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Key words:	*Acer campestre,* aclonifen, *Alnus glutinosa*, annual meadow grass, *Betula pubescens*, *Betula pendula,* Boxer, broadleaved trees, Centium, clomazone, *Cornus alba, Crataegus monogyna,* dimethachlor, dimethenamid-P, Dual Gold, field pansy, florasulam, flufenacet, flumioxazine, *Fraxinus excelsior,* Goltix WG, Groundsel, herbicides, knotgrass, Mayweeed, metazachlor, metosulam, small nettle, nursery stock, ornamentals, pendimethalin, *Rosa rubiginosa,* s–metolachlor, shepherds purse, *Sorbus aucuparia*, common speedwell, Springbok, Stomp 400 SC, Sumimax, Terano, Teridox, tree seedbeds, weeds, weed control

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

AUTHENTICATION FOR HNS 155

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

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GROWER SUMMARY

Headline

- A range of herbicide products have been assessed for their crop safety and efficacy in controlling annual weeds in broadleaved tree seedbeds and the most successful so far have been identified.

Background and expected deliverables

Weed control still presents a significant challenge for tree seedling growers. Small-seeded crops in particular are vulnerable to herbicide damage and also to weed competition early in the life of the crop. Many growers rely on expensive partial soil sterilisation and hand weeding to keep the crops clean from weeds. Hand weeding is becoming increasingly expensive and soon will not be justified for the value of the crop.

The last herbicide screening trial (HNS 31a) was completed almost 10 years ago. Since then a number of herbicides have been withdrawn and another range of herbicides has become available. A number of new herbicides from the agricultural and vegetable sector have potential for use in tree seed-beds. Some of the characteristics of these herbicides have been determined from experimental work in vegetables (FV 256), roses (HNS 132), cut flowers (BOF 51) and other nursery stock crops (HNS 139).

This project aims to determine the crop safety and relative efficacy of new herbicides for control of weeds in small-seeded broadleaved tree species.

For the first year, 11 herbicide products were tested for safety and weed control efficacy on four small-seeded tree species. For the second year (reported here), 6 of these herbicides advanced for further testing on a wider range of tree species. In the third (final) year it is intended to test the most promising herbicides in combination or in programmes to provide optimum weed control, particularly in the early life of the crop.

Summary of the project and main conclusions

Seed beds of *Acer campestre* (L.), *Alnus glutinosa* (L.) Gaertn., *Betula pendula* Roth., *Cornus alba* (L.), *Crataegus monogyna* Jacq., *Fraxinus excelsior* (L.), *Rosa rubiginosa* (L.), and *Sorbus aucuparia* (L) were prepared on 24 April 2008 and treated with pre-emergence herbicides on 5 May 2008 as listed below (Table 1).

Table 1. Herbicide treatments

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control			
2.	Stomp 400 SC	pendimethalin (400 /L)	1.0 L/ha	LTA*
3.	Not named	aclonifen	1.0 L/ha	Not in UK
4.	*New Code A*	Not disclosed	0.65 kg/ha	Not in UK
5.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha	LTA
6.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha	LTA
7.	Teridox	dimethachlor	1.5 L/ha	Not in UK

*Long-Term Arrangements for Extension of Use.

Weed control

The effect of the herbicide treatments on weed control 60 days after treatment (recorded 3 July 2008) is shown below (Fig. 1).

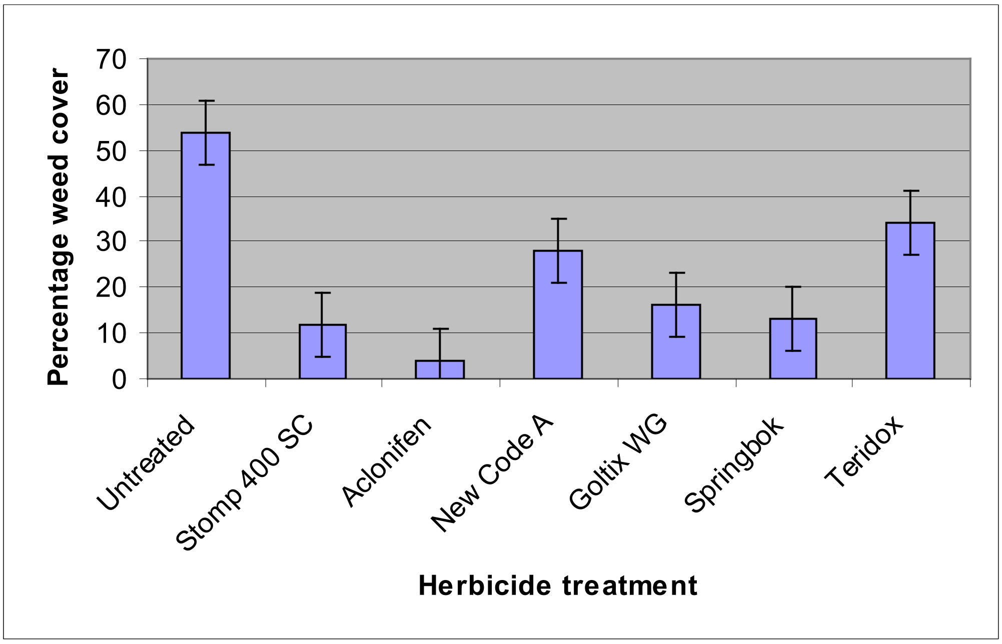

Figure 1. Weed seedlings per m^2 following herbicide treatments. When comparing treatments, differences falling within the error bar (LSD) range are not significant at P = 0.05.

