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Project leader:	John Atwood, ADAS UK Ltd
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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.

John Atwood
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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 currently rely on both expensive partial soil sterilisation treatments 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 Since then a number of herbicides have been withdrawn and another range of herbicides has become available.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 relative efficacy of new herbicides for control of weeds in small-seeded broadleaved tree species and their subsequent crop safety.

For the first year (reported here), individual herbicide products have been tested for safety and weed control efficacy on four small-seeded tree species. For the second and third years it is intended to devise and test the most promising herbicides in combinations or programmes to provide optimum weed control particularly in the early life of the crop and broaden the range of crop species tested.

Summary of the project and main conclusions

Seed beds of *Alnus glutinosa, Betula pubescens, Crataegus monogyna* and *Sorbus aucuparia* were prepared on 1 May 2007 and treated with pre-emeregence or post emegence (treatment 6, Boxer) herbicides 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[1] or 2.0 L/ha[2]	LTA*
3.	212 H 50WP	Not disclosed	30 gm/ha[1] or 60 gm/ha[2]	Not in UK
4.	Not named	aclonifen	1.0 L/ha[1] or 2.0 L/ha[2]	Not in UK
5.	A9950A	Not disclosed	1.3 kg/ha[1] or 2.6 kg/ha[2]	Not in UK
6.	Boxer	florasulam (50 g/L)	25 gm/ha[1] or 50 gm/ha[2]	LTA
7.	BUK9900H	Not disclosed	1.6 L/ha[1] or 3.2 L/ha[2]	Not in UK
8.	Centium	clomazone (360 g/L)	0.125 L/ha[1]or 0.250 L/ha[2]	LTA
9.	Dual Gold	s – metolachlor 960 (g/L)	0.8 L/ha[1] or 1.6 L/ha[2]	Not in UK
10.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha[1] or 3.0 kg/ha[2]	LTA
11.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha[1] or 2.5 kg/ha[2]	LTA
12.	Terano	flufenacet + metosulam (60 : 2.5 % w/w)	0.375 kg/ha[1] or 0.750 kg/ha[2]	Not in UK

[1] *Sorbus aucuparia, Betula pendula, Alnus glutinosa,* [2] *Crataegus monogyna*

*Long-Term Arrangements for Extension of Use.

Weed control

The effect of the herbicide treatments (lower rates) on weed control 50 days after treatment (recorded 28 June 2007) is shown below (Fig. 1).

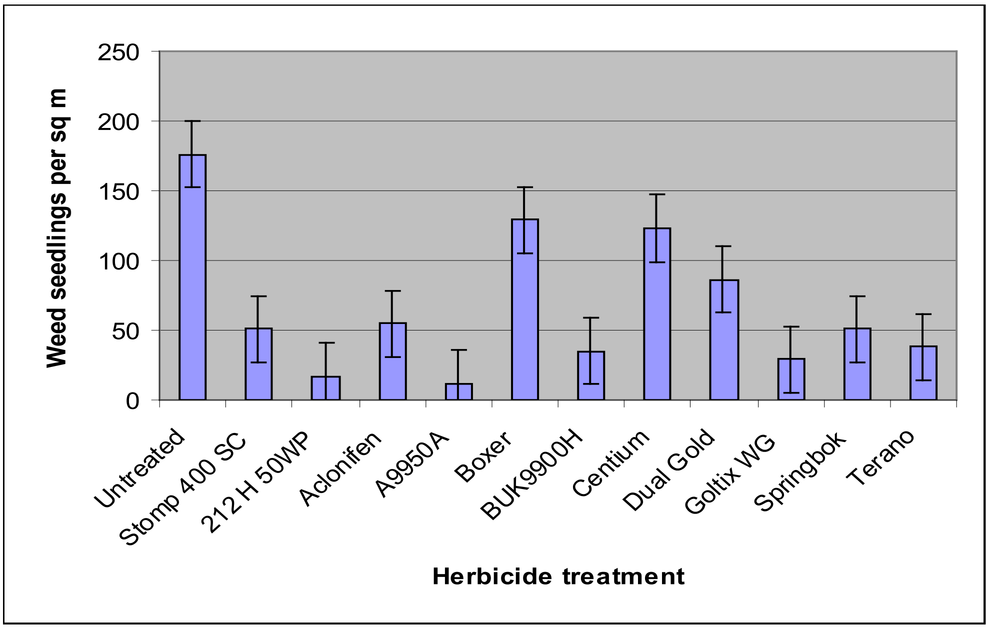

Figure 1. Weed seedlings per m^2 following herbicide treatments. When comparing treatments, differences falling within the error bar (SED) range are not significant at P = 0.05.

