Project title	Hardy Ornamental Nursery Stock: Preventing outdoor container grown nursery stock plants rooting through into capillary sand-beds via the use of herbicide treatments to the surface of the bed.
Project number:	HNS 167
Project leader:	John Atwood, ADAS UK Ltd.
Report:	Final report, March 2009
Previous report	
Key staff:	John Atwood, ADAS, Project Leader David Hutchinson, ADAS Associate, project worker Chris Dyer, ADAS, statistician
Location of project:	Darby Nursery Stock Ltd. Methwold, Norfolk, IP26 4PW & Kingfisher Nursery, Gedney Hill, Spalding, Lincs, PE12 0RU.
Project coordinator:	Alastair Hazel, Darby Nursery Stock Ltd. Methwold, Norfolk, IP26 4PW.
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Buddleija, capillary sand-beds, Chikara, container plants, diflufenican, Efford sand-beds, *Erica* x *darleyensis,* flazasulfuron, flumioxazin, hardy ornamental nursery stock, herbicides, Hurricane SC, nursery stock, ornamentals, pendimethalin, rooting through, *Spiraea,* Stomp 400SC, Sumimax, *Vinca,* weed control, *Weigelia*

AUTHENTICATION FOR HNS167

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

Senior Horticultural Consultant

ADAS UK Ltd

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Report authorised by:

Dr W E Parker

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GROWER SUMMARY

Headline

- A range of herbicide products have been assessed for their efficacy in preventing outdoor container grown nursery stock plants rooting through into capillary sand-beds and the most successful have been identified.

Background and expected deliverables

Outdoor capillary sand-beds are an efficient method for delivering optimum levels of water to container grown plants, allowing little waste in summer and permitting efficient drainage of excessive winter rainfall. The use of such beds helps to ensure the growth of a strong healthy root system on plants and hence the development of quality plants.

However, one drawback of capillary sand-beds is that some plant species root out of the container and into the sand. This is problematic in that it takes more time to lift and clean a crop and significant damage to the surface of the capillary sand-bed occurs at lifting.

Some growers tackle this issue by covering the surface of the bed with micro-perforated polythene or a non-woven / woven fabric, such as Tex-R or Mypex. However, the polythene products require frequent replacement, some of the fabric materials can impede the capillary action with smaller pot sizes and some plant species still manage to root through some of the covering materials.

In terms of chemical alternatives to prevent rooting through, the quaternary ammonium product Gloquat C was used by growers for many years until it was withdrawn. In recent years the herbicide Ardent (diflufenican + trifluralin) has been used, but as a result of the active ingredient trifluralin not being included in Annex 1 of Council Directive 91/414/EEC, professional products containing trifluralin are to be withdrawn. Ardent has not been available since 31 August 2008.

The withdrawal of Ardent has posed growers problems in preventing rooting through into sand-beds with no proven alternative herbicide treatment. Ardent also had the added benefit of providing some measure of weed control on the surface of the bed. Finding a replacement to Ardent is crucial to the continued successful employment of capillary sand-bed technology in the UK.

Summary of the project and main conclusions

During 2008, two screening experiments were conducted to assess herbicide treatments with potential to prevent rooting through as well as providing useful weed control. One experiment was undertaken on a heather nursery, using the more vigorous *Erica* x *darleyensis* cultivars. The other experiment was undertaken on a general nursery stock site using four vigorous shrub species, *Spiraea, Weigela, Buddleija* and *Vinca*. The same treatments were used at both sites (Table 1) and were applied to plots laid out on the sand-bed immediately prior to setting down newly potted plants.

