.7	100.0	100.0	100
P (ANOVA)	0.037	ns	ns	0.002	<0.001	<0.001
df	14	14	14	14	14	14
S.E.D	30.41	40.14	42.26	19.55	13.84	9.98
L.S.D.	65.19	ns	ns	41.9	29.69	21.41

ns = not significant

Only two sowings were successful; a sowing of field collected *Sagina procumbens* on 18 July failed to germinate. These results generally confirm the pot seeding work carried out on *Sagina procumbens* in 2006 reported in the 2006 and 2007 annual reports where Flexidor 125, Butisan S and Terano all gave good control. Dual Gold performed better in the 2006 study than in the 2008 nursery trial. Teridox, Springbok and New Code A were not available for testing at the time.

Senecio vulgaris (groundsel)

An average of 53 seedlings per control pot germinated from the first sowing, 30 from the second sowing and 7 from the third. Conditions were drier at the second and third sowing date. None of the treatments gave complete control of groundsel. The most effective treatment was Teridox which gave 78% control at the first assessment, 17 days after seeding (Table 19). Partial (43%) control was achieved initially with Butisan S, Springbok and Terano (Table 19) although the latter results were not statistically significant. Two further sowings were made 34 and 58 days after spraying to assess the persistence of control. The results (Table 19) indicated that Teridox gave control of a sowing at 34 days but not 58 days. Butisan S and Springbok performed better at the later sowings indicating persistence of at least 58 days where 91% control was achieved from Butisan S and 41% control from Springbok (Table 19) although these differences were not statistically significant. Terano also showed some persistence with 77% control of a sowing made 58 days after spraying. Flexidor 125, Dual Gold and New Code A were all less effective for groundsel control.

Table 19. Percentage control of groundsel sowings made 2, 34 and 58 days after treatment (DAT)

	Sowing 1:23 May (2 DAT)			**Sowing 2:24 June (34 DAT)**		**Sowing 3:18 July (58 DAT)**	
Treatment	**9 Jun**	**20 Jun**	**2 Jul**	**16 Jul**	**30 Jul**	**30 Jul**	**13 Aug**
1. Untreated control	0	0	0	0	0	0	0
2. Teridox 3.0 L/ha	78.2	62.0	50.0	48.5	33.5	0	23.6
3.Flexidor 125 1.0 /ha	4.4	0	0	32.7	6.7	0	0
4. Butisan S 2.5 L/ha	43.5	13.9	0	12.5	23.3	90.9	70.5
5. Springbok 2.5 L/ha	43.5	13.9	0	68.7	26.7	40.9	41.3
6. Dual Gold 1.6 L/ha	13.0	0	0	29.3	0	0	0
7. Terano 0.75 kg/ha	43.5	34.5	6.7	62.0	40.0	77.2	64.7
8. New Code A	30.5	24.2	16.7	30.3	0	0	17.6
P (ANOVA)	ns	ns	0.049	ns	ns	0.045	0.031
df	14	14	14	14	14	14	14
S.E.D	36.77	26.71	14.84	20.88	18.12	46.85	33.03
L.S.D.	ns	ns	31.8	ns	ns	99.9	70.85

ns = not significant

These results generally confirm the pot seeding work carried out in 2006 reported in the 2006 and 2007 annual reports, although better control was achieved in those tests. Butisan S and Terano gave complete control, Dual Gold was partially effective and Flexidor was ineffective. Teridox, Springbok and New Code A were not available for testing at the time.

		
Figure 2. Untreated groundsel	*Figure 3.* Teridox treated	*Figure 4.* Butisan treated
		
Figure 5. Flexidor 125	*Figure 6.* Terano treated	*Figure 7.* Springbok treated

Cardamine hisuta and C. flexuosa (hairy bittercress and flexuous bittercress)

Three sowings were made using different batches of *Cardamine flexuosa* seed but none of the seed germinated. However, a mixed population of *Cardamine flexuosa* and *Cardamine hirsuta* germinated in the pots of the plant species phytotoxicity screening section of the trial enabling some observations to be made. Because of the variability of the distribution it was not possible to identify any statistically significant effects but there were indications of good control from Flexidor 125, Dual Gold and Terano. Dual Gold had not performed well in the 2006 pot seeded trial so the results for this herbicide should be treated with caution. The indications are that Teridox and New Code A are not particularly effective for control of either species of bittercress.

Moss and liverwort

All treatments except Flexidor 125 gave good control of a natural infestation of moss and liverwort that developed on the pots of the plant species phytotoxicity screening section of the trial (Table 20). By the time of the assessment two treatments had been applied 21 May 2008 and 29 August 2008.

Table 20. Percentage control of moss and liverwort assessed 2 October 2008

Treatment	Moss	Liverwort	Combined
1. Untreated control	0	0	0
2. Teridox 3.0 L/ha	98.4	100	99.7
3.Flexidor 125 1.0 /ha	0	0	0
4. Butisan S 2.5 L/ha	100	100	100
5. Springbok 2.5 L/ha	100	100	100
6. Dual Gold 1.6 L/ha	100	100	100
7. Terano 0.75 kg/ha	100	100	100
8. New Code A	100	93.0	94.0
P (ANOVA)	<0.001	<0.001	<0.001
df	14	14	14
S.E.D	19.1	6.4	4.0
L.S.D.	40.9	13.8	8.7

Container plant nursery experiments – phytotoxicity screening

In the summer experiment herbicide applications were made to subjects immediately after potting on 21 May 2008 and again in full leaf on 29 August. The most significant effects were noted on and *Hebe* 'Margaret', where several treatments caused stunting and or foliage yellowing.

Table 21. Plant quality score – percentage phytotoxicity

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 a significant reduction in quality at marketing)
8	10 – 20% damage
9	5 – 10% damage
10	No damage (as untreated controls)

Veronica 'Ulster Dwarf Blue'

When examined 19 days after treatment (9 June 2008) plants were just establishing and were fairly variable. At this stage Flexidor 125 was the only treatment to have caused stunting and reddening of the foliage. However, by 37 days after treatment (20 June 2008), all of the treatments had caused stunting, the most severe effects being caused by Terano. Recovery took place so that by August, prior to the second application, all of the treatments were potentially marketable. The second application of Flexidor 125 caused more damage but plants were considered marketable by the 2 October 2008 assessment although of a lower quality score than other treatment. By 9 March 2009 (data not shown) earlier treatment effects appeared to have worn off and all plants appeared to be starting into growth normally, including those treated with winter herbicides, there was insufficient new growth to score at this assessment date.

Table 22. Plant quality scores (0-10 scale) for *Veronica* Ulster Blue Dwarf after summer treatment. (0-10, 0 = dead, 10 = good).