The most effective treatments for weed control were A9950A (Fig. 2) at both rates and Terano (Fig 3) at the higher rate. These were the only treatments to maintain a good weed control (<10% cover) through to the end of the experiment in September.

Figure 2. Use of A9950A resulted in very good weed control and crop vigour in *Sorbus*, August 2007

Figure 3. Good weed control from Terano in July, but reduced vigour in *Alnus.*

Stomp 400 SC

Stomp 400 SC was moderately effective at both rates and maintained some weed control through to the end of the experiment. There was a high population of annual meadow grass and field pansy at the site and Stomp 400 SC failed to give complete control of these. In addition Stomp 400 SC did not control groundsel or mayweed, a known weakness of this herbicide (Fig. 4)

Figure 4. Mayweed and groundsel in Stomp 400 SC plots

Figure 5. Good weed control apart from annual meadow grass in 212H 50WP plots

212H 50WP

212H 50WP controlled all weed species apart from annual meadow grass. Because of the high population of annual meadow grass (Fig. 5), the overall level of weed control was only moderate.

Aclonifen

Aclonifen was much more effective at the higher rate than at the lower rate. At the higher rate, 80% weed control was maintained up to September. Aclonifen controlled most weeds but groundsel was resistant and the high population of field pansy was only partially controlled.

A9950A

A9950A was one of the most effective herbicides in the experiment. Weed control was well maintained through to September (Fig. 6). The only weakness noted was poor control of groundsel. The high populations of annual meadow grass and field pansy were well controlled.

Figure 6. A9950A provided good weed control but reduced germination in *Crataegus*

Figure 7. Untreated

Boxer

Boxer was the only herbicide to be used as a post-emergence treatment against existing weeds. It was relatively ineffective against two of the most prevalent weeds on the site, annual meadow grass and field pansy. As a result the overall weed control was poor. However it did provide control of groundsel and mayweed.

BUK9900H

BUK9900H controlled most weed species apart from field pansy. Because of the high population of field pansy, the overall level of weed control was only moderate.

Centium

Centium failed to control most of the broadleaved weeds although at the higher rate the high population of annual meadow grass was completely controlled. Overall weed control was poor at the low rate and moderate at the higher rate.

Dual Gold

Overall weed control from Dual Gold was poor, particularly at the lower rate where a range of broadleaved weeds including a high population of field pansy was not controlled. At the higher rate, control of annual meadow grass was good and there was 88% control of groundsel.

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 moderate to poor because of the failure to control a high population of field pansy. Control of the other broadleaved weeds and annual meadow grass was good especially at the higher rate (Fig. 8).

Figure 8. Goltix WG treatment on *Betula*

Figure 9. Springbok treatment on *Betula* showing field pansy.

Springbok

Weed control was moderate to poor because of the failure to control a high population of field pansy (Fig 9). Control of the other broadleaved weeds and annual meadow grass was good especially at the higher rate.

Terano

Terano was very effective when used at the higher rate. At the end of August Terano achieved 94% weed control with the predominant weeds groundsel and field pansy.

Crop safety

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

Based on the germination results and crop vigour score a summary of crop tolerance is given in Table 2.

Table 2. Crop tolerance of herbicides

	Alnus	*Betula*	*Crataegus*	*Sorbus*
Stomp 400 SC	mS	T	T	T
212 H 50WP	S	S	S	S
Aclonifen	T	T	S	S
A9950A	T	S	S	T
Boxer	T	T	mS	mS
BUK9900H	T	S	S	S
Centium	mS	T	T	T
Dual Gold	T	T	S	S
Goltix WG	T	T	T	T
Springbok	T	T	S	S
Terano	S	T	S	S

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

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

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

Figure 10. Alnus treated with A9950A offered good weed control and crop vigour – see untreated control in the background

Figure 11. Betula treated with aclonifen.