Table 1. Herbicide treatments applied at experimental sites

No.	***Trade name***	***Active ingredient***	***Rate***	***Approval status***
1	Untreated control			
2	New Code A	not disclosed	1.0 kg/ha	Not in UK
3	Hurricane SC	diflufenican 500 g/L	0.1 L/ha	LTA
4	Hurricane SC	diflufenican 500 g/L	0.2 L/ha	LTA
5	Stomp 400SC	pendimethalin 400 g/L	3.3 L/ha	SOLA
6	Sumimax	flumioxazin 300 g/L	0.1 L/ha	SOLA
7	Chikara	flazasulfuron 25% w/w	0.15 kg/ha	Non crop areas
8	Stomp 400SC + Hurricane SC	pendimethalin 400 g/L + diflufenican 500 g/L	3.3 L/ha + 0.1 L/ha	SOLA / LTA

Plants were lifted in November and the amount of rooting through assessed. A further lifting assessment was made in March for the shrub species. For the heather crops, Stomp 400SC (pendimethalin), Chikara (flazasulfuron) and New code A prevented rooting through completely for both cultivars tested. Sumimax (flumioxazin) had a partial effect but Hurricane SC (diflufenican) was ineffective.

For vigorous nursery stock species, rooting through proved more difficult to prevent. Of the four species tested, *Buddleja* and *Spiraea* had the most vigorous root system and Chikara was the only treatment to largely prevent rooting through on *Buddleja*. Other treatments such as New Code A and Sumimax appeared to have a small effect on some species but were much less consistent.

The effect on the root system in the pots was also studied. For heathers the treatments New Code A and Chikara did reduce the amount of root reaching the bottom of the pot. Although the root system was healthy there was less root at the bottom of the pot which is of

commercial concern. Stomp 400SC had no adverse effect on rooting within the pot. The root system of *Spiraea* was unaffected by the Chikara treatment but there was a small reduction in the amount of *Buddleja* root.