	Assessment date					
Treatment	**9/6/08**	**20/6/08**	**2/7/08**	**13/8/08**	**11/9/08**	**2/10/08**
1. Untreated control	8.0	9.0	9.7	10.0	9.7	8.0
2. Teridox 3.0 L/ha	8.7	4.7	7.7	8.2	9.7	8.7
3.Flexidor 125 1.0 /ha	7.0	5.7	8.7	7.8	8.0	7.0
4. Butisan S 2.5 L/ha	9.0	4.0	6.0	9.1	8.7	9.0
5. Springbok 2.5 L/ha	9.3	3.7	6.0	9.3	9.7	9.3
6. Dual Gold 1.6 L/ha	8.0	6.3	9.3	8.9	7.7	8.0
7. Terano 0.75 kg/ha	8.3	2.7	5.3	9.1	8.0	8.3
8. New Code A	8.3	4.0	6.3	7.3	8.0	8.3
P (ANOVA)	ns	0.002	0.005	0.029	ns	ns
df	14	14	14	14	14	14
S.E.D	1.048	1.242	1.063	0.692	0.906	1.048
L.S.D.	ns	2.665	2.281	1.483	ns	ns

ns = not significant

		
Figure 8. Veronica untreated	*Figure 9.* Dual Gold treated	*Figure 10.* Terano treated
		
Figure 11. Flexidor 125 treated	*Figure 12.* Butisan S treated	*Figure 13.* Springbok treated

Hebe ‘Margaret’

Terano consistently caused damage to *Hebe* Margaret (Table 23). As in 2007 the treatment caused brown spotting to the leaves below the shoot tips. The severity was slightly worse than in 2007 and would have caused the plants to have reduced marketability. Dual Gold and New Code A also caused shoot tip yellowing. A similar bleaching effect being noted from Dual Gold in 2007, however the yellowing caused by New Code A was more severe.

Table 23. Plant quality scores (0-10 scale) for *Hebe* 'Margaret' after summer treatment. (0-10, 0 = dead, 10 = good).

	Assessment date		
Treatment	**9/6/08**	**11/9/08**	**2/10/08**
1. Untreated control	10.0	10.0	10.0
2. Teridox 3.0 L/ha	10.0	10.0	10.0
3.Flexidor 125 1.0 /ha	10.0	10.0	10.0
4. Butisan S 2.5 L/ha	10.0	10.0	10.0
5. Springbok 2.5 L/ha	10.0	10.0	10.0
6. Dual Gold 1.6 L/ha	8.3	10.0	8.3
7. Terano 0.75 kg/ha	6.7	7.7	6.7
8. New Code A	7.3	10.0	7.3
P (ANOVA)	ns	0.017	ns
df	14	14	14
S.E.D	1.43	0.60	1.43
L.S.D.	ns	1.29	ns

ns = not significant

Following winter treatment Hebe 'Margaret' was damaged by the treatment Skirmish 495SC + Butisan S causing scorch to the upper leaves in 2008. This treatment had not caused damage in 2007. As many Hebes are treated with Butisan S routinely in the winter without damage it may be assumed that the Skirmish 495SC component was responsible for the damage. Sumimax caused scorching of the upper leaves in 2007 but not in 2008. Chikara appeared safe in both years. In 2007 Hebe 'Margaret' had shoot tip bleaching following Dual Gold treatment.

Figure 14. Hebe untreated

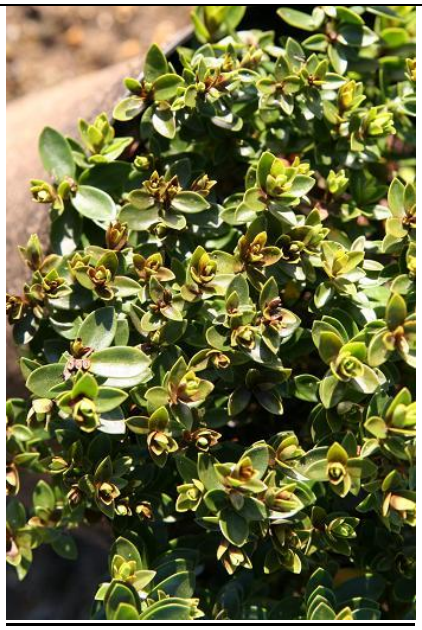


Figure 15. Sumimax treated

Figure 16. Dual Gold treated

Figure 17. Terano treated

Escallonia ‘Red Dream’

The only summer treatment to cause damage to *Escallonia* was Terano which caused a severe tip scorch. Plants were rendered unmarketable with an average quality score of 4. Skirmish 495SC + Butisan S and Sumimax caused some upper foliage bronzing when applied as a winter treatment, but the damage was compounded by winter cold damage. No other summer or winter treatments caused damage.

Figure 18. Escallonia Terano treated

Vinca major ‘Maculata’

No summer treatments caused damage but Sumimax applied as a winter treatment caused small black leaf spotting on the uppermost leaves.

Figure 19. untreated

Figure 20. Vinca treated with Sumimax

Potentilla ‘Red Ace’

No treatment effects were noted in 2008, but in 2007 *Potentilla* ‘Summer Sorbet’ treated with Butisan S was slightly reduced in growth compared with the control. Where two applications had been applied in a programme the effect was more marked than where Butisan S was applied as a winter treatment to dormant plants.

Other species

Kolkwitzia, Sambucus, Berberis, Choisya, Lonicera, Santolina and *Spiraea* were not affected by any of the summer or winter treatments. In 2007 *Buddleia* was damaged by Flexidor 125, Skirmish and Chikara.

B:* Echinochloa crus-galli (*Cockspur grass) experiment

Field nursery experiments

The herbicide treatments were applied on 1 August 2008 when the rootstocks were in active growth. An assessment of plant quality and phytotoxicity was made on 8 August, 13 August and 29 August 2008.

Table 24. Effect of treatment on *Prunus* ‘Colt’plant quality score, 8 August 2008 (0-10, 0 = dead, 10 = good)

Treatment	Product / Rate	Score
1.	Untreated control	10
2.	Butisan S 2.5 L/ha	9
3.	Springbok 2.5 L/ha	8
4.	Crystal 4.0 L/ha	8
5.	Dual Gold1.6 L/ha	9
6.	Artist 2.5 kg/ha	5
7.	Laser 2.25 L/ha + Dual Gold 1.6 L/ha + Nufarm Cropoil 0.8%	9

Assessment scores were consistent across all replications so there was no variability to assess by ANOVA.

Artist caused a severe scorch to the terminal growth and general growth stunting (Fig 22). Leaves below the terminal shoot were relatively unaffected.

Figure 21. *Prunus* 'Colt' prior to spraying

Figure 22. *Prunus* 'Colt' tips damaged by Artist

All other treatments caused very minor distortion/hardening to the terminal growth. The effect was initially more marked from Springbok and Crystal compared with Butisan S, Dual Gold or the Laser + Dual Gold + Newfarm Oil combination. However these differences were rapidly outgrown and by the final assessment on 29 August 2008 only the trees treated with Artist were still showing obvious symptoms.

Artist, Crystal and the Laser + Dual Gold combination were the only treatments to cause a significant reduction in crop height. Artist was the only treatment to cause unacceptable damage to the crop.

No cockspur grass germinated in 2008 on this site so no weed assessments were made. Results from 2006 and 2007 indicated that Artist, Butisan S, and Dual Gold had the best residual activity for cockspur grass control and Laser + Newfarm Oil was effective as a post emergence treatment.