Alnus

The most effective safe treatment was A9950A (Fig. 10). Aclonifen, Dual Gold, Stomp 400 SC and Goltix WG also appeared safe but were less effective for weed control. A9950A failed to control groundsel, but it might be possible to add Goltix WG for groundsel control.

Betula

The only safe treatments were Stomp 400 SC, aclonifen, Goltix WG and Springbok. All of these herbicides were similar in overall efficacy providing only moderate weed control (60-70% control). Aclonifen has the better weed control spectrum (Fig. 11) and should be tested at a higher rate or in combination with Stomp 400 SC or Goltix. The aclonifen + Stomp 400 SC combination has been tested in some vegetable crops.

Crataegus

The only treatments that proved adequately safe were Stomp 400 SC, Centium and Goltix WG. None of these treatments provided adequate weed control. A9950A severely reduced the plant population (Fig. 6) but did not adversely affect plant vigour. The lower dose rate of A9950A used with the other tree species was effective for weed control and may prove safe enough for use in *Crataegus*. Alternatively a combination of Stomp + Centium should be tested - this combination has been used effectively in cut flowers and vegetable crops.

Sorbus

The most effective safe treatment was A9950A. Stomp 400 SC, Centium and Goltix WG also appeared safe but were less effective for weed control. A9950A failed to control groundsel, but it might be possible to add Goltix WG or Centium for groundsel control.

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 of crop safety or longer-term effectiveness before recommendations can be developed. The most promising new treatments are not yet available commercially so a cost/benefit analysis 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 £1800/ha based on three weeding sessions of 100hrs/ha @ £6/hr = £600 per session.

Action points for growers

- When commercially available A9950A should be used as a treatment for weed control in *Alnus* and *Sorbus* and has possible potential for use in *Crataegus* but at a lower rate than was tested here.

- When commercially available aclonifen should be used as a treatment for weed control in *Betula.*

- Prior to the availalability of A9950A 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 available for use from 2007.

Further herbicide screening was carried out on a range of tree seedlings HNS 31 & HNS 31a (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 BUK9900H. Centium was successfully used in certain seed-raised cut flower crops (BOF51) (Hanks, 2005). A further herbicide range including A9950A, 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. For the first year (reported here), individual herbicide products have been tested for safety and weed control efficacy on four small-seeded tree species. For the second year it is intended to devise and test the most promising herbicides in combinations or programmes to provide optimum weed control particularly in the early life of the crop.

Materials and Methods

Crop details

Four seedbeds were prepared, one each for each of the test species used in the experiment; *Alnus glutinosa* (L.) Gaertn., *Betula pubescens* Ehrh., *Crataegus monogyna* Jacq., and *Sorbus aucuparia* L.

The soil (medium sandy loam) was initially cultivated using a Lemkin Rubin cultivator, beds were then formed using a 1.35m Bartschi bed former on 27 April 2007.

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.

Seed was mixed with fine sand and sown directly on the soil surface on 1 May 2007 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:

Alnus glutinosa	0.2 kgs per 100m
Betula pubescens	0.2 kgs per 100m
Crataegus monogyna	3.0 kgs per 100m
Sorbus aucuparia	0.25 kgs per 100m

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

Irrigation was applied after sowing as required. Two top dressings of 75 kg/ha Calcium nitrate were applied at end June 2007 and end July 2007. 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 3) (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. It was anticipated that *Crataegus* would be more tolerant of herbicides than *Alnus, Betula* or *Sorbus* so herbicide treatments were applied at either standard rate (*Crataegus*) or half rate (*Alnus, Betula* and *Sorbus*)

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 9 May 2007 except for post emergence treatment 6 (Boxer) which was applied on 29 May 2007 when weeds were at the 4 true leaf stage. The crop at this stage was the following growth stages; *Alnus* 1-2 true leaf, *Betula* cotyledon – 1 true leaf, *Crataegus* 1-2 true leaf, *Sorbus* 2-3 true leaf.