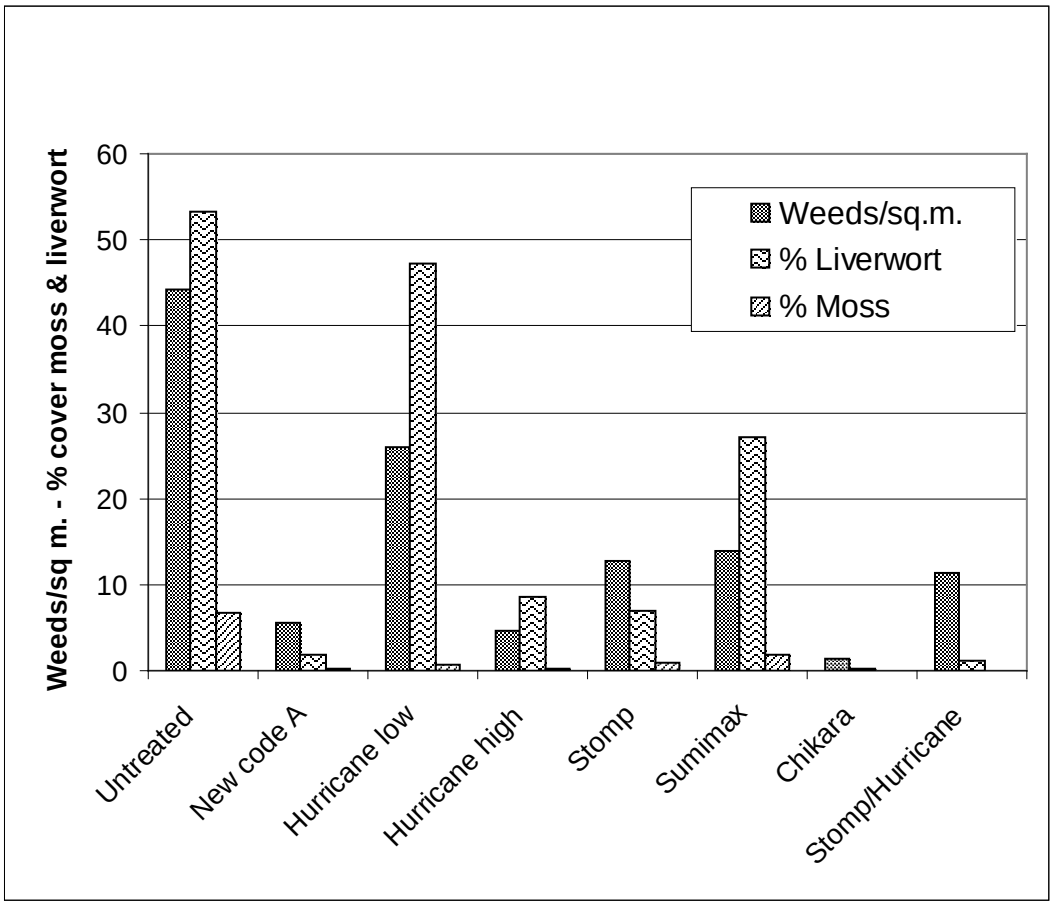


*Figure 1.*The effect of treatment on weed cover (weeds/m^2) and percentage cover by liverwort and moss in sand-beds, Kingfisher Nursery, assessed 4 November 2008.

The most prevalent weeds across the two sites were annual meadow grass (*Poa annua*), American willowherb (*Epilobium ciliatum*), and liverwort (*Marchantia polymorpha*. Groundsel (*Senecio vulgaris*), Canadian fleabane (*Conyza Canadensis*) and moss (*Funaria hygrometrica*) were also present to a lesser extent. Overall Chikara gave the best weed control. (Fig. 1). Sumimax gave some control of groundsel and moss. Hurricane SC controlled willowherb. New Code A gave good control of annual meadow grass. Weed control from Stomp 400SC was poorer but it did control liverwort to some extent. Unfortunately it now seems unlikely that New Code A will be developed for the UK or European market.

In conclusion, Chikara appears to have potential for use as a sand-bed treatment for container grown shrubs for reducing rooting through and for general weed control. Chikara has UK approval for use as a total herbicide on land not intended to bear vegetation. The current approval does not allow use on sand-beds so a SOLA would be required to permit this use. For heathers the rate used may need to be reduced to avoid inhibiting root development in the pot. Stomp 400SC may be a satisfactory alternative for heather beds but the formulation is unpopular with some users and the active ingredient may be withdrawn in the future under the latest EC proposals.

A study was also conducted to check leachate levels in the sand-bed drainage water following a December application of Stomp 400SC and Chikara. No residues were found in the drainage water.

Financial benefits

The main cost to growers from excess rooting through is increased maintenance cost for the sand-beds, increased time spent lifting plants for dispatch and re-sanding and levelling every year instead of every 5 years. The cost of repairing a sand-bed is estimated at £1.50/m^2 for sand and £0.20/m^2 for labour per year, representing an overall cost of £17,000 per ha.

There are estimated to be 120 ha of sand-beds in Great Britain. The total cost of repair would be £2.04 million per annum in the absence of a suitable sand-bed treatment, compared with £408,000 per annum for repair one year in five. This gives a saving of £1.63 million per annum.

In addition the cost of lifting a pot is estimated to be four times for a plant which has rooted through due to additional time spent cleaning compared with a clean pot,. The cost of lifting could therefore be 4p per pot compared with 1p per pot. For 120 ha of sand-beds this additional cost is estimated at £3,675 per annum given a cost of £0.03 per pot and an average stocking rate of 125,000 pots per ha.

There are also possible benefits (not costed) if the sand-bed herbicide treatments were applicable to gravel beds and resulted in improved weed control compared with standard treatments.

Action points for growers

- Chikara appears to have potential for use as a sand-bed treatment to prevent rooting through and gave excellent weed control of the predominant weed species in

this study (annual meadow grass and American willowherb) and liverwort. A SOLA would be required to allow this use.

- Chikara may need to be used at a reduced rate for heathers to ensure full root development in the pot.
- Stomp 400SC is an alternative sand-bed treatment for heathers which gave better root development in the pot.
- Because of the limited number of species tested in this project over one season it would be advisable for growers to be cautious and try a small area first before scaling-up to treating larger areas.

SCIENCE SECTION

Introduction

Outdoor capillary sand-beds are an efficient method for delivering optimum levels of water to container grown plants, allowing little waste in summer and permitting efficient drainage of excessive winter rainfall. The use of such beds helps to ensure the growth of a strong healthy root system on plants and hence the development of quality plants.

A serious issue with container grown plants on capillary sand-beds is that some plant species root out of the container and into the sand. This is problematic in that it takes more time to lift and clean a crop and it can potentially significantly damage the surface of the capillary sand-bed at lifting.