Table 25. Effect of treatment on Prunus 'Colt', crop height (cm) 13 August 2008

Treatment	Product / Rate	Height
1.	Untreated control	93.2
2.	Butisan S 2.5 L/ha	91.5
3.	Springbok 2.5 L/ha	88.1
4.	Crystal 4.0 L/ha	84.6
5.	Dual Gold1.6 L/ha	91.5
6.	Artist 2.5 kg/ha	84.2
7.	Laser 2.25 L/ha + Dual Gold 1.6 L/ha + Nufarm Cropoil 0.8%	85.7
	P (ANOVA)	0.015
	df	12
	SED	2.534
	LSD	5.521

C. Equisetum arvense *(field horsetail) experiment*

Results from 2006-7 indicated that Headland Fortune was the most effective of the adjuvants tested. A range of hormone herbicides was tested in 2007, all with Headland Fortune adjuvant. The infestation on the 2007 plots was lower and more variable than in 2006. Probably as a result of the wetter summer, the amount of re-growth from the treatments was greater than in 2006. I.T. Dicamba and Headland Link (dichlorprop-p) had no significant effect when applied with Headland Fortune, but the combination of one or both products with Agroxone significantly reduced the re-growth by 28 August 2007.

Following treatment in 2007, records were taken of the frond re-growth in 2008. All treatments except I.T. Dicamba significantly reduced the re-growth. The most effective treatments were those including Agroxone, with the Agroxone + I.T. Dicamba treatment giving the most reduction (around 20% of the control). Weedazol-TL was not as effective in this experiment as in 2006-7.

Table 26. Effect on herbicides on field horsetail (fronds/m^2) in 2008 following June 2007 treatment

No.	Product	Active ingredient	Product rate	Fronds / m^2
1.	Untreated control			254
2.	Weedazol-TL + Headland Fortune	amitrol (225 g/L) + adjuvant	20.0 L/ha + 2.0 L/ha	163
3.	Agroxone + Headland Fortune	MCPA (500 g/L)+ Adjuvant	6.0 L/ha + 2.0 L/ha	130
4.	I.T. Dicamba + Headland Fortune	dicamba (480 g/L) + adjuvant	5.0 L/ha + 2.0 L/ha	282
5.	Headland Link + Headland Fortune	dichlorprop-p (600 g/L) + adjuvant	2.4 L/ha + 2.0 L/ha	179
6	Agroxone + I.T. Dicamba + Headland Fortune	MCPA (500 g/L) + dicamba (480 g/L) + + adjuvant	6.0 L/ha + 5.0 L/ha + 2.0 L/ha	55
6.	Agroxone + I.T. Dicamba + Headland Link + Headland Fortune	MCPA (500 g/L) + dicamba (480 g/L) + dichlorprop-p (600 g/L) + adjuvant	6.0 L/ha + 5.0 L/ha + 2.4 L/ha + 2.0 L/ha	69
			P (ANOVA)	<0.001
			df	12
			S.E.D	34.5
			L.S.D	75.2

D. Rorrippa sylvestris *(creeping yellow cress) experiment*

In 2006 the Weedazol-TL, Glyfos and Cleancrop Unival treatments both gave the most immediate control of creeping yellow cress. By 2007 however only the Cleancrop Unival treatment was giving virtually full control although Weedazol-TL was the next best treatment. The Weedazol-TL treatment was less effective when used in 2007 than in 2006 with re-growth occurring by the end of August and in the following year (Table 27). Cleancrop Unival and I.T. Dicamba were again the most effective treatments, with a rapid knockdown and no re-growth the following year. There was no advantage in mixing other herbicides with Cleancrop Unival or I.T. Dicamba.

Table 27. Percentage cover of *R. sylvestris* in 2008 following May 2007 treatment

Treatment	Product	Active ingredient	Product rate	% cover
1.	Untreated control			81.7
2.	Weedazol-TL	amitrole (225 g/L)	20.0 L/ha	56.7
3.	Cleancrop Unival	triclopyr (240 g/L)	6.0 L/ha	0
4.	Herboxone	2,4 D (500 g/L)	3.3 L/ha	31.7
5.	IT Dicamba	dicamba (480 g/L)	5 L/ha	0
6.	Headland Link	dichlorprop-p (600 g/L)	2.4 L/ha	70.0
7.	Herboxone +	2,4 D (500 g/L) +	3.3 L/ha	0
	IT Dicamba +	dicamba (480 g/L) +	5 L/ha	
	Unival	triclopyr (240 g/L)	6.0 L/ha	
8.	Herboxone +	2,4 D (500 g/L) +	3.3 L/ha	0
	I.T.Dicamba +	dicamba (480 g/L) +	5 L/ha	
	Headland Link	dichlorprop-p (600 g/L)	2.4 L/ha	
9.	Cleancrop Unival +	triclopyr (240 g/L) +	6.0 L/ha	0
	I.T.Dicamba +	dicamba (480 g/L) +	5 L/ha	
	Headland Link	dichlorprop-p (600 g/L)	2.4 L/ha	
			P (ANOVA)	<0.001
			df	16
			S.E.D	12.72
			L.S.D	26.97

Figure 23. Cress untreated

Figure 24. Cress treated with Weedazol-TL

Figure 25. Cress treated with Cleancrop Unival (cress eradicated leaving grasses only)

E. Calistegia sepium *(false hedge bindweed) experiment*

Efficacy assessments

In 2006 the most effective treatments for initial control were the hormone containing products Herboxone (2,4-D) and I.T. Dicamba. I.T. Dicamba either alone or with Roundup was the most effective treatment for longer-term persistence, having less re-growth than other treatments. None of the treatments completely prevented re-growth in 2007. The most effective treatment was the combination of I.T. Dicamba with Roundup applied in June 2006. In 2007 a later (July) application was tried. The bindweed had developed fully by this stage Again the most effective treatments for immediate knockdown were those including I.T. Dicamba . Whilst the Herboxone treatment had controlled all existing bindweed foliage there were signs of re-growth at the time of recording. Re-growth in the plots was very variable in 2008 (Table 28). There were no statistically significant differences but there was an indication confirming the earlier results that combinations of I.T. Dicamba or Herboxone with Roundup tended to give the best control although none of the treatments had eradicated the bindweed. Because I.T Dicamba causes a good knockdown in the first season it is probably better to apply the Roundup as a tank mix in July rather than in September as a separate spray.

Table 28. Percentage cover of *C. sepium* in 2008 following 2007 treatment

No.	Product / Rate	Timing	% Cover
1.	Untreated control		66.3
2.	Centium 0.33 L/ha + Roundup 5 L/ha	19 July	41.7
3.	Centium 0.33 L/ha	19 July	18.3
	Roundup 5 L/ha	13 Sept	
4.	Herboxone 3.3 L/ha + Roundup 5 L/ha	19 July	24.1
5.	Herboxone 3.3 L/ha	19 July	9.4
	Roundup 5 L/ha	13 Sept	
6.	IT.Dicamba 5 L/ha + Roundup 5 L/ha	19 July	8.3
7.	IT Dicamba 5 L/ha	19 July	38.3
	Roundup 5 L/ha	13 Sept	
8.	Starane 2 2 L/ha + Roundup 5 L/ha	19 July	45.0
9.	Starane 2 2 L/ha	19 July	30.0
	Roundup 5 L/ha	13 Sept	
10.	Herboxone 6 L/ha + IT Dicamba 5 L/ha + Starane 2 2 L/ha + Roundup 5 /ha	19 July	31.7
11.	Herboxone 6 L/ha + IT Dicamba 5 L/ha + Starane 2 2 L/ha	19 July	41.9
	Roundup 5 L/ha	13 Sept	
		P (ANOVA)	ns
		df	16
		S.E.D	29.77
		L.S.D	ns

ns = not significant

Results from the 2008 sprayed trial confirm the good knockdown achieved with I.T. Dicamba (Table 29). Good results were also achieved with Cleancrop Unival. Sumimax and Flazasulfuron did give some control but less than the two hormone treatments. These two herbicides are likely to be used for residual annual weed control and were included in the experiment to test for phytotoxicity arising from directed treatment.