Table 3. 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[1] or 2.0 L/ha[2]	LTA*
3.	212 H 50WP	Not disclosed	30 gm/ha[1] or 60 gm/ha[2]	Not in UK
4.	Not named	aclonifen	1.0 L/ha[1] or 2.0 L/ha[2]	Not in UK
5.	A9950A	Not disclosed	1.3 kg/ha[1] or 2.6 kg/ha[2]	Not in UK
6.	Boxer	florasulam (50 g/L)	25 gm/ha[1] or 50 gm/ha[2]	LTA
7.	BUK9900H	Not disclosed	1.6 L/ha[1] or 3.2 L/ha[2]	Not in UK
8.	Centium	clomazone (360 g/L)	0.125 L/ha[1]or 0.250 L/ha[2]	LTA
9.	Dual Gold	s – metolachlor 960 (g/L)	0.8 L/ha[1] or 1.6 L/ha[2]	Not in UK
10.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha[1] or 3.0 kg/ha[2]	LTA
11.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha[1] or 2.5 kg/ha[2]	LTA
12.	Terano	flufenacet + metosulam (60 : 2.5 % w/w)	0.375 kg/ha[1] or 0.750 kg/ha[2]	Not in UK

[1] *Sorbus aucuparia, Betula pendula, Alnus glutinosa*

[2] *Crataegus monogyna*

*Long-Term Arrangements for Extension of Use.

Assessments

Weed control

The number of weed seedlings was recorded on 28 June 2007. Assessments were made using two 0.135 m^2 quadrads per sub-plot, randomly placed within the central 1.5m x 0.5m of the sub-plot. Further assessments of percentage weed cover were made on 19 July 2007 and 23 August 2007 on a whole plot basis.

Crop assessments

The number of crop seedlings was recorded on 28 June 2007. Assessments were made using two 0.135 m^2 quadrads per sub-plot, randomly placed within the central 1.5m x 0.5m of the sub-plot.

Crop vigour and phytotoxicity was assessed on 28 June 2007 19 July 2007 and 23 August 2007 using a scoring system (Table 4)

Table 4. 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 treatments except Boxer, Centium and Goltix WG significantly reduced the emergence of *Alnus* seedlings with 212H 50WP causing the greatest reduction (Table 5). However because of the relatively high seed rate used, the target population of 200 seedlings per bed m (270 per m^2) was exceeded in all treatment plots.

Although *Betula* germinated well there was more variability in emergence. 212H 50WP, A9950A, and BUK9900H caused a significant reduction in emergence, with A9950A causing the greatest reduction. The herbicide treatments Stomp 400 SC, Boxer, Centium, Dual Gold, Goltix WG and Springbok had the best germination counts. All treatments apart from A9950A achieved the target plant population.

Germination of *Sorbus* was slightly lower, but still above the target population. The herbicide treatments Stomp 400 SC, A9950A and Centium were the safest, causing no significant reduction in emergence. Treatments 212 H 50WP and aclonifen were the most damaging causing populations to be excessively thinned.

Crataegus germinated at a reduced rate with the crop population lower than target. Herbicide treatments Stomp 400 SC, Boxer, Centium and Goltix WG were the safest; none of these significantly reduced the plant poluation. 212H 50WP, aclonifen, A9950A, BUK9900H, Dual Gold, Springbok and Terano all significantly reduced the plant population. 212H 50WP and BUK9900H were the most damaging.

Table 5. Number of crop seedlings per m^2 following herbicide treatment

Treatment	Product	*Alnus*	*Betula*	*Crataegus*	*Sorbus*
1.	Untreated	1643	1280	136	619
2.	Stomp 400 SC	1090	1310	163	562
3.	212 H 50WP	494	560	2	44
4.	Aclonifen	1019	927	42	165
5.	A9950A	690	30	57	474
6.	Boxer	1574	1174	150	446
7.	BUK9900H	659	587	20	365
8.	Centium	1458	1208	138	565
9.	Dual Gold	1253	1544	62	420
10.	Goltix WG	1549	1026	131	446
11.	Springbok	1174	1234	59	343
12.	Terano	881	932	74	402
	P (ANOVA)	<0.001	0.003	<0.001	<0.001
	df	22	22	22	22
	SED	179.3	293.8	34.3	78.6

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 4), any treatment with a mean score of greater than 3 could be commercially acceptable but scores of 4 and above would be ideal.