Some growers tackle this issue by covering the surface of the bed with micro-perforated polythene or a non-woven/woven fabric, such as Tex-R or Mypex^{TM}. However, the polythene products require frequent replacement, some of the fabric materials can impede the capillary action with smaller pot sizes and some plant species still manage to root through some of the covering materials.

In terms of chemical alternatives to prevent rooting through, the quaternary ammonium product Gloquat C was used by growers for many years until it was withdrawn. Following the results of an earlier screening trial – HNS 35d (Rowell, 1996) - the herbicide Ardent (diflufenican + trifluralin) has been used, but as a result of the active ingredient trifluralin not making Annex 1 of Council Directive 91/414/EEC, professional products containing trifluralin are to be withdrawn. Ardent has not been available since 31 August 2008.

The withdrawal of Ardent has left a considerable gap in the control of rooting through into sand-beds with no proven alternative herbicide treatment. The product also had the added benefit of providing some measure of weed control on the surface of the bed. Finding a replacement to Ardent is crucial to the continued successful employment of capillary sand-bed technology in the UK.

Materials and methods

Site locations

Two experiments were set up in June 2008 to test herbicide combinations applied to the sand-beds before standing down in order to prevent rooting through. Two sites were used:

1. Darby Nursery Stock Ltd., to test the effect of treatments on container grown shrubs.

2. Kingfisher Nurseries to test the effect of treatments on heathers.

Experimental design

The experiments were laid out in a randomised split plot design with two treatment factors: 1) herbicide treatment (8 in total); 2) crop species (four species at Darby Nursery Stock, two species at Kingfisher Nurseries), with three replicate blocks giving a total of 24 main plots. The experimental layout differed slightly at the two sites because of the different dimensions of the sand-beds and the plants tested:

1. At Darby Nursery Stock, the plots were 1.5 m wide and 2 m long, divided into four sub-plots each containing five plants of a crop species. There were 0.3 m pathways between plots and a 0.5 m pathway between blocks. The rows of pots were placed on one half of the plot, the other half of the plot was used for recording weed growth in the sand-bed (for layout see Appendix 1).
2. At Kingfisher nursery the plots were 1.5 m wide and 1m long, divided into two sub-plots each containing 20 plants of a crop species. There were 0.1m pathways between plots. Two empot carriers each containing 20 plants of a single species were placed in the centre of each plot. The remainder of the plot was used for recording weed growth in the sand-bed (for layout see Appendix 2).

Herbicide treatments

The herbicide treatments used (Table 2) were common to both sites.

Table 2. Herbicide treatments applied at experimental sites

No.	***Trade name***	***Active ingredient***	***Rate***	***Approval status***
1	Untreated control			
2	New Code A	not disclosed	1.0 kg/ha	Not in UK
3	Hurricane SC	diflufenican 500 g/L	0.1 L/ha	LTA
4	Hurricane SC	diflufenican 500 g/L	0.2 L/ha	LTA
5	Stomp 400SC	pendimethalin 400 g/L	3.3 L/ha	SOLA
6	Sumimax	flumioxazin 300 g/L	0.1 L/ha	SOLA
7	Chikara	flazasulfuron 25% w/w	0.15 kg/ha	Non crop areas
8	Stomp 400SC + Hurricane SC	pendimethalin 400 g/L + diflufenican 500 g/L	3.3 L/ha + 0.1 L/ha	SOLA / LTA

Treatments were applied in 2000 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 (Darby Nursery Stock) or with a Cooper-Pegler CP-15 Knapsack Sprayer with a 1.5 m boom with (green) fan jet spray nozzles (Kingfisher Nursery). Treatments were applied on 4 July 2008 (Darby Nursery Stock) and 18 June 2008 (Kingfisher Nursery). Following application of the herbicide treatments to the sand-bed, the plants were stood down on the beds in the plot arrangement described below.