Table 29. Percentage cover of *C. sepium* in 2008 following June 2008 treatment

Treatment		Assessment date		
		10\07\08	**27\08\08**	**26\09\08**
1. Untreated control		62.5	62.5	51.2
2. IT Dicamba (dicamba 480 g/L),	5.0 L/ha	3.8	0	0.5
3. Cleancrop Unival (triclopyr 240 g/L)	6.0 L/ha	2.5	0	0.8
4. Sumimax (flumioxazin 300 g/L)	0.1 L/ha	40.0	40	28.8
5. Chikara (flazasulfuron 25 % w/w)	0.2 kg/ha	37.5	42.5	30.0
	P (ANOVA)	<0.001	<0.001	0.015
	df	12	12	12
	S.E.D	8.14	7.66	13.95
	L.S.D	17.73	16.7	30.38

Phytotoxicity assessments

Both I.T. Dicamba and Cleancrop Unival caused some foliage browning and stunting to the *Malus* shoots adjacent to the sprayed swath (Figs 30 & 31). The damage caused by Cleancrop Unival was more severe and long lasting (Fig. 30). It also resulted in a substantial reduction in shoot growth by the send of the season (Table 31). Although I.T. Dicamba and Sumimax appeared to slightly reduce the overall quality score, the differences were not significant (Table 30). Scores of more than 7 could be regarded as commercially acceptable.

Table 30. Mean plant quality score (0-10) for *Malus* following June 2008 treatment directed alongside stoolbed row (0-10, 0 = dead, 10 = good)

Treatment		Assessment date		
		10\07\08	**27\08\08**	**26\09\08**
1. Untreated control		10.0	9.5	10.0
2. IT Dicamba (dicamba 480 g/L),	5.0 L/ha	9.0	7.5	8.0
3. Cleancrop Unival (triclopyr 240 g/L)	6.0 L/ha	7.0	4.8	6.5
4. Sumimax (flumioxazin 300 g/L)	0.1 L/ha	9.5	9.5	8.5
5. Chikara (flazasulfuron 25 % w/w)	0.2 kg/ha	9.0	9.5	10.0
	P (ANOVA)	ns	0.001	0.013
	df	12	11	12
	S.E.D	1.032	0.920	0.958
	L.S.D	ns	2.024	2.086

ns = not significant

Table 31. Effect of herbicide treatment on *Malus* stoolbed shoot height (cm) recorded 26 September 2008

Treatment		**Height (cm)**
1. Untreated control		62.2
2. IT Dicamba (dicamba 480 g/L),	5.0 L/ha	62.1
3. Cleancrop Unival (triclopyr 240 g/L)	6.0 L/ha	48.4
4. Sumimax (flumioxazin 300 g/L)	0.1 L/ha	61.5
5. Chikara (flazasulfuron 25 % w/w)	0.2 kg/ha	72.2
	P (ANOVA)	ns
	df	8
	SED	8.9
	LSD	ns

ns = not significant

Figure 26. Bindweed IT Dicamba + Roundup

Figure 27. Bindweed untreated

Figure 28. *Malus* stoolbed untreated

Figure 29. Dicamba

Figure 30. Cleancrop Unival

Conclusions

A. Weed seedling container experiments

Bittercress

For growing season treatments the industry standards Ronstar 2G and Flexidor 125 had good pre-emergence activity against New Zealand, flexuous and hairy bittercress. Of the new herbicides tested for growing season use, only Terano had good activity in all experiments. The 2006 pot seeded experiments showed that Terano would also control all three bittercress species at 3-4 leaf stage, whereas the other treatments such as Flexidor 125 only gave post emergence control of hairy bittercress, the New Zealand and flexuous being more resistant.

For winter treatments, in addition to the above, Venzar Flowable, Skirmish, Chikara, Sumimax 50WP and New Code B were effective in the 2006 pot seeded experiments for pre-emergence control of all three bittercress species. Skirmish, Terano, Sumimax and Chikara also providing control up to 3-4 true leaves of all three species. Hairy bitter cress was the only bittercress species to be controlled post-emergence by Flexidor 125, Ronstar 2G and Venzar Flowable, the other two species were resistant once germinated. This difference explains why New Zealand and flexuous bittercress have become the predominant species on nurseries.

Butisan S did not give complete control of hairy bittercress in either the 2006 pot seeded experiment or the 2008 summer trial, but gave better control of New Zealand and flexuous bittercress in the 2006 trials. Springbok appeared similar in performance to Butisan S for bittercress control. Stomp 400SC, Dual Gold, Goltix WG, Teridox and New code A all gave incomplete, inconsistent or only short term control of the three bittercress species.

Common Mouse-ear

All results on common mouse ear are from the pot seeded experiments in 2006 as this species was not included in the 2007-8 nursery experiments. All pre-emergence treatments except Ronstar 2G and Goltix WG controlled common mouse-ear but Stomp 400SC, New Code B and Dual Gold gave only partial control. Venzar Flowable, Skirmish, Terano, Chikara and Sumimax also gave good control at all stages up to 3-4 true leaves and Flexidor 125 up to 1-2 true leaves. The other herbicides were relatively ineffective for post emergence control.

For post emergence control only Flexidor 125 and Terano would be suitable for summer use but Venzar Flowable, Skirmish, Terano, Chikara and Sumimax are all possible winter treatments. New Coded A, Teridox and Springbok were not tested against common mouse ear, but American data suggests New Code A would be active.

Willowherb

Willowherb was well controlled pre-emergence by all herbicides except Flexidor 125, Goltix WG and Stomp 400 SC in pot seeded experiments. Venzar Flowable, Skirmish, and Sumimax also gave control up to 3-4 true leaves. Interestingly, Chikara gave excellent post-emergence control slightly better than the pre-emergence control and similarly Stomp 400 SC, Flexidor 125 and Goltix WG also had some early post-emergence activity in spite of poor pre-emergence control in the 2006 pot seeded experiments. The 2008 nursery experiments also confirmed good control from Butisan S, Springbok and Dual Gold. Terano and Teridox gave partial control and Flexidor 125 and New Code A inconsistent control. Of the new treatments suitable for growing season use, Dual Gold appears to have the most potential for willowherb control. For winter use, the newer treatments, Skirmish, Sumimax and Chikara all have good potential, including post emergence control.

Pearlwort

In the pot seeded experiments all pre-emergence treatments except Ronstar 2G and Goltix WG controlled pearlwort completely. At the 1-2 true leaf stage, pearlwort was much more difficult to control with only Skirmish, Terano, Chikara and Sumimax giving full control. Of these, only Skirmish and Sumimax worked quickly. Only Skirmish controlled the 3-4 true leaf seedlings and control was slow, taking more than 21 days. In the 2008 nursery experiment Flexidor 125, Butisan S and Terano all gave good control. Dual Gold performed better in the 2006 study than in the 2008 nursery trial. For growing season treatment Flexidor 125 is still one of the best treatments, however newer treatments, Terano and Dual Gold have potential. and Terano could take out 1-2 leaf seedling. For winter use, newer treatments Skirmish Terano Chikara and Sumimax all have potential with Skirmish having the best post emergence activity.