Herbicide treatment A9950A stood out as giving exceptionally good vigour scores by the end of the season for *Alnus, Crataegus,* and *Sorbus* (Table 6). Although A9950A did cause some reduction in crop emergence for all three species it was not significant for *Sorbus* and within an acceptable range for *Alnus.* However the thinning of *Crataegus* was too severe to be acceptable. The *Crataegus* was treated at the x1 rate and a reduced rate should be tested against this species.

For *Alnus* the other treatments giving good vigour scores at both recording dates were 212H 50WP, aclonifen, Dual Gold and Goltix WG. Of these however, 212H 50WP severely reduced crop emergence.

Betula retained good crop vigour when treated with Stomp 400 SC, aclonifen, Boxer, Goltix

WG and Springbok. A9950A and BUK9900H were particularly damaging.

The *Crataegus* proved quite prone to damage, although it had been anticipated that the crop would be more resistant to herbicides and as a result higher doses were applied. Treatments that appeared to have least effect on crop vigour were Stomp 400 SC, A9950A, Centium and Goltix WG. Of these A9950A however severely reduced the crop emergence.

The results for *Sorbus* were very clear cut. Only Stomp 400 SC, A9950A, Centium and Goltix WG gave acceptable crop vigour, all other treatments reduced the crop vigour substantially.

Table 6. The effect of herbicide treatment on crop vigour score (1 = poor, 5 = good)

Treatment	Product	*Alnus*		*Betula*		*Crataegus*		*Sorbus*	
		Recording date							
		19/07	23/08	19/07	23/08	19/07	23/08	19/07	23/08
1.	Untreated	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2.	Stomp 400 SC	4.3	3.7	4.0	4.7	4.7	5.0	3.7	4.0
3.	212 H 50WP	3.7	4.3	3.3	4.7	1.0	1.0	1.0	1.0
4.	Aclonifen	4.0	5.0	4.3	5.0	1.0	2.3	1.0	2.0
5.	A9950A	2.7	5.0	1.3	1.0	2.7	5.0	5.0	4.7
6.	Boxer	2.0	4.0	3.7	4.7	3.3	3.3	3.0	3.3
7.	BUK9900H	1.3	4.0	2.3	3.0	1.0	3.0	1.0	2.0
8.	Centium	2.7	3.7	3.3	4.0	3.7	5.0	4.0	4.0
9.	Dual Gold	3.7	4.0	3.3	4.0	1.3	3.3	1.7	2.3
10.	Goltix WG	4.7	4.3	4.3	4.7	5.0	5.0	3.7	4.3
11.	Springbok	3.3	4.3	4.7	5.0	1.3	4.7	1.7	2.3
12.	Terano	1.3	3.0	2.7	4.7	1.0	5.0	2.0	2.0
	P (ANOVA)	<0.001	0.43	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	df	22	22	22	22	22	22	22	22
	SED	0.424	0.837	0.563	0.464	0.477	0.613	0.272	0.449

Weed control assessments

The most effective treatments for weed control were A9950A at both rates and Terano at the higher rate. These were the only treatments to maintain a good weed control (<10% cover) through to the end of the experiment in September (Table 8).

Stomp 400 SC

Stomp 400 SC was moderately effective at both rates and maintained some weed control through to the end of the experiment. There was a high population of annual meadow grass (*Poa annua* L.) and field pansy (*Viola arvensis* Murray) at the site and Stomp 400 SC failed to give complete control of these (Table 8). In addition Stomp 400 SC did not control groundsel (*Senecio vulgaris* L.) or ray-less mayweed (*Matricaria matricariodes* Porter), a known weakness of this herbicide.

212H 50WP

212H 50WP controlled all weed species apart from annual meadow grass (Tables 8 and 9). Because of the high population of annual meadow grass, the overall level of weed control was only moderate.

Aclonifen

Aclonifen was much more effective at the higher rate than at the lower rate. At the higher rate, weed control was good, maintaining 80% control at the end of the experiment (Table 9). Aclonifen controlled most weeds but groundsel was resistant and the high population of field pansy was only partially controlled.

A9950A

A9950A was one of the most effective herbicides in the experiment. Weed control was well maintained through to the end of the experiment (Table 9). The only weakness noted was poor control of groundsel. The high populations of annual meadow grass and field pansy were well controlled.