Plant species and crop husbandry

At Darby Nursery Stock, the plant species tested were *Buddleija* 'Black Knight', *Spiraea japonica* 'Firelight', *Vinca major* 'Maculata' and *Weigelia florida* 'Follis Purpureus'. All were newly potted from 9 cm liners in mid June 2008. The growing media was:

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

At Kingfisher Nurseries the plant species were *Erica* x *darleyensis* 'White Perfection' and *Erica darleyensis* 'Helen'. All were newly potted from rooted plugs in early June 2008. The growing media was:

100% Medium grade peat
1.0 kg/m^3 Osmocote Exact 3-4 month
1.5 kg/m^3 Osmocote Exact 12-14 month
0.8 kg/m^3 Magnesium limestone

No other pesticide or fertilizer applications were made during the period of the experiment. Irrigation was supplied by capillary uptake from the sand-beds.

Assessments

Kingfisher Nurseries - heathers

1. Rooting through was assessed on 11 November 2008 by carefully lifting the trays of plants and measuring the length of root lifted with the plants. Results were expressed as a percentage of the untreated control.
2. Weed control was assessed on 17 September 2008 and 4 November 2008 by counting the number of seedling weeds within the plot area that was not covered by heather plants, a total of 1.5 m^2 per plot. Results were converted to weeds/m^2. Moss and liverwort infestation was assessed as percentage cover.
3. Crop height for each species was assessed on 17 September 2008 by measuring the maximum height of the 20 plants within an empot carrier for each plot.
4. The plants were examined for signs of phytotoxicity on 17 September 2008 and 11 November 2008.

Darby Nursery Stock – shrub species

1. Rooting through was assessed on 11 November 2008 and 9 March 2009 by carefully lifting two (11 November) or three (9 March) plants and measuring the length of root lifted with the plants. Two assessments were made because at the November assessment the *Weigelia* and *Vinca* had only slightly rooted through,
2. Weed control was assessed on 17 September 2008 and 11 November 2008 by counting the number of seedling weeds within the plot area that was not covered by plant subjects, a total of 1.3 m^2 per plot. Results were converted to weeds/m^2. Moss and liverwort infestation was assessed as percentage cover.
3. Crop height was assessed on 17 September 2008 by measuring the height of the three central plants for each species for each plot.
4. The plants were examined for signs of phytotoxicity on 17 September 2008 and 11 November 2008.

Statistical analyses

All data were subjected to analysis of variance (ANOVA). Where F ratios were significant, means were separated using the least significant difference (L.S.D.) test.

Herbicide leaching assessment

An assessment of the risk from herbicide leaching was made at Kingfisher Nurseries by treating two entire non-cropped sand-beds on 8 December 2008. One was treated with Stomp 400SC at 3.3 L/ha, the other was treated with Chikara at 0.15 kg/ha, both applied in a water volume of 2,000 L/ha. Treatments were applied using a Cooper-Pegler CP-15 Knapsack Sprayer with a 1.5 m boom with (green) fan jet spray nozzles. Following treatment there was relatively little precipitation during December (Appendix 3).

The heaviest precipitation fell in the first half of February (53 mm) as snow (Appendix 3). Water samples were collected from the sand-bed drains on 18 February 2009 following a thaw of accumulated snowfall and on 9 March 2009 after a further 16 mm of rainfall had accumulated. The samples were kept frozen until analysis. Analysis was done by QTS Analytical Ltd, East Malling Research, East Malling, Kent, ME19 6BJ to a reporting limit of 1 µg/l for flazasulfuron and 0.25 µg/l for pendimethalin.

Results and discussion

Kingfisher Nurseries - heathers

Rooting through

All of the heather plants (*Erica* x *darleyensis* 'Mary Helen' and 'White Perfection') were lifted on 11 November and the amount of rooting through assessed (Table 3). Stomp 400SC, Chikara and New Code A prevented rooting through completely for both cultivars tested (Figs. 2 and 3), Sumimax had a partial effect and Hurricane SC was ineffective.