Groundsel

For groundsel, the most effective pre-emergence treatments in pot seeded experiments were Butisan S, Venzar Flowable, Ronstar 2G, Terano, Goltix WG, Chikara and Sumimax all giving complete control. Dual Gold gave partial control. Stomp 400 SC, Flexidor 125, Skirmish and New Code B granules were ineffective. The 2008 nursery experiment broadly confirmed these results for the herbicides tested, although the performance of Terano, Butisan S and Dual Gold was less consistent than the results achieved earlier.

Teridox, a newer treatment not previously tested, preformed relatively well and has potential as a growing season control for groundsel although persistence may not be sufficient. The metazachlor co-formulation with dimethenamid-p in Springbok appeared no better than the straight metazachlor product Butisan S and New Code A gave minimal control. Of the newer treatments for winter use, Chikara and Sumimax appear to have the best potential including early post emergence 1-2 true leaf control. At the 3-4 true leaf stage only Chikara gave rapid kill. Venzar Flowable was effective but slower acting

Willows

All results on willow are from the pot seeded experiments in 2006 as this species was not included in the 2007-8 nursery experiments. Both willow species *Salix caprea* and *Salix cinerea* responded similarly to treatments. All treatments except Stomp 400 SC gave good pre-emergence control but only Venzar Flowable, Skirmish, Chikara, Sumimax and New Code B granules gave control at stages up to 3-4 leaf. As the commonly used herbicides Ronstar 2G and Flexidor 125 gave good pre-emergence control when used just prior to sowing it must be assumed that reported difficulty in control of these species is due to a lack of sufficient persistence of the herbicides. It is therefore recommended that herbicides should be freshly applied as soon as the seed is seen on the wind. There is little scope for post emergence control as the herbicides with post emergence activity are too damaging to be applied during the growing season.

Container herbicides general

Of the newer treatments Terano, Skirmish, Chikara and Sumimax were all effective on most of the target weeds tested. However Skirmish, Chikara, and Sumimax are known to have a strong contact action so will only have potential for use during the dormant season on nursery stock.

Dual Gold has potential for use as a summer spray treatment, as a supplement to Flexidor 125. Compared with Flexidor 125 the control of willowherb is very good and groundsel is better (but inconsistent), and there are some significant weaknesses in the control of bittercress and mouse ear. The initial observations on a range of container-grown stock indicate that Terano and Dual Gold might be safe enough for summer use. It is hoped that Dual Gold will be registered for use on some arable crops in the UK with the possibility of a SOLA for use on ornamentals. It has potential for use as a tank mixture with Flexidor 125 as the weed spectra are complimentary.

Terano caused damage to *Hebe* and more severe damage to *Escallonia*. Terano would appear to be the stronger herbicide but with more risk of damage.

There are no plans to introduce Terano into the UK market although it has been tested on ornamentals in Germany. If introduction appears more likely, further work would be needed to establish safety on a wider range of crops.

Teridox appears relatively safe as a growing season treatment in container grown nursery stock. It failed to control some important weeds such as bittercress and willowherb but the control of groundsel could be particularly useful if it was used in tank mix or sequence with other herbicides. Teridox may be introduced into the UK market but it is unlikely to be available in the near future.

Butisan S and Springbok appeared to have similar efficacy against the weed species tested. Both had with good performance against pearlwort, mouse ear, and willowherb. Control of groundsel and bittercress was more variable although there were indications that New Zealand and flexuous bittercress were better controlled Both products contain metazachlor which has been known to cause scorch to soft growth in early summer however damage was not seen in these experiments. At present neither product has a label recommendation on container grown stock although Butisan S is approved for use for use on field grown nursery stock. Both products would require a SOLA for use on container grown stock.

Chikara, Sumimax and Skirmish all have good potential for use as winter herbicides in nursery stock. Sumimax already has a SOLA for use on ornamentals. Chikara and Skirmish would require a SOLA application for use on ornamentals. The activity against some species of overwintered weed seedlings is better than the current standard Butisan S + Flexidor 125, as well as providing longer term residual control.

Cockspur grass

For pre-emergence control of Cockspur grass, Butisan S, Stomp 400 SC, Kerb Flo, Artist, Crystal and Dual Gold were all very effective for both strains tested in both the summer and autumn pot experiments. For post emergence control all the specific graminicides tested had useful activity even up to the 10 true leaf stage. Laser was faster acting in the autumn tests and provided the better control of 10 true leaf plants in the summer. These results were confirmed in the field experiments where Butisan S, Artist and Dual Gold all proved to be very effective in providing residual control. Butisan S and Artist have known contact activity and significant damage was noted where Artist was applied over the tree foliage. Dual Gold and Crystal have relatively little contact activity and so should prove safer for use over actively growing foliage. Of the two, Dual Gold provided better control, but Crystal is already available in the UK. Laser was tested as a selective contact herbicide and proved very effective, controlling 60 cm high Cockspur grass, without damaging the crop.

Field horsetails

Field horsetail proved difficult to completely eradicate. Weedazol-TL and Agroxone treatments gave effective control in the season of treatment. Weedazol-TL was the only treatment to give a significant reduction in horsetail re-growth the following year in both of two years of experiments. Although Agroxone consistently gave a very good initial knockdown there was variability in the amount of re-growth in the following year. In the 2006 experiment re-growth in 2007 was not significantly reduced, but in the 2007 experiment on a different site re-growth in 2008 was substantially reduced. None of the other hormone herbicides tested in 2007 were effective when used alone, but when used in addition to Agroxone, re-growth the following year was reduced. In conclusion both Weedazol-TL and Agroxone are worth using for field horsetails control. Agroxone gives the best knockdown in the year of treatment and the addition of other hormone herbicides such as dicamba are worthwhile in order to reduce re-growth the following season.

The use of different adjuvants in the first experiment did not give rise to significant differences in control, but there were indications that Headland Fortune was more effective and the use of this combination resulted in the least re-growth the following year.

Creeping yellow cress

Weedazol-TL, Glyfos, and Cleancrop Unival controlled creeping yellow cress in the 2006 experiment. Cleancrop Unival was the only treatment to substantially reduce the re-growth in the following season although Weedazol-TL also gave a good reduction. Similarly in the 2007 experiment, Cleancrop Unival gave a rapid knockdown in 2007 with no re-growth seen in 2008. Weedazol-TL was less effective in 2007, possibly due to a wetter season. Overall Cleancrop Unival was the most consistently effective treatment. Cleancrop Unival (triclopyr) is no longer available but similar formulations of triclopyr are available as Garlon or Timbrel.

False hedge bindweed

False hedge bindweed could be controlled for one season but was difficult to eradicate. Whilst Herboxone (2,4-D), or I.T. Dicamba proving quite effective during the treatment season it was only the combination of I.T. Dicamba + Roundup that significantly reduced the re-growth the following year. The combination of July applied hormone herbicides in a tank mix with Roundup proved effective again on a different site in 2007.