Boxer

Boxer was the only herbicide to be used as a post-emergence treatment against existing weeds. It was relatively ineffective against two of the most prevalent weeds on the site, annual meadow grass and field pansy. As a result the overall weed control was poor. However it did provide control of groundsel and mayweed.

BUK9900H

BUK9900H controlled most weed species apart from field pansy (Tables 8 and 9). Because of the high population of field pansy, the overall level of weed control was only moderate.

Centium

Centium did not control most of the broad leaved weeds although at the higher rate the high population of annual meadow grass was completely controlled. Overall weed control was poor at the low rate, moderate at the higher rate.

Dual Gold

Overall weed control from Dual Gold was quite poor, particularly at the lower rate where a range of broadleaved weeds including a high population of field pansy were not controlled. At the higher rate control of annual meadow grass was good and there was 88% control of groundsel (Table 7).

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 only moderate to poor because of the failure to control a high population of field pansy. Control of the other broadleaved weeds and annual meadow grass was good especially at the higher rate.

Springbok

Weed control was only moderate to poor because of the failure to control a high population of field pansy. Control of the other broadleaved weeds and annual meadow grass was good especially at the higher rate.

Terano

Terano was very effective when used at the higher rate. By the end of the experiment Terano achieved 94% weed control with the predominant weeds groundsel and field pansy.

Table 7. Number of weed seedlings per m^2 following herbicide treatment

Treatment	Product	Rate	Total weeds	Annual meadow grass	Groundsel	Nettle, small	Knotgrass	Field pansy	Mayweed	Shepherds purse	Speedwell, common	Other weeds
1.	Untreated	[1]	176	84	2	0	4	30	1	2	2	51
		[2]	217	126	17	15	0	25	17	0	10	7
2.	Stomp 400 SC	x0.5	51	10	15	0	6	12	0	0	0	
		x1	37	7	12	0	0	5	5	0	0	8
3.	212 H 50WP	x0.5	17	14	0	0	1	1	0	0	0	
		x1	35	35	0	0	0	0	0	0	0	0
4.	Aclonifen	x0.5	55	5	12	0	5	21	1	0	0	
		x1	17	0	10	0	0	7	0	0	0	0
5.	A9950A	x0.5	12	1	7	0	4	0	0	0	0	
		x1	22	0	20	0	0	0	0	0	0	2
6.	Boxer	x0.5	129	74	4	0	2	15	0	1	4	
		x1	187	146	2	0	0	27	0	2	10	0
7.	BUK9900H	x0.5	35	0	0	1	2	14	0	1	1	
		x1	22	0	0	0	0	22	0	0	0	0
8.	Centium	x0.5	123	53	3	0	6	31	0	2	2	
		x1	67	0	5	5	0	30	17	2	2	6
9.	Dual Gold	x0.5	86	7	5	1	9	31	3	5	0	
		x1	42	0	2	0	0	30	2	0	0	10
10.	Goltix WG	x0.5	29	3	1	0	1	12	0	0	1	
		x1	37	0	2	0	0	30	0	0	2	5
11.	Springbok	x0.5	51	2	3	0	2	25	0	0	1	
		x1	27	0	0	0	0	22	0	0	0	5
12.	Terano	x0.5	38	0	7	0	1	16	0	0	0	
		x1	0	0	0	0	0	0	0	0	0	0
	P (ANOVA)		<0.001									
	df		22									
	SED		23.81[1]									
			18.13[2]									

[1] For comparison between x0.5 rate treatments

[2] For comparison between x1 rate treatments

Table 8. Percentage weed cover and predominant weed species following herbicide treatment