Table 3. Effect of treatment on percentage rooting through (control = 100%) of heathers at Kingfisher Nurseries, assessed 11 November 2008

			% rooting through	
Treatment		**Rate**	**Mary Helen**	**White Perfection**
1	Untreated control		100.0	100.0
2	New Code A	1.0 kg/ha	0	0
3	Hurricane SC	0.1 L/ha	83.3	83.3
4	Hurricane SC	0.2 L/ha	100	91.7
5	Stomp 400SC	3.3 L/ha	0	0
6	Sumimax	0.1 L/ha	58.3	33.3
7	Chikara	0.15 kg/ha	0	0
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	0	0
		P (ANOVA)	<0.001	<0.001
		df	14	14
		S.E.D	9.83	10.45
		L.S.D.	21.09	22.41

Figure 2. Erica x darleyensis showing rooting through on untreated bed

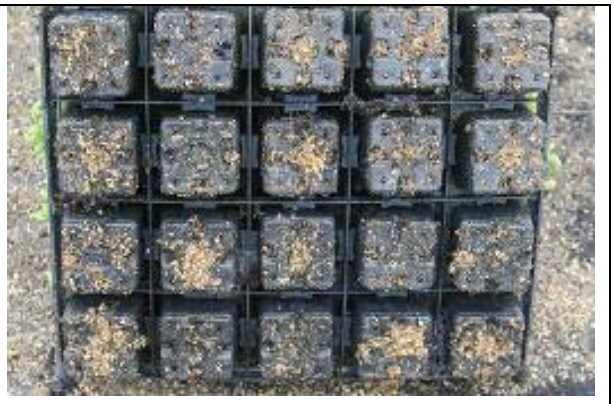


Figure 3. Erica x *darleyensis* with no rooting through on Chikara treated bed

Observations were also made on the effect of treatment on the root system in the pots. For heathers the treatments New Code A and Chikara did reduce the amount of root reaching the bottom of the pot (Fig. 4). Although the root system was healthy there was less root at the bottom of the pot which raised concerns. Stomp 400SC had no adverse effect on rooting within the pot.

Figure 4. Slightly less root at the bottom of the pot (*Erica X darleyensis*) on the Chikara treated bed RHS compared with the Stomp 400SC treated bed LHS.

Weed control

The most prevalent seedling weeds were groundsel (*Senecio vulgaris*), American willowherb (*Epilobium ciliatum*), annual meadow grass (*Poa annua*) and sow thistle (*Sonchus*) (Tables 4 and 5). There were no significant differences between treatments at the first assessment on 17 September 2008 (Table 4). By the second assessment on 4 November 2008 only Chikara and Hurricane SC at the higher rate gave statistically significant weed control compared with the untreated control. Overall, Chikara gave the best weed control with good control of all of the weeds present. Sumimax did not have sufficient persistence and failed to control annual meadow grass germinating later in the autumn (Table 5)

Table 4. Effect of treatment on mean weed numbers (per m^2) at Kingfisher Nurseries on 17 September 2008

			Mean weeds/m^2						
	Treatment	**Product rate**	**Annual meadow grass**	**Bittercress, flexuous**	**Canadian fleabane**	**Groundsel**	**Sow thistle**	**Willowherb, American**	**Total**
1	Untreated control		3.38	0.26	1.30	5.98	3.38	6.24	20.5
2	New Code A	1.0 kg/ha	0	0.52	0.52	3.64	0.78	2.60	8.1
3	Hurricane SC	0.1 L/ha	5.46	0.26	0.26	8.84	2.60	2.08	19.5
4	Hurricane SC	0.2 L/ha	1.04	0	0.26	8.06	0.26	0.52	10.1
5	Stomp 400SC	3.3 L/ha	0	0.52	0	5.46	5.90	6.76	16.9
6	Sumimax	0.1 L/ha	1.04	0.26	0	3.12	1.30	1.56	7.3
7	Chikara	0.15 kg/ha	0	0	0.78	0.26	0	0	1.0
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	0.52	0.26	0.52	8.06	0.26	3.64	13.3
		P (ANOVA)	ns	ns	ns	ns	ns	ns	ns
		df	14	14	14	14	14	14	14
		S.E.D	2.087	0.405	0.442	3.053	1.445	3.660	6.85

Table 5. Effect of treatment on mean weed numbers (per m^2) at Kingfisher Nurseries on 4 November 2008