The most effective treatment in 2007 for weed control was *New Code A*. Reducing the rate by 50% in 2008 severely reduced the efficacy and particularly the persistence of control. In 2008 none of the treatments maintained complete control for the duration of the trial although aclonifen gave very good control for two months. Stomp 400SC and Springbok were the next most effective treatments followed by Goltix WG (Figure 1). Teridox was disappointing for the range of weeds in this trial.

Stomp 400 SC

Stomp 400 SC was moderately effective and maintained some weed control through to the end of the experiment. There was a high population of fat hen (*Chenopodium album* L.) which was well controlled. There was partial control of knotgrass (*Polygonum aviculare* L.), field pansy (*Viola arvensis* Murray), shepherd's-purse (*Capsella bursa-pastoris* L.) and common speedwell (*Veronica officionalis* L.). Annual meadow grass (*Poa annua* L.) black bindweed (*Fallopia conuluvulus*) and small nettle (*Urtica urens* L.), however were not well controlled

Aclonifen

Aclonifen was the most effective herbicide particularly in the early stages, controlling most weeds. As persistence was lost, some annual meadow grass, field pansy (as in 2007) and common speedwell developed. Control of fat hen was good throughout.

New Code A

New Code A was much less effective at the lower rate used in 2008. The only weeds controlled well at this rate were annual meadow grasses. There was partial control of fat hen, small nettle and shepherd's-purse.

Goltix WG

Although this herbicide can be used as a selective contact treatment, in this experiment it was used as a short-term residual. Weed control was acceptable for the first two months but only moderate to poor over the trial duration as persistence was lost. Annual meadow grass and shepherd's-purse were very well controlled. There was partial control of black bindweed, fat hen and common speedwell but little control of knotgrass, small nettle and field pansy.

Springbok

Weed control was only moderately effective, although Springbok maintained some weed control through to the end of the experiment. Apart from feverfew (*Chrysanthemum parthenium* L. Bernh.) no other weeds were well controlled. There was partial control of small nettle, field pansy, shepherd's-purse and common speedwell. Annual meadow grass, black bindweed and knotgrass were not controlled.

Teridox

Weed control was disappointing although annual meadow grass was well controlled.

Crop safety

Crops were assessed for germination by seedling count and by visual assessment of phytotoxicity/vigour using a scoring system (Table 2).

Table 2. Phytotoxicity and crop vigour score key

Score	**Nature of phytotoxicity damage**
1	Plant death

2	Severally damaged and/or reduced growth
3	Slight damage/slightly reduced growth
4	Commercially acceptable damage
5	No visible signs of damage compared to control.

Based on the germination results and crop vigour, score a summary of crop tolerance is provided in Table 3.

Table 3. Crop tolerance of herbicides (includes results from 2007 – see 1st year report for treatment details)

	Acer	***Alnus***	***Betula***	***Cornus***	***Crataegus***	***Fraxinus***	***Rosa***	***Sorbus***
Stomp 400 SC	T	T	T	T	T	T	T	T
Sumimax 50WP		S	S		S			S
Aclonifen	T	S	S	T	S	T	T	S
New Code A	T	S	S	T	T	T	T	T
Boxer		T	T		mS			mS
New Code B		S	S		S			S
Centium		mS	T		T			T
Dual Gold		T	T		S			S
Goltix WG	T	T	mS	T	T	T	T	T
Springbok	T	T	T	T	T	T	T	S
Terano		S	T		S			S
Teridox	T	S	S	T	T	T	T	

T = Tolerant (final vigour assessment mean score > or = 4)

mS= Moderately susceptible (final vigour assessment score > 3)

S = Susceptible (final vigour assessment score < or =3) or germination reduced by >60%

Where 2 years data is available the average is used to categorise.

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Effect of herbicides in different tree species

The effect of the different herbicides in each species is listed below and compared to the untreated control (Figure 2)

Figure 2 Untreated control

Acer campestre

None of the herbicide treatments reduced germination significantly. This species was only tested in 2008. Aclonifen reduced the crop vigour initially but plants recovered after three months (Figure 3). All other treatments were completely safe.

Stomp 400SC, New Code A, Goltix WG, Springbok and Teridox all have potential for use on Acer. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.

Figure 3 Acer treated with aclonifen. Some initial reduction in vigour but plants recovered.

Alnus glutinosa

Some herbicide treatments caused a significant reduction in the number of seedlings that emerged. The safest treatments were Stomp 400SC (Figure 5), Goltix WG and Springbok where the reductions were relatively minor both in 2007 and 2008. Aclonifen, *New Code A* (Figure 4) and Teridox all reduced germination substantially in 2008 although aclonifen had been safer in 2007. *New Code A* had also reduced germination in 2007. It had been hoped that a lower rate would prove safer in 2008 although this was not the case. Stomp 400SC caused some reduction in vigour initially but the plants recovered. Goltix WG and Springbok were relatively safe. Results were similar in 2007.

Goltix WG and Springbok have good potential for use on Alnus glutinosa, a higher rate of Springbok might even be tolerated. Stomp 400SC could be used but causes some vigour reduction. New Code A reduces germination but may have potential as a follow up treatment post germination.

Figure 4 Alnus treated with *New Code A* good weed control and crop vigour – untreated in the background

Figure 5 Alnus treated with Stomp 400SC, a relatively safe treatment.

Betula pendula

This crop is very sensitive to herbicides. Only Stomp 400SC (Figure 6) and Springbok (Figure 7) were consistently safe in both 2007 and 2008, having minimal effect on germination and acceptable crop vigour. Although all treatments reduced vigour initially, by the end of the season the Stomp 400SC and Springbok treatments were of acceptable quality. Although Goltix WG and aclonifen (Figure 8) appeared safe in 2007 (on *Betula pubescens*) both caused a substantial reduction in germination in 2008.