Treatment	Product	Rate	% cover 19/07/07	% cover 23/08/08	Annual meadow grass	Groundsel	Fat Hen	Field pansy	Nightshade, black	Mayweed	Speedwell, common
1.	Untreated	[1]	64.4	78.3							
		[2]	50.0	90.0	x			x		x	x
2.	Stomp 400 SC	x0.5	16.1	28.1							
		x1	16.7	33.3	x		x	x		x	
3.	212 H 50WP	x0.5	7.8	17.7							
		x1	13.3	28.3	x						
4.	Aclonifen	x0.5	16.7	38.9							
		x1	5.0	20.0	x			x	x		
5.	A9950A	x0.5	2.1	7.2							
		x1	2.3	5.0		x					
6.	Boxer	x0.5	48.9	71.1							
		x1	33.3	76.7	x					x	x
7.	BUK9900H	x0.5	16.9	35.6							
		x1	5.0	20.0				x			
8.	Centium	x0.5	50.6	67.8							
		x1	33.3	35.0				x		x	x
9.	Dual Gold	x0.5	35.6	51.7							
		x1	25.0	41.7		x	x			x	
10.	Goltix WG	x0.5	19.4	34.4							
		x1	15.0	36.7	x			x	x		
11.	Springbok	x0.5	15.6	28.9							
		x1	7.3	18.3		x		x		x	
12.	Terano	x0.5	8.3	20.6							
		x1	0.3	6.7		x		x			
	P (ANOVA)		<0.001	<0.001							
	df		22	22							
	SED		4.9[1]	8.3[1]							
			5.2[2]	5.1[2]							

x denotes the predominant weed species

[1] For comparison between x0.5 rate treatments

[2] For comparison between x1 rate treatments

Conclusions

Alnus

The most effective safe treatment was A9950A. Aclonifen, Dual Gold, Stomp 400 SC and Goltix WG also appeared safe but were less effective for weed control. A9950A failed to control groundsel, but it might be possible to add Goltix WG for groundsel control. Clopyralid can be used in some tree species for post emergence groundsel control (Willoughby *et al.*, 2006).

Betula

The only safe treatments were Stomp 400 SC, aclonifen, Goltix WG and Springbok. All of these herbicides were similar in overall efficacy providing only moderate weed control (60-70% control). Aclonifen has the better weed control spectrum and should be tested at a higher rate or in combination with Stomp 400 SC or Goltix. The aclonifen + Stomp 400 SC combination has been tested in some vegetable crops.

Crataegus

The only treatments that proved adequately safe were Stomp 400 SC, Centium and Goltix WG. None of these treatments provided adequate weed control. A9950A severely reduced the plant population but did not adversely affect plant vigour. The lower dose rate of A9950A used with the other tree species was effective for weed control and may prove safe enough for use in *Crataegus*. Alternatively a combination of Stomp + Centium should be tested - this combination has been used effectively in cut flowers and vegetable crops.

Sorbus

The most effective safe treatment was A9950A. Stomp 400 SC, Centium and Goltix WG also appeared safe but were less effective for weed control. A9950A failed to control groundsel, but it might be possible to add Goltix WG or Centium for groundsel control.

General

The herbicide A9950A shows great promise for use in small-seeded tree seedbeds. Even at the lower rate of use, weed control was superior to most of the other treatments and the crop vigour of *Alnus* and *Sorbus* was not significantly affected. These two species are normally very sensitive to herbicides. For *Crataegus* the rates of herbicides may have been too high and lower rates particularly for A9950A should be tested.

Technology transfer

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

References

Atwood, J. (2006). Control of problem weeds in Hardy Nursery Stock. 1st Annual Report for HDC Project HNS 139.

Atwood, J. (2007). Control of problem weeds in Hardy Nursery Stock. 2nd Annual Report for HDC Project HNS 139.

Brough, W. (1993). Evaluation of weed control treatments in tree and shrub seed beds and first year outdoor transplants. Final report for HDC Project HNS 31.

Brough, W. (1997). Tree and shrub seed beds: continued evaluation of weed control treatments. Final report for HDC Project HNS 31a.

Burgess, C. (2006). Roses: Triazine-free herbicide programmes. 1st Annual Report for HDC Project HNS 132.

Cooper, P. (1982). Seedbed herbicide trials. Rev. Luddington Exp. Hort. Stn for 1981 pp32-6

Hanks, G. (2005). Outdoor flowers: an evaluation of herbicides. Final report for HDC Project BOF 51.

Knott, C. (2006a). Vegetables: Solutions to the loss of active ingredients for weed control in vegetable crops. 2nd Annual Report for HDC Project HNS 256.

Knott, C. (2006b). Brassicas: To investigate safe and effective new herbicides for weed control to replace those lost through the EU review. 2nd Annual Report for HDC Project HNS 270.