The re-growth in the following year 2008 was more variable than in 2007 making comparisons difficult but the combination of Dicamba + Roundup appears to be one of the more consistent treatments with good initial knockdown and substantial reduction the following year. It is likely that several years of repeated treatment will be necessary to eradicate this weed.

In a phytotoxicity screening trial a number of treatments were tested for safety when used as a directed spray alongside a *Malus* stoolbed. The vigorous soft growth of a stoolbed is very vulnerable to damage making this a sensitive test. Chikara and Sumimax proved completely safe. Dicamba was initially damaging but the shoot growth recovered. Cleancrop Unival however proved extremely damaging causing shoot death and reducing growth.

Technology transfer

Since the last annual report an HDC news article on control of creeping yellow cress was published. Earlier articles covered results of the container seedling weed experiments and the cockspur grass experiments.

References

Coupland, D. and Peabody, D.V. (1981). Effect of four foliage herbicides on field horsetail *Equisetum arvense*. Weed Science 29 (1):113-119.

Eelden, H. and Bulcke, R. (1998). Identification of bittercress species (*Cardamine* L.) in ornamental nurseries and their response to isoxaben. Abstracts "Ornamentals: developing the future", conference at St. Catherine's College Oxford, 29 June - 1 July 1998. Association of Applied Biologists.

Hallgren, R. (1996). Control of common horse tail (*Equisetum arvense*) in fallow. Agriculture – pests, diseases and weeds. Swedish Crop Protection Conference Uppsala 37:325-329.

Hoagland, R.E., Hirase, K. (2003). Isolation and study of arylacylamidase activity from propanil-resistant barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.]. Proceedings of the Southern Weed Science Society. 43:347.

Kahn, M.A and Kahn, B.M. (2003). Efficacy of different herbicides on the yield and yield components of Maize. Asian Journal of Plant Science 2 (3):300-304.

Marshall, G. (1984). A review of the control of *Equisetum arvense* L. (field horsetail). Aspects of Applied Biology 8:3-42.

Merbach, I. (1993). Control of *Equisetum arvense* L. (field horsetail) on waste land with splitted and reduced doses of MCPA. Zeitschrift fuer Pflanzenkrankheiten und Pflanzenschutz 100 (3):317-342.

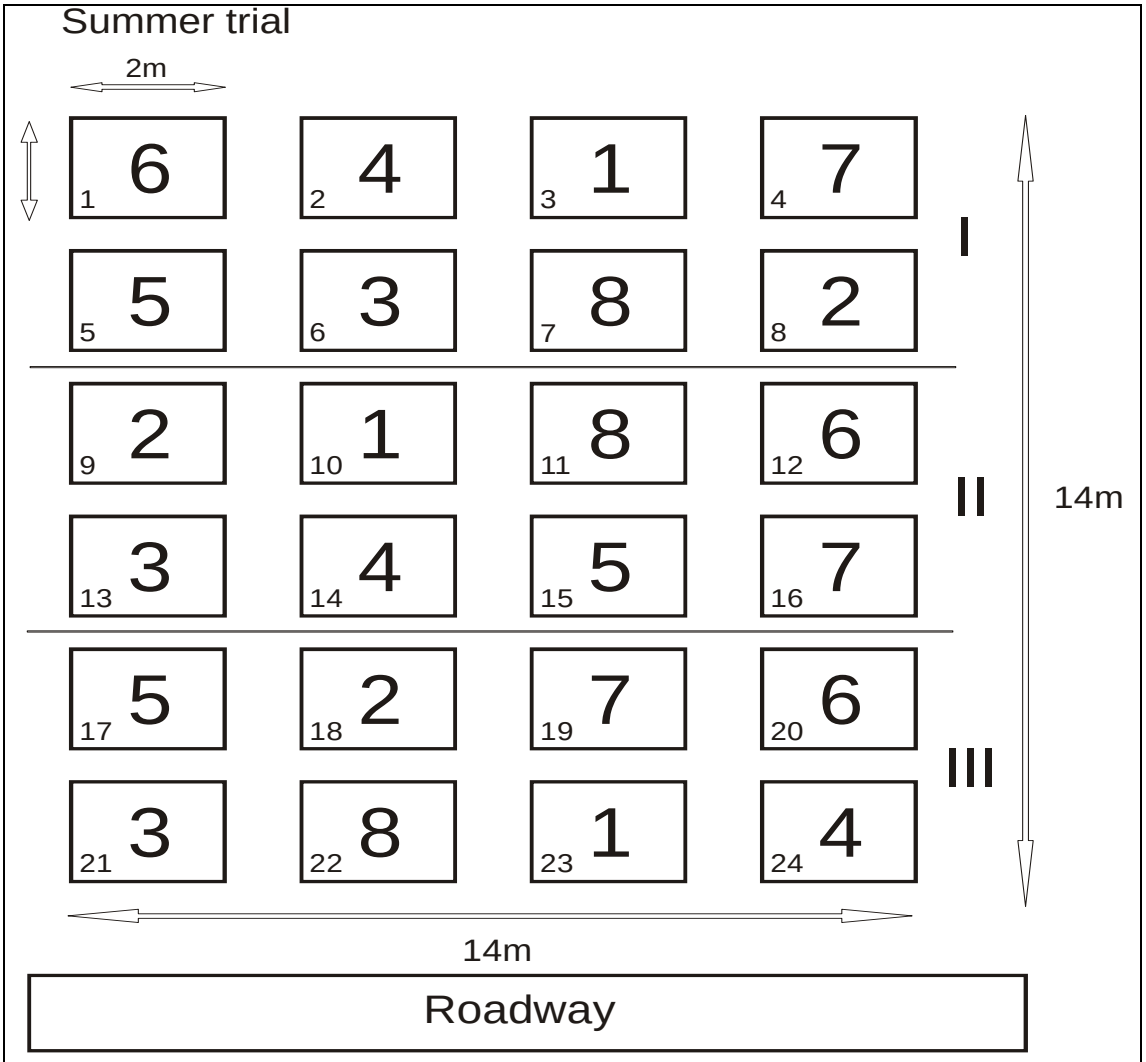
Nilsson, H. and Hallgren, R. (1991). Control of *Equisetum arvense* with herbicides. A greenhouse experiment. Agriculture – pests, diseases and weeds. Swedish Crop Protection Conference Uppsala 32:297-303.

Vezina, L. (1990). Efficacy of herbicide programmes used in barley and maize on *Equisetum arvense* L populations in Quebec Canada. Weed Research 30 (1):71-79.