Stomp 400SC and Springbok have potential for use on Betula, but care is needed as this crop is subject to vigour reduction following herbicide use.

Figure 6 Betula treated with Stomp 400SC, a relatively safe treatment.

Figure 7 Betula treated with Springbok, also relatively safe.

Figure 8   Betula treated with aclonifen.

Cornus alba

This crop appeared very tolerant of the herbicides tested. Germination and crop vigour were not affected by any of the treatments.

*Stomp 400SC, aclonifen (*Figure 9)*, New Code A, Goltix WG, Springbok and Teridox all have potential for use on Cornus. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.*

Figure 9 Cornus treated with aclonifen.

Crataegus monogyna

It had been thought that this crop was more tolerant of herbicides so in 2007 higher rates of herbicides were used. However only Stomp 400SC (2 L/ha) and Goltix WG (3 L/ha) were safe at higher rates. So in 2008 lower rates were used similar to the other crops. In addition to the Stomp 400SC (Figure 10) and Goltix WG, Springbok and Teridox were safe when used at lower rates. Aclonifen and *New Code A* caused a significant but acceptable reduction in germination and all except aclonifen and Teridox retained acceptable vigour throughout the trial.

Stomp 400SC, New Code A, Goltix WG and Springbok all have potential for use on Crataegus. The higher rates of Stomp 400SC and Goltix WG used in 2007 should also be safe.

Figure 10 Crataegus treated with Stomp 400SC.

Fraxinus excelsior

This crop appeared very tolerant of the herbicides tested. Germination and crop vigour was not affected by the treatments except for aclonifen which reduced germination and crop vigour. There was some recovery by the end of the season.

Stomp 400SC, New Code A, Goltix WG (Figure 11), Springbok and Teridox all have potential for use on Fraxinus. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.

Figure 11 *Fraxinus* treated with Goltix WG. Most treatments were safe to this crop.

Rosa rubiginosa

This crop appeared quite tolerant of the herbicides tested. Germination and was not affected by the treatments except for aclonifen which reduced germination. Stomp 400SC and aclonifen reduced crop vigour initially but there was good recovery by the end of the season.

Stomp 400SC, New Code A, Goltix WG, Springbok (Figure 12) and Teridox all have potential for use on Rosa. As the crop appeared to have good tolerance It is possible that higher rates of New Code A*, Goltix WG and Springbok than those tested could be used.*

Figure 12 *Rosa* treated with Springbok.

Sorbus aucuparia

This crop is very sensitive to herbicides. Only Stomp 400SC (Figure 15) and New Code A (Figure 13) were consistently safe in both 2007 and 2008, having minimal effect on germination and acceptable crop vigour by the end of the season. Springbok and Goltix WG gave more variable results reducing either germination or vigour in one of the two years tested. Aclonifen (Figure 14) caused crop loss in both years.

Stomp 400SC and New Code A have potential for use on Sorbus, but care is needed as this crop is subject to vigour reduction following herbicide use.

Figure 13 *New Code A* very good weed control and crop vigour in *Sorbus*, August 2007

Figure 14 Aclonifen again caused crop failure in *Sorbus*

Figure 15 Stomp treatment on Sorbus

General

The herbicide New Code A shows good promise for use in small-seeded tree seedbeds but it will be necessary to use it at the 1.3 kg/ha dose rate used in 2007 to ensure good weed control. At the 1.3 kg/ha rate it is likely to be safe on *Acer*, *Cornus, Crataegus, Fraxinus, Rosa* and *Sorbus* but not *Alnus* or *Betula*. In the event of *New Code A* not becoming available to the UK, aclonifen, Stomp 400SC or Springbok are likely to be the next best options for weed control or Goltix WG for shorter term control. A combination of treatments is likely to be necessary to give adequate weed control. For *Betula* and *Alnus* the safer options are Stomp 400SC and Springbok. Teridox was tested for the first time in 2008 but weed control was poor at the rate used and there was insufficient crop tolerance to continue with this product.

Financial benefits

The production of tree seedlings is an important sector of the amenity tree market with production of 60 million seedlings per annum and sales of £15 million. Broadleaved tree seedlings make up the majority of the market.

The financial benefits to the industry of the project should result from

- More reliable control of weeds through the development of sustainable herbicide programmes.
- Reduced losses and reduced costs due to weed competition and hand weeding.

It is not possible to determine precise financial benefits from this project as yet, because all of the treatments tested require further development either on crop safety or longer-term effectiveness before recommendations can be developed. The most promising new treatments are not yet available commercially so the cost cannot be determined yet. However initial indications are that some of the current cost of hand weeding seedbeds of broadleaved tree species might be reduced if not eliminated. The current hand-weeding cost is estimated at £1,800/ha based on three weeding sessions of 100hrs/ha @ £6/hr = £600 per session.

Action points for growers

- When commercially available, *New Code A* should be used as a treatment for weed control in *Acer*, *Cornus, Crataegus, Fraxinus, Rosa* and *Sorbus*

- Stomp 400SC or Springbok have potential for safe use on *Betula.*

- Goltix WG or Springbok have potential for safe use on *Alnus*.

- Prior to the availability of New Code A or aclonifen, Stomp 400 SC and Goltix WG have potential for use in *Alnus, Betula, Crataegus* and *Sorbus*, and Springbok in *Alnus* and *Betula*, but more work is needed to test herbicide combination treatments.