			Mean weeds/m^2					
	Treatment	**Product rate**	**Annual meadow grass**	**Canadian fleabane**	**Groundsel**	**Sow thistle**	**Willowherb, American**	**Total**
1	Untreated control		29.9	0.26	2.08	1.3	9.1	44.2
2	New Code A	1.0 kg/ha	0	0	2.60	0	2.08	5.5
3	Hurricane SC	0.1 L/ha	20.5	0.26	1.82	0.78	2.34	26.0
4	Hurricane SC	0.2 L/ha	0.5	0.26	1.82	0.52	1.56	4.7
5	Stomp 400SC	3.3 L/ha	0.8	4.68	0.52	0.52	5.72	12.7
6	Sumimax	0.1 L/ha	5.7	0	1.56	1.04	3.12	14.0
7	Chikara	0.15 kg/ha	0.3	0	0	0.52	0.52	1.3
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	0.8	1.30	1.04	0.78	7.54	11.4
		P (ANOVA)	0.005	ns	ns	ns	0.005	0.007
		df	14	14	14	14	14	14
		S.E.D	7.25	2.108	1.295	0.661	7.25	18.26
		L.S.D.	15.54	ns	ns	ns	15.54	39.15

Liverwort was present at the Kingfisher Nurseries site. There were no significant differences between treatments at the first assessment (17 September 2008), but by the second assessment (4 November 2008) all treatments except Hurricane SC applied at 0.1 L/ha and Sumimax had significantly reduced liverwort growth. Although moss was present at this site, the infestation was too low to allow meaningful comparisons between treatments to be made (Table 6).

Table 6. Effect of treatment on mean percentage cover by moss and liverwort at Kingfisher Nurseries, assessed 17 September and 4 November 2008

			% cover			
			Moss		**Liverwort**	
Treatment		**Product rate**	17/09/08	04/11/08	17/09/08	04/11/08
1	Untreated control		1.0	6.7	23.5	53.3
2	New Code A	1.0 kg/ha	0	0.2	1.0	1.9
3	Hurricane SC	0.1 L/ha	0.7	0.7	18.7	47.3
4	Hurricane SC	0.2 L/ha	0.3	0.3	1.8	8.5
5	Stomp 400SC	3.3 L/ha	0	0.7	1.3	7.0
6	Sumimax	0.1 L/ha	0.3	1.0	13.3	27.2
7	Chikara	0.15 kg/ha	3.0	0.2	0	0.2
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	0.3	1.2	0.2	1.2
		P (ANOVA)	ns	ns	ns	0.048
		df	14	14	14	14
		S.E.D	1.32	2.457	10.7	18.26
		L.S.D.	ns	ns	ns	39.15

Crop height

The sand-bed treatments had a slight effect in numeric terms on the height of the two *Erica* cultivars, (particularly New Code A on 'White Perfection' (Table 7). However, these differences were not statistically significant. There was a tendency for the treatments causing most root reduction (Table 3) to have an accompanying reduction in height particularly on 'White Perfection'.

Table 7. Effect of treatment on the mean height (cm) of *Erica* x *darleyensis* cultivars, assessed 17 September 2008

Treatment			Mean height (cm)	
		Rate	**Mary Helen**	**White Perfection**
1	Untreated control		100.0	138.3
2	New Code A	1.0 kg/ha	91.7	110.0
3	Hurricane SC	0.1 L/ha	97.7	126.7
4	Hurricane SC	0.2 L/ha	98.3	116.7
5	Stomp 400SC	3.3 L/ha	93.3	138.3
6	Sumimax	0.1 L/ha	95.0	128.3
7	Chikara	0.15 kg/ha	100.0	113.3
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	98.3	118.3
		P (ANOVA)	ns	ns
		df	13	14
		S.E.D	11.15	12.81

Phytotoxicity

There was no evidence of visual phytotoxicity to the foliage caused by any of the treatments.