Appendices

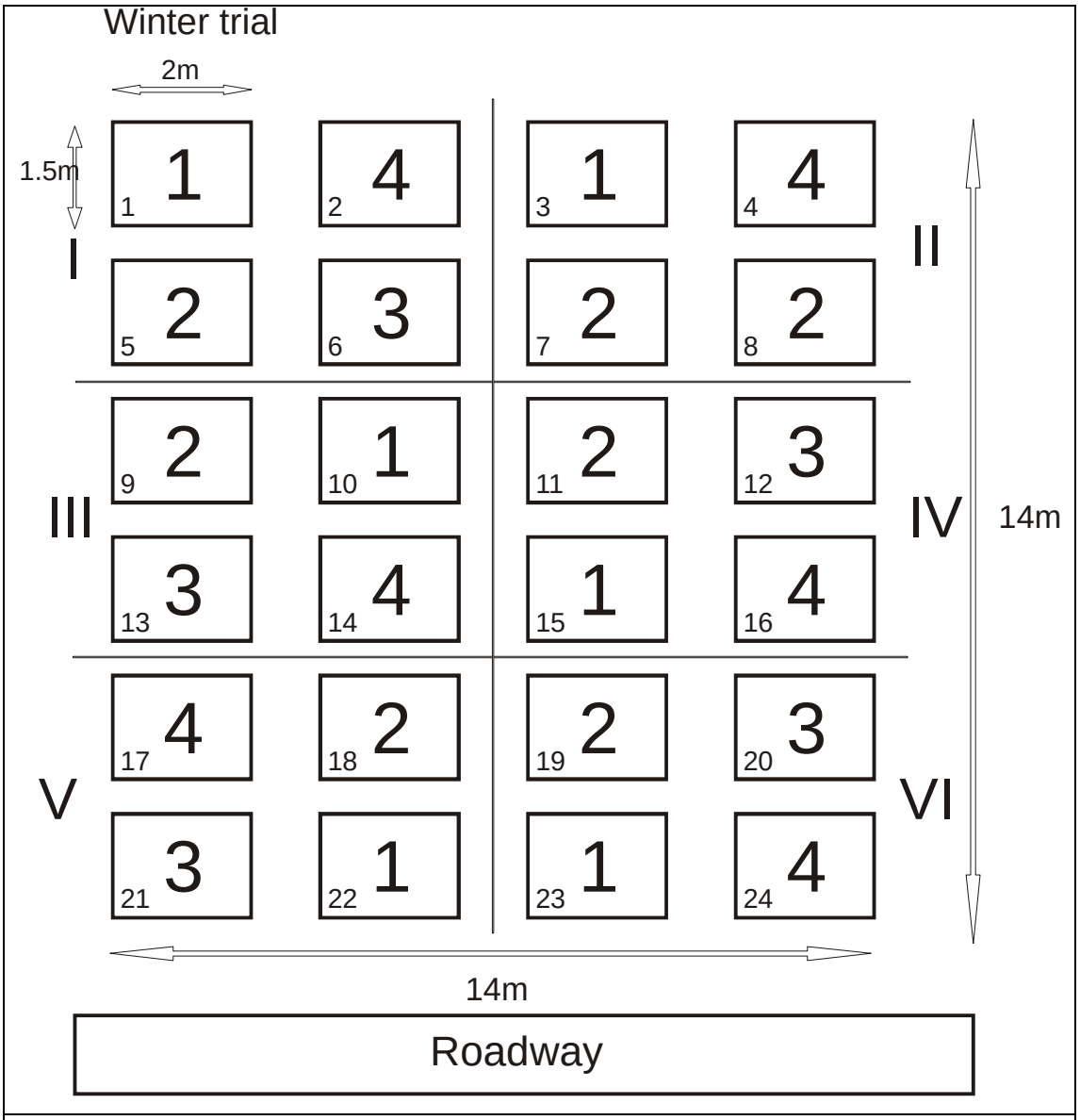
Appendix 1: A. Weed seedling container experiments

Summer herbicide experiment layout



Treatment	*Chemical*	*Rate*
1	Untreated control	
2	Teridox (A50898)	3.0 L/ha
3	Flexidor 125	1.0 L/ha
4	Butisan S	2.5 L/ha
5	Springbok	2.5 L/ha
6	Dual Gold	1.6 L/ha
7	Terano	0.75 kg/ha
8	Barricade 65WG	2.6 kg/ha

Winter herbicide experiment layout

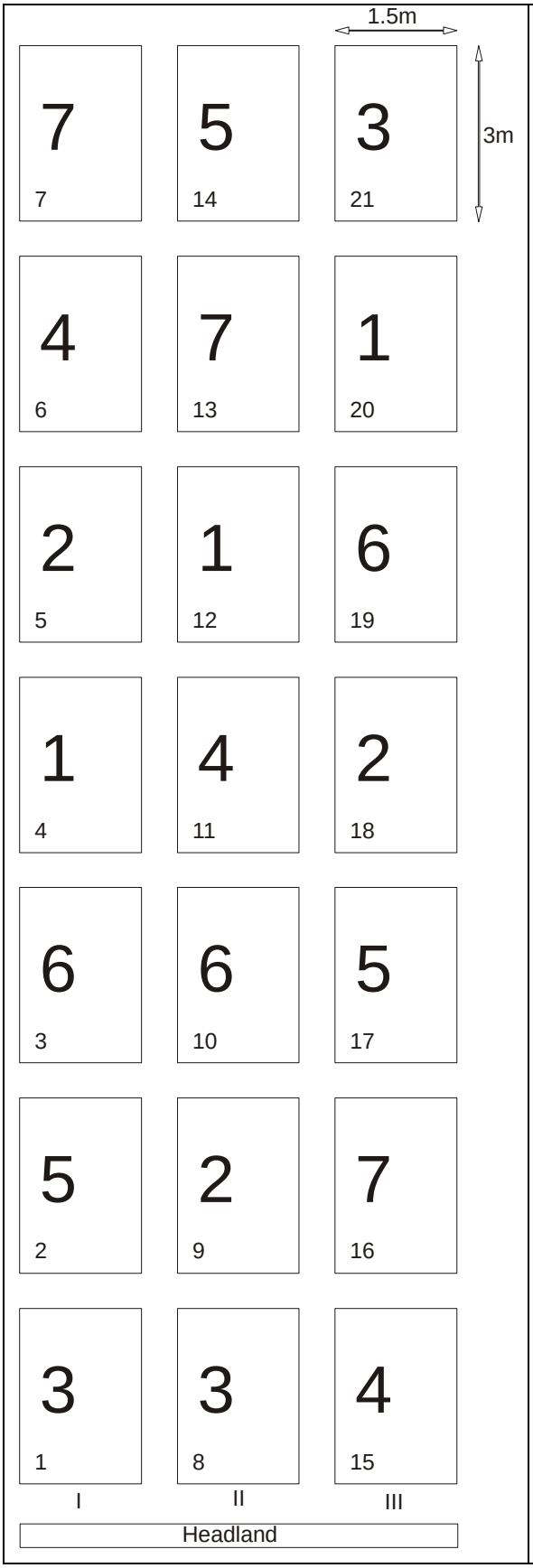


Treatment	*Chemical*	*Rate*
1	Untreated control	
2	Skirmish 495SC	1.0 L/ha
	+ Butisan S	2.5 L/ha
3	Flazasulfuron	200 gm/ha
4	Sumimax	100 mL/ha