SCIENCE SECTION

Introduction

Weed control still presents a significant challenge for tree seedling growers. Small-seeded crops in particular are vulnerable to herbicide damage and also to weed competition early in the life of the crop. Many growers are relying on expensive partial soil sterilisation and hand weeding to keep the crops clean from weeds. Hand weeding is becoming increasingly expensive and soon will not be justified for the value of the crop.

The last herbicide screening trial for tree seedbeds (HNS 31a) was completed almost 10 years ago. Since then a number of herbicides have been withdrawn and another range of herbicides have become available.

A comprehensive herbicide screening programme was done in the period 1976-81 at Luddington EHS (Cooper, 1982) from which recommendations were developed for the use of Quintex (propham/fenuron/CIPC), Enide (diphenamid), simazine, Tenoran (chloroxuron), Dacthal (chlorthal-dimethyl) and Brasoran + Kerb (azipotryne + propyzamide). Unfortunately only Dacthal and Kerb remain currently available for use.

Further herbicide screening was carried out on a range of tree seedlings HNS 31 & HNS 3a (Brough, 1993; 1997) indicating that, of the herbicides tested, Venzar (lenacil), Butisan (metazachlor) and Flexidor (isoxaben) had some potential for use in tree seedbeds, but the safe rate of use was relatively low and did not give adequate weed control. Unfortunately follow-up post-emergence applications were found to give an unacceptable level of damage.

Further studies were carried out by Willoughby *et al*. (2003, 2007) screening a number of herbicides on a range of tree species including *Alnus*, *Betula*, *Crataegus* and *Sorbus*. They found that Devrinol (napropamide) and Stomp (pendimethalin) had some potential for use in tree seedbeds although *Betula* was damaged by both, *Sorbus* and *Alnus* were tolerant of Devrinol only and *Crataegus* would tolerate a Devrinol-Stomp mixture. Devrinol is most effective when applied during winter months, so its use is limited to autumn or winter sown seedbeds and has limited value in spring sown seedbeds.

Brough (1997) concluded that the use of a partial soil sterilant, Basamid (dazomet) was necessary to achieve adequate weed control. In commercial practice Basamid is now used for some small-seeded tree crops mainly to counter re-plant problems but also to provide some measure of weed control. Basamid is relatively expensive and whilst it reduces the weed population in the seedbeds it does not provide any residual weed control. At present commercial practice is to follow up with low rates of Stomp (pendimethalin). However, weed control is not always adequate with this combination.

More recently a further range of herbicides have become available with potential for use in seed-raised horticultural crops. A number of these have been successfully used in field vegetable crops (FV 256, FV 270) (Knott, 2006a,b) including Centium (clomazone), 212H - now named Sumimax (flumioxazine), aclonifen, Boxer (florasulam) and New Code B. Centium was successfully used in certain seed-raised cut flower crops (BOF51) (Hanks, 2005). A further herbicide range including New Code A, Dual Gold (s – metolachlor), Terano (metosulam + flufenacet) and Springbok (metazachlor + dimethenamid-p) were used in screening experiments on nursery stock (HNS 139) (Atwood 2006, 2007) and roses (HNS 132) (Burgess, 2006). It is thought that some of these herbicides may have potential for use in tree seed-beds.

The current study aims to determine the relative efficacy and crop safety of new herbicides for control of weeds in vulnerable seedling tree species. In the first year 11 herbicides (Stomp 400SC (pendimethalin), 212 H 50WP (flumioxazine), aclonifen (aclonifen), New Code A (undisclosed), Boxer (florasulam), New Code B (not disclosed), Centium (clomazone), Dual Gold (s-metolachlor), Goltix WG (metamitron), Springbok (metazachlor + dimethenamid-p) and Terano (flufenacet + metosulam)) were tested on four small-seeded tree species (*Alnus glutinosa, Betula pubescens, Crataegus monogyna* and *Sorbus aucuparia*). Although Boxer (florasulam), Centium (clomazone) and Dual Gold (s-metolachlor) were safe to a number of subjects weed control was poor at the rates used so it was decided not to proceed with these products in the second year although they may be used in conjunction with other herbicides in later trials. New Code C (flumioxazine), New Code B (not disclosed) and Terano (flufenacet + metosulam) were damaging to the majority of subjects so trials on these herbicides were discontinued.

Materials and Methods

Crop details

Eight seedbeds were prepared, one each for each of the test species used in the experiment; *Acer campestre* (L.), *Alnus glutinosa* (L.) Gaertn*., Betula pendula* Roth.*, Cornus* *alba* (L.), *Crataegus monogyna* Jacq., *Fraxinus excelsior* (L.), *Rosa rubiginosa* (L.), and *Sorbus aucuparia* (L).

The soil (medium sandy loam) was initially cultivated using a Lemkin Rubin cultivator; beds were then formed using a 1.35 m Bartschi bed former on 24 April 2008. Soil analysis showed the soil to have pH 6.0, P index 5, K index 2+ and Mg index 1, organic matter 1.6%.

A base dressing of 500 kg/ha Norsk Hydro complex partner (N 12%, P_2O_5 11%, K_2O 18%, MgO 3% + S) was incorporated into the bed prior to sowing.

For small seeded species *Alnus, Betula* and *Rowan,* seed was mixed with fine sand and sown directly on the soil surface, all other species were sown directly at a depth of 10mm on 28 April 2008 using an Egedal combi 5 row drill (25cms between rows) with the intention of producing a final density of 200 plants per meter of bed. The following seed rates were used:

Acer campestre	6.80 kgs per 100m
Alnus glutinosa	0.38 kgs per 100m
Betula pendula	0.22 kgs per 100m
Cornus alba	2.80 kgs per 100m
Crataegus monogyna	4.80 kgs per 100m
Fraxinus excelsior	4.00 kgs per 100m
Rosa rubiginosa	1.00 kgs per 100m
Sorbus aucuparia	0.30 kgs per 100m

The seed source was Forestart Ltd and was of various UK provenances. After sowing 25B horticultural grit (2 to 5 mm) was applied at a target depth of 3 mm.