Willoughby, I., Clay, D. and Dixon, F. (2003). The effect of pre-emergent herbicides on ger mination and early growth of broadleaved species used for direct seeding. Forestry 76: 83-94.

Willoughby, I., Dixon, F. L., Clay, D. and Jinks, R. L. (2007). Tolerance of broadleaved tree and shrub seedlings to preemergence herbicides. New Forest 34:1-12.

Willoughby, I., Jinks, R. L. and Stokes, V. (2006). The tolerance of newly emerged broadleaved tree seedlings to the herbicides clopyralid, cycloxydim and metazachlor. Forestry 79: 599-608.

Appendices

Appendix 1: Experimental layout

Block	*Sorbus*		*Alnus*		*Betula*		*Crataegus*	
	Sub plot No	Treatment	Sub plot No	Treatment	Sub plot No	Treatment	Sub plot No	Treatment
I	1s	5	1a	5	1b	5	1c	5
	2s	6	2a	6	2b	6	2c	6
	3s	3	3a	3	3b	3	3c	3
	4s	10	4a	10	4b	10	4c	10
	5s	1	5a	1	5b	1	5c	1
	6s	4	6a	4	6b	4	6c	4
	7s	12	7a	12	7b	12	7c	12
	8s	2	8a	2	8b	2	8c	2
	9s	9	9a	9	9b	9	9c	9
	10s	11	10a	11	10b	11	10c	11
	11s	8	11a	8	11b	8	11c	8
	12s	7	12a	7	12b	7	12c	7
II	13s	4	13a	4	13b	4	13c	4
	14s	7	14a	7	14b	7	14c	7
	15s	2	15a	2	15b	2	15c	2
	16s	9	16a	9	16b	9	16c	9
	17s	5	17a	5	17b	5	17c	5
	18s	11	18a	11	18b	11	18c	11
	19s	3	19a	3	19b	3	19c	3
	20s	12	20a	12	20b	12	20c	12
	21s	1	21a	1	21b	1	21c	1
	22s	10	22a	10	22b	10	22c	10
	23s	8	23a	8	23b	8	23c	8
	24s	6	24a	6	24b	6	24c	6
III	25s	3	25a	3	25b	3	25c	3
	26s	8	26a	8	26b	8	26c	8
	27s	5	27a	5	27b	5	27c	5
	28s	6	28a	6	28b	6	28c	6
	29s	1	29a	1	29b	1	29c	1
	30s	11	30a	11	30b	11	30c	11
	31s	2	31a	2	31b	2	31c	2
	32s	4	32a	4	32b	4	32c	4
	33s	12	33a	12	33b	12	33c	12
	34s	9	34a	9	34b	9	34c	9
	35s	10	35a	10	35b	10	35c	10
	36s	7	36a	7	36b	7	36c	7

	< 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 g/L)	1.0 L/ha[1] or 2.0 L/ha[2]	LTA*
3.	212 H 50WP	Not disclosed	30 gm/ha[1] or 60 gm/ha[2]	Not in UK
4.	Not named	aclonifen (600 g/L)	1.0 L/ha[1] or 2.0 L/ha[2]	Not in UK
5.	A9950A	Not disclosed	1.3 kg/ha[1] or 2.6 kg/ha[2]	Not in UK
6.	Boxer	florasulam (50 g/L)	25 gm/ha[1] or 50 gm/ha[2]	LTA
7.	BUK9900H	Not disclosed	1.6 L/ha[1] or 3.2 L/ha[2]	Not in UK
8.	Centium	clomazone (360 g/L)	0.125 L/ha[1]or 0.250 L/ha[2]	LTA
9.	Dual Gold	s – metolachlor (960 g/L)	0.8 L/ha[1] or 1.6 L/ha[2]	Not in UK
10.	Goltix WG	metamitron (70 % w/w)	1.5 kg/ha[1] or 3.0 kg/ha[2]	LTA
11.	Springbok	metazachlor + dimethenamid-P (200 : 200 g/L)	1.25 kg/ha[1] or 2.5 kg/ha[2]	LTA
12.	Terano	flufenacet + metosulam (60 : 2.5 % w/w)	0.375 kg/ha[1] or 0.750 kg/ha[2]	Not in UK

*Long-Term Arrangements for Extension of Use.