Appendix 2: B: **Echinochloa crus-galli *(cockspur grass) experiment***

Experiment layout

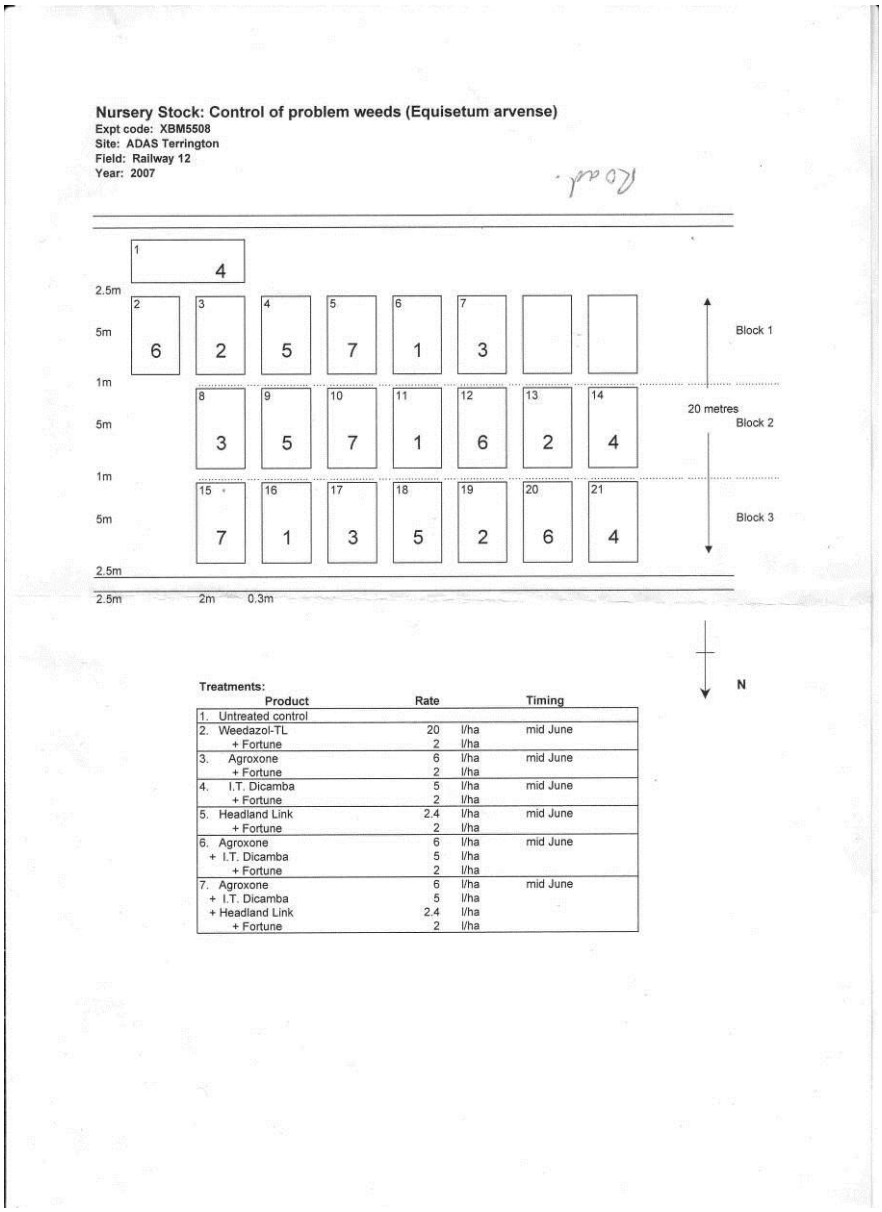
Plot Layout



Treatment	*Product*	*Product rate*
1.	Untreated control	
2.	Butisan S	2.5 L/ha
3.	Springbok	2.5 L/ha
4.	Crystal	4 L/ha
5.	Dual Gold	1.4 L/ha
6.	Artist	2.5 kg/ha
7.	Laser + Actipron + Dual Gold	2.25 L/ha 0.8 % 1.4 L/ha

Appendix 3: C. Equisetum arvense *(field horsetail) experiment*

Experiment layout



Nursery Stock: Control of problem weeds (Equisetum arvense)
Expt code: XBM5508
Site: ADAS Terrington
Field: Railway 12
Year: 2007

Road

1	4						
2	3	4	5	6	7		
6	2	5	7	1	3		
8	9	10	11	12	13	14	
3	5	7	1	6	2	4	
15	16	17	18	19	20	21	
7	1	3	5	2	6	4	

2.5m
5m
1m
5m
1m
5m
2.5m
2.5m 2m 0.3m

Block 1
20 metres
Block 2
Block 3
N

Treatments:

Product	Rate		Timing
1. Untreated control			
2. Weedazol-TL	20	l/ha	mid June
+ Fortune	2	l/ha	
3. Agroxone	6	l/ha	mid June
+ Fortune	2	l/ha	
4. I.T. Dicamba	5	l/ha	mid June
+ Fortune	2	l/ha	
5. Headland Link	2.4	l/ha	mid June
+ Fortune	2	l/ha	
6. Agroxone	6	l/ha	mid June
+ I.T. Dicamba	5	l/ha	
+ Fortune	2	l/ha	
7. Agroxone	6	l/ha	mid June
+ I.T. Dicamba	5	l/ha	
+ Headland Link	2.4	l/ha	
+ Fortune	2	l/ha	

Appendix 4: D.* Rorrippa sylvestris *(creeping yellow cress) experiment

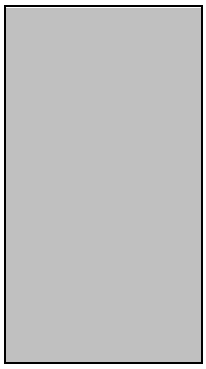
Experiment layout

Nursey Stock Control of Problem Weeds: *Rorrippa sylvestris.* Field Expts 2007. Goregate Hall, Dereham, Norfolk.

Block	1	1	1	1	1	1	1	1	1
Treatment	2	8	1	3	5	7	9	4	6
Plot number	1	2	3	4	5	6	7	8	9
	2	2	2	2	2	2	2	2	2
	9	1	6	4	5	8	7	2	3
	10	11	12	13	14	15	16	17	18
	3	3	3	3	3	3	3	3	3
	2	5	6	3	7	8	4	9	1
	19	20	21	22	23	24	25	26	27

Treatment	Product	Product Rate	Timing
1	Untreated		
2	Weedazole	20 l/ha	Mid May
3	Unival	6 l/ha	Mid May
4	Herboxone	3.3 l/ha	Mid May
5	IT Dicamba	5 l/ha	Mid May
6	Headland Link	2.4 l/ha	Mid May
7	Herboxone + IT Dicamba + Unival	3.3 l/ha + 5 l/ha + 6 l/ha	Mid May
8	Herboxone + IT Dicamba + Headland Link	3.3 l/ha + 5 l/ha + 2.4 l/ha	Mid May
9	Unival + IT Dicamba + Headland Link	6 l/ha + 5 l/ha + 2.4 l/ha	Mid May

Plot Dimensions



2.0 m

1.5 m

Appendix 5: E.* Calistegia sepium *(false hedge bindweed) experiment

Experiment layout; control experiment

False Hedge Bindweed Experiment 2007 Frank P Matthews Ltd Tenbury Wells Worcs.														
				III										
				4										
				33										
O Telegraph pole														
Block	II	II	II	II	II	II	II	II	II	II	II			
Treatment	5	4	11	6	1	3	8	7	9	10	2			
Plot No	22	21	20	19	18	17	16	15	14	13	12			
													Continues >	
Block		I	I	I	I	I	I	I	I		I	I	I	
Treatment		5	11	9	2	7	4	1	8		6	3	10	
Plot No		11	10	9	8	7	6	5	4		3	2	1	

												HEDGE
<Previous page												
III	III	III		III	III	III	III	III	III	III		
6	10	7		1	8	9	5	2	11	3		
32	31	30		29	28	27	26	25	24	23		

Experiment layout; phytotoxicity experiment