There was rainfall of 8 mm prior to applying treatments; the next rainfall was 8 mm on the 16 May 2008 and 3 mm on the 19 May 2008. There was heavy rain at the end of May, a total of 89 mm from 27-29 May 2008. Temperatures were normal for the time of year.

Irrigation was applied after sowing as required. Two top dressings of 75 kg/ha Calcium nitrate were applied at the end of June 2008 and again at the end of July 2008. Apart from the experimental treatments, no pesticides were applied.

Experimental design

Experiments were laid out in a randomized split plot design with two treatment factors: (i) chemical treatment (Table 4) (main plots) and (ii) tree species (sub-plots); with three replicate blocks. Each sub plot was 1.5 m x 2 m. The experimental layout is shown in Appendix 1.

All treatments were applied in 400 L water/ha at 2-bar pressure using a CO_2-pressurised Oxford Precision Sprayer with a 1.5 m boom and F03-110 spray nozzles. Treatments were applied pre-emergence of crop and weeds on 5 May 2008.

Table 4: Herbicide treatments

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control			
2.	Stomp 400 SC	pendimethalin (400 /L)	1.0 L/ha	LTA*
3.	Not named	aclonifen	1.0 L/ha	Not in UK
4.	New Code A	Not disclosed	0.65 kg/ha	Not in UK
5.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha	LTA
6.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha	LTA
7.	Teridox	dimethachlor	1.5 L/ha	Not in UK

*Long-Term Arrangements for Extension of Use.

Assessments

Weed control

The number of weed seedlings was recorded on 5 June 2008. Assessments were made using two 0.135 m^2 quadrats per sub-plot, randomly placed within the central 1.5 m x 0.5 m of the sub-plot. Further assessments of percentage weed cover were made on 1 July 2008 and 30 July 2008 on a whole plot basis.

Crop assessments

The number of crop seedlings was recorded on 5 June 2008. Assessments were made using two 0.135 m^2 quadrats per sub-plot, randomly placed within the central 1.5 m x 0.5 m of the sub-plot.

Crop vigour and phytotoxicity was assessed on 6 June 2008, 1 July 2008 and 30 July 2008 using a scoring system (Table 5)

Table 5. Phytotoxicity and crop vigour score key

Score	Nature of phytotoxicity damage
1	Plant death
2	Severally damaged and/or reduced growth
3	Slight damage/slightly reduced growth
4	Commercially acceptable damage
5	No visible signs of damage compared to control.

Results and Discussion

Crop assessments

Crop germination

All crops germinated successfully with seedling populations generally at or above the target population of 200/m^2. *Sorbus* was slightly below target at 165 seedlings / m^2 (Table 6).

None of the herbicide treatments reduced *Acer campestre* or *Cornus alba* germination significantly; these species appear very tolerant of all the herbicides tested. *Fraxinus excelsior* and *Rosa rubiginosa* were similarly very tolerant but aclonifen reduced germination of these two species.

Four of the herbicide treatments caused a significant reduction in the number of *Alnus glutinosa* seedlings emerged (Table 6). The safest treatments were Stomp 400SC, Goltix WG and Springbok where the reductions were relatively minor both in 2007 and 2008. Aclonifen, New Code A and Teridox all reduced germination substantially in 2008 although aclonifen had been safer in 2007. *New Code A* had also reduced germination to a lesser extent in 2007. It had been hoped that a lower rate would prove safer in 2008 although this was not the case

Betula pendula is very sensitive to herbicides. Only Stomp 400SC and Springbok were consistently safe in both 2007 and 2008, having minimal effect on germination. Although Goltix WG and aclonifen appeared safe in 2007 (on *Betula pubescens*) both caused a substantial reduction in germination in 2008 on *B. pendula*.

It had been thought that *Crataegus monogyna* was more tolerant of herbicides so in 2007 higher rates of herbicides were used. However only Stomp 400SC (2 L/ha) and Goltix WG (3 L/ha) were safe at higher rate. In 2008 lower rates were used similar to the other crops. In addition to the Stomp 400SC and Goltix WG, Springbok and Teridox were safe when used at lower rate. Aclonifen and New Code *A* caused a significant but acceptable reduction in germination.

Sorbus aucuparia is very sensitive to herbicides. Only Stomp 400SC and New Code A were consistently safe in both 2007 and 2008, having minimal effect on germination. Springbok and Goltix WG gave more variable results reducing either germination or vigour in one of the two years tested. Aclonifen caused crop loss in both years.

Table 6. Number of crop seedlings per m^2 following herbicide treatment

Treatment	Product	*Alnus*	*Betula*	*Crataegus*	*Sorbus*	*Fraxinus*	*Cornus*	*Rosa*	*Acer*
1.	Untreated	306	438	297	165	318	452	302	242
2.	Stomp 400 SC	277	447	272	168	306	593	240	261
3.	Aclonifen	41	176	221	0	222	500	214	209
4.	New Code A	115	115	237	124	312	564	347	292
5.	Goltix WG	222	174	283	97	344	562	316	235
6.	Springbok	300	332	265	194	328	549	272	227
7.	Teridox	58	34	278	153	334	593	235	235
	P (ANOVA)	<0.001	<0.001	0.035	<0.001	0.014	0.625	0.008	0.119
	df	12	12	12	12	12	12	12	12
	SED	34.7	55.4	20.5	24.7	27.2	84.9	30.1	26.0
	LSD	75.6	120.8	44.7	53.9	59.2	185.0	65.6	56.6

Crop vigour and phytotoxicity

Past experiments have shown that vigour reduction can be a serious problem when herbicides are used in tree seedbeds. Using the scoring key (Table 5), any treatment with a mean score of greater than 3 could be commercially acceptable but scores of 4 and above would be ideal.

In general Stomp 400SC and Goltix WG were the safest treatments with good vigour scores across most species. Herbicide treatment New Code A also stood out in 2007 as giving good vigour scores by the end of the season for *Alnus, Crataegus,* and *Sorbus.* Similar results were achieved in 2008, also for *Acer, Cornus, Fraxinus* and *Rosa* although as in 2007 there was an initial vigour check to *Alnus* and *Sorbus* even though a lower rate was used. Aclonifen, Springbok and Teridox tended to reduce crop vigour more than the other treatments but were acceptable to some species.

Acer was largely unaffected by the treatments (Table 7) except for aclonifen which caused an initial check. However all treatments including aclonifen had full vigour by the end of the season.

For *Alnus,* aclonifen and Teridox reduced germination substantially and caused severe initial vigour reductions (Table 8). Aclonifen had appeared safer in 2007 in both respects. As in 2007, New Code A, reduced germination but gave acceptable vigour. Stomp 400SC, Goltix WG and Springbok were safer – Goltix WG and Springbok giving the best results.

Only Stomp 400SC and Springbok gave acceptable germination and crop vigour in *Betula* (Table 9). Aclonifen and Goltix WG had appeared safer in 2007 but caused both germination and vigour reductions in 2008.

Cornus was largely unaffected by the treatments (Table 10).

The *Crataegus* suffered less damage in 2008 (Table 11) as lower treatment rates were used than in 2007. Aclonifen was the only treatment to cause a severe loss of vigour – although even here there was good recovery.

Fraxinus and *Rosa* were largely unaffected by the treatments (Tables 12 and 13) except for aclonifen which reduced germination and caused an initial check.

All treatments reduced *Sorbus* crop vigour initially (Table 14) but apart from aclonifen treatments all recovered by the end of the season. In 2007 only Stomp 400 SC, New Code

A, Springbok and Goltix WG gave acceptable crop vigour, all other treatments reduced the crop vigour substantially.

Table 7: Acer – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	5.0	5.0	5.0
3.	Aclonifen	3.0	3.0	5.0
4.	New Code A	4.3	4.5	5.0
5.	Goltix WG	4.0	4.5	5.0
6.	Springbok	4.0	4.7	5.0
7.	Teridox	4.7	4.7	5.0
	P (ANOVA)	<0.001	<0.001	
	Df	12	12	
	SED	0.241	0.304	
	LSD	0.546	0.663	

Table 8: Alnus – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	3.3	3.8	5.0
3.	Aclonifen	2.0	1.3	5.0
4.	New Code A	3.0	2.8	5.0
5.	Goltix WG	4.3	3.7	5.0
6.	Springbok	4.0	4.2	5.0
7.	Teridox	2.3	1.7	4.3
	P (ANOVA)	<0.001	<0.001	0.468
	Df	12	12	12
	SED	0.333	0.553	0.356
	LSD	0.726	1.204	0.776

Table 9 :. Betula – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	2.0	2.8	4.3
3.	Aclonifen	2.7	2.7	4.3
4.	New Code A	2.0	1.3	3.3
5.	Goltix WG	2.3	2.0	3.3
6.	Springbok	2.3	2.5	3.8
7.	Teridox	1.7	1.3	2.7
	P (ANOVA)	<0.001	<0.001	0.105
	Df	12	12	12
	SED	0.389	0.356	0.736
	LSD	0.835	0.776	1.605

Table 10:. Cornus – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	4.0	4.0	5.0
3.	Aclonifen	4.0	4.0	5.0
4.	New Code A	4.0	4.0	5.0
5.	Goltix WG	4.3	4.0	5.0
6.	Springbok	4.0	4.3	5.0
7.	Teridox	4.0	4.0	4.7
	P (ANOVA)	<0.001	<0.001	0.468
	df	12	12	12
	SED	0.178	0.178	0.178
	LSD	0.388	0.388	0.388

Table 11:. Crataegus – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	5.0	4.7	5.0
3.	Aclonifen	2.0	1.0	4.0
4.	New Code A	4.7	3.3	5.0
5.	Goltix WG	5.0	4.7	5.0
6.	Springbok	5.0	4.8	5.0
7.	Teridox	4.0	3.0	4.3
	P (ANOVA)	<0.001	<0.001	0.088
	df	12	12	12
	SED	0.178	0.291	0.378
	LSD	0.388	0.634	0.824

Table 12:. Fraxinus – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	5.0	4.7	4.7
3.	Aclonifen	3.0	2.0	5.0
4.	New Code A	5.0	4.7	5.0
5.	Goltix WG	5.0	4.8	5.0
6.	Springbok	5.0	4.3	5.0
7.	Teridox	4.0	4.3	5.0
	P (ANOVA)		<0.001	0.468
	Df	12	12	12
	SED		0.395	0.178
	LSD		0.861	0.388

Table 13:. Rosa – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	2.7	3.3	5.0
3.	Aclonifen	2.0	1.7	5.0
4.	New Code A	4.0	4.2	5.0
5.	Goltix WG	4.7	5.0	5.0
6.	Springbok	3.0	3.8	5.0
7.	Teridox	3.3	3.8	4.3
	P (ANOVA)	<0.001	<0.001	0.468
	Df	12	12	12
	SED	0.325	0.323	0.356
	LSD	0.709	0.704	0.776

Table 14: Sorbus – the effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	6 June 2008	1 July 2008	30 July 2008
1.	Untreated	5.0	5.0	5.0
2.	Stomp 400 SC	3.3	2.8	5.0
3.	Aclonifen	1.0	1.0	1.0
4.	New Code A	3.3	1.7	5.0
5.	Goltix WG	3.0	2.5	5.0
6.	Springbok	4.0	3.2	5.0
7.	Teridox	3.3	2.0	5.0
	P (ANOVA)	<0.001	<0.001	
	Df	12	12	12
	SED	0.418	0.457	
	LSD	0.910	0.996	

Weed control assessments

The most effective treatment in 2007 for weed control was New Code A. Reducing the rate by 50% in 2008 severely reduced the efficacy and particularly the persistence of control. In 2008 none of the treatments maintained complete control for the duration of the trial although aclonifen gave very good control for 2 months, Stomp 400SC and Springbok were the next most effective treatments followed by Goltix WG (Tables 15 and 16). Teridox was disappointing for the range of weeds controlled in this experiment.

<u>Stomp 400 SC</u>

Stomp 400 SC was moderately effective and maintained some weed control through to the end of the experiment. There was a high population of fat hen (*Chenopodium album* L.) which was well controlled. There was partial control of knotgrass (*Polygonum aviculare* L.), field pansy (*Viola arvensis* Murray), shepherds purse (*Capsella bursa-pastoris* L.) and common speedwell (*Veronica officionalis* L.) (Table 15). Annual meadow grass (*Poa annua* L.) black bindweed (*Fallopia conuluvulus*) and small nettle (*Urtica urens* L.), however were not well controlled

<u>Aclonifen</u>

Aclonifen was the most effective herbicide particularly in the early stages, controlling most weeds. As persistence was lost some annual meadow grass, field pansy (as in 2007), and common speedwell developed. Control of fat hen was good throughout.

<u>New Code A</u>

New Code A was much less effective at the lower rate used in 2008. The only weeds controlled well at this rate were annual meadow grass. There was partial control of fat hen, small nettle and shepherds purse.

<u>Goltix WG</u>

Although this herbicide can be used as a selective contact treatment, in this experiment it was used as a short-term residual. Weed control was quite good for the first 2 months but only moderate to poor over the trial duration as persistence was lost. Annual meadow grass and shepherds purse were very well controlled. There was partial control of black bindweed, fat hen and common speedwell but little control of knotgrass, small nettle and field pansy.

<u>Springbok</u>

Weed control was only moderately effective and maintained some weed control through to the end of the experiment. Apart from feverfew (*Chrysanthemum parthenium* L. Bernh.) no other weeds were well controlled. There was partial control of small nettle, field pansy, shepherds purse and common speedwell. Annual meadow grass, black bindweed and knotgrass were not controlled.

Teridox

Weed control was disappointing although annual meadow grass was well controlled.

Table 15:. Number of weed seedlings per m^2 following herbicide treatment

Treatment	Product	Total weeds	Annual meadow grass	Black bindeweed	Fat Hen	Feverfew	Knotgrass	Nettle, small	Field pansy	Shepherds purse	Speedwell, common
1.	Untreated	24.8	4.1	0.7	12.3	2.0	0.4	1.3	2.1	0.8	1.1
2.	Stomp 400 SC	12.1	6.2	0.5	1.2	0.1	0.2	1.0	0.4	0.4	0.2
3.	Aclonifen	1.5	0.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
4.	New Code A	13.5	1.0	0.4	5.5	0.2	1.1	0.5	3.4	0.4	0.6
5.	Goltix WG	9.8	0.6	0.2	4.0	0.4	0.8	1.0	1.3	0.0	0.4
6.	Springbok	16.0	4.8	0.8	7.0	0.0	0.6	0.4	0.5	0.4	0.4
7.	Teridox	18.2	1.3	0.8	8.0	1.3	1.1	1.4	3.5	0.4	0.4
	P (ANOVA)	0.005			0.091						
	df	12			12						
	SED	4.26			3.63						
	LSD	9.28			7.91						

Table 16: Percentage weed cover following herbicide treatment

Treatment	Product	% cover 3/07/08	% cover 30/07/08
1.	Untreated	54	80
2.	Stomp 400 SC	12	34
3.	Aclonifen	4	26
4.	New Code A	28	61
5.	Goltix WG	16	53
6.	Springbok	13	35
7.	Teridox	34	75
	P (ANOVA)	<0.001	<0.001
	df	12	12
	SED	3.62	6.75
	LSD	7.89	14.7

Conclusions

Acer campestre

None of the herbicide treatments reduced germination significantly. This species was only tested in 2008. Aclonifen reduced the crop vigour initially but plants recovered after 3 months. All other treatments were completely safe.

Stomp 400SC, New Code A, Goltix WG, Springbok and Teridox all have potential for use on Acer. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.

Alnus glutinosa

Some herbicide treatments caused a significant reduction in the number of seedlings emerged. The safest treatments were Stomp 400SC, Goltix WG and Springbok where the reductions were relatively minor both in 2007 and 2008. Aclonifen, New Code A and Teridox all reduced germination substantially in 2008 although aclonifen had been safer in 2007. New Code A had also reduced germination in 2007. It had been hoped that a lower rate would prove safer in 2008 although this was not the case. Stomp 400SC caused some reduction in vigour initially but the plants recovered, Goltix WG and Springbok were relatively safe, results were similar in 2007.

Goltix WG and Springbok have good potential for use on Alnus glutinosa, a higher rate of Springbok might even be tolerated. Stomp 400SC could be used but causes some vigour reduction. New Code A reduces germination but may have potential as a follow up treatment post germination.

Betula pendula

This crop is very sensitive to herbicides. Only Stomp 400SC and Springbok were consistently safe in both 2007 and 2008, having minimal effect on germination. and acceptable crop vigour. Although all treatments reduced vigour initially, by the end of the season the Stomp 400SC and Springbok treatments were of acceptable quality. Although Goltix WG and aclonifen appeared safe in 2007 (on *Betula pubescens*) both caused a substantial reduction in germination in 2008.

Stomp 400SC and Springbok have potential for use on Betula, but care is needed as this crop is subject to vigour reduction following herbicide use.

Cornus alba

This crop appeared very tolerant of the herbicides tested. Germination and crop vigour was not affected by any of the treatments.

Stomp 400SC, aclonifen, New Code A, Goltix WG, Springbok and Teridox all have potential for use on Cornus. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.

Crataegus monogyna

It had been thought that this crop was more tolerant of herbicides so in 2007 higher rates of herbicides were used. However only Stomp 400SC (2 L/ha) and Goltix WG (3 L/ha) were safe at higher rate. So in 2008 lower rates were used similar to the other crops. In addition to the Stomp 400SC and Goltix WG, Springbok and Teridox were safe when used at lower rates. Aclonifen and New Code A caused a significant but acceptable reduction in germination and all except aclonifen and Teridox retained acceptable vigour throughout the trial.

Stomp 400SC, New Code A, Goltix WG and Springbok all have potential for use on Crataegus. The higher rates of Stomp 400SC and Goltix WG used in 2007 should also be safe.

Fraxinus excelsior

This crop appeared very tolerant of the herbicides tested. Germination and crop vigour was not affected by the treatments except for aclonifen which reduced germination and crop vigour. There was some recovery by the end of the season.

Stomp 400SC New Code A, Goltix WG, Springbok and Teridox all have potential for use on Fraxinus. As the crop appeared to have good tolerance It is possible that higher rates than those tested could be used.

Rosa rubiginosa

This crop appeared quite tolerant of the herbicides tested. Germination and was not affected by the treatments except for aclonifen which reduced germination. Stomp 400SC and aclonifen reduced crop vigour initially but there was good recovery by the end of the season.

Stomp 400SC, New Code A, Goltix WG, Springbok and Teridox all have potential for use on Rosa. As the crop appeared to have good tolerance It is possible that higher rates of New Code A, Goltix WG and Springbok than those tested could be used.

Sorbus aucuparia

This crop is very sensitive to herbicides. Only Stomp 400SC and New Code A were consistently safe in both 2007 and 2008, having minimal effect on germination and acceptable crop vigour by the end of the season. Springbok and Goltix WG gave more variable results reducing either germination or vigour in one of the two years tested. Aclonifen caused crop loss in both years.

Stomp 400SC and New Code A have potential for use on Sorbus, but care is needed as this crop is subject to vigour reduction following herbicide use.

General

The herbicide New Code A shows good promise for use in small-seeded tree seedbeds but it will be necessary to use it at the 1.3 kg/ha dose rate used in 2007 to ensure good weed control. At the 1.3 kg/ha rate it is likely to be safe on *Acer*, *Cornus, Crataegus, Fraxinus, Rosa* and *Sorbus* but not *Alnus* or *Betula*. In the event of *New Code A* not becoming available to the UK, aclonifen, Stomp 400SC or Springbok are likely to be the next best option for weed control or Goltix WG for shorter term control. A combination of treatments is likely to be necessary to give adequate weed control. For *Betula* and *Alnus* the safer options are Stomp 400SC and Springbok. Teridox was tested for the first time in 2008 but weed control was poor at the rate used and there was insufficient crop tolerance to continue with this product.

Technology transfer

No technology transfer activities were undertaken during the first year of this project.

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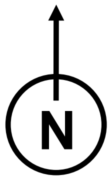
Appendices

Appendix 1: Experimental layout

Species block layout



Fraxinus	Acer
Crataegus	Rosa
Cornus	Alnus
Betula	Sorbus

Plot randomisation (the same for all species)

	Plot number	Treatment No	Herbicide Treatment
Block 1	1	6	Springbok
	2	3	Aclonifen
	3	4	New Code A
	4	5	Goltix
	5	1	Untreated
	6	2	Stomp
	7	7	Teridox
Block 2	8	7	Teridox
	9	1	Untreated
	10	5	Goltix
	11	4	New Code A
	12	6	Springbok
	13	2	Stomp
	14	3	Aclonifen
Block 3	15	6	Springbok
	16	3	Aclonifen
	17	4	New Code A
	18	5	Goltix
	19	7	Teridox
	20	2	Stomp
	21	1	Untreated

Plot dimensions

	< 1.5m >
< 2.0m >	Sub plot five rows of one species I I I I I < 1.35m > Bed

Appendix 2: Treatment list

Treatment	Product	Active ingredient	Product application rate	Approval status
1.	Untreated control			
2.	Stomp 400 SC	pendimethalin (400 /L)	1.0 L/ha	LTA*
3.	Not named	aclonifen	1.0 L/ha	Not in UK
4.	New Code A	Not disclosed	0.65 kg/ha	Not in UK
5.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha	LTA
6.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha	LTA
7.	Teridox	dimethachlor	1.5 L/ha	Not in UK

*Long-Term Arrangements for Extension of Use.