Darby Nursery Stock – shrub species

Rooting through

At the first assessment 11 November 2008 only the *Spiraea* and *Buddleja* had rooted through strongly. The *Weigelia* had rooted through to a small extent and the *Vinca* had not rooted through at all. Of the four species tested *Buddleja* had the most vigorous root system and Chikara was the only treatment to largely prevent rooting through in November (Table 4, Fig. 4). For the other species, there were no clear differences between treatments. The shrub species were less affected by Stomp 400SC compared with the heathers.

Table 8. Effect of treatment on rooting through of shrubs at Darby Nursery Stock, assessed 11 November 2008

Treatment		Rate	*Rooting through (cm)*		
			Buddleja	***Spiraea***	***Weigelia***
1	Untreated control		2.83	0.77	0.42
2	New Code A	1.0 kg/ha	3.83	0.25	0
3	Hurricane SC	0.1 L/ha	4.00	0.58	0.17
4	Hurricane SC	0.2 L/ha	3.33	0.54	0.25
5	Stomp 400SC	3.3 L/ha	3.17	0.67	0.17
6	Sumimax	0.1 L/ha	2.50	0.42	0.25
7	Chikara	0.15 kg/ha	0.17	0.08	0
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	3.50	0.50	0.33
		P (ANOVA)	0.054	ns	ns
		df	14	14	14
		S.E.D	1.047	0.212	0.268

A further lifting on 9 March 2009 (Table 9) showed that *Buddleja* had continued to root strongly but the other species had only rooted through to a relatively small extent. The *Vinca* had not rooted through at all. Chikara was the only treatment to noticeably reduce rooting through in *Buddleja* (Fig. 5), however this difference was not quite statistically significant due to the loss of a number of plants from the trial.

Table 9. Effect of treatment on rooting through of shrubs at Darby Nursery Stock, assessed 9 March 2009

Treatment		Rate	*Rooting through (cm)*		
			Buddleja	***Spiraea***	***Weigelia***
1	Untreated control		11.4	1.6	0.6
2	New Code A	1.0 kg/ha	12.3	3.2	0.2
3	Hurricane SC	0.1 L/ha	9.6	1.8	1.2
4	Hurricane SC	0.2 L/ha	11.9	1.3	1.1
5	Stomp 400SC	3.3 L/ha	8.3	2.0	1.0
6	Sumimax	0.1 L/ha	9.4	1.2	1.8
7	Chikara	0.15 kg/ha	1.3	0.7	0
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	17.8	1.9	0.9
		P (ANOVA)	ns	ns	ns
		df	10	13	13
		S.E.D	5.78	1.541	0.723

Figure 5. Effect of Chikara treatment on rooting-through of *Buddleija* (right) compared with untreated beds (left).

The root system of *Spiraea* was unaffected by the Chikara treatment but there was a small reduction in the amount of *Buddleija* root in November 2008. There was no difference in the *Buddleja* root system compared with the untreated at the March 2009 assessment.

Weed control

At Darby Nursery Stock the majority of seedling weeds were Canadian fleabane and groundsel (Table 10). Weed control differences were not statistically different but numerically Chikara appeared to give good control of both weeds present. None of the other treatments controlled Canadian Fleabane. Sumimax appeared to give some control of groundsel numerically although the result was not statistically significant.

Table 10. Effect of treatment on mean weed numbers (per m^2) at Darby Nursery Stock, assessed 17 September and 4 November 2008

			Weeds/m²					
			Canadian fleabane		**Groundsel**		**Total**	
Treatment		**Rate**	**17/09/08**	**04/11/08**	**17/09/08**	**04/11/08**	**17/09/08**	**04/11/08**
1	Untreated control		5.4	8.5	2.7	1.3	8.0	9.8
2	New Code A	1.0 kg/ha	4.0	6.7	1.6	1.8	5.6	8.7
3	Hurricane SC	0.1 L/ha	8.0	15.2	3.3	2.2	11.4	17.4
4	Hurricane SC	0.2 L/ha	4.9	10.0	3.3	1.8	8.3	12.3
5	Stomp 400SC	3.3 L/ha	5.1	9.8	2.0	0.7	7.1	10.7
6	Sumimax	0.1 L/ha	8.7	10.7	0.9	0.4	9.6	11.4
7	Chikara	0.15kg/ha	0.4	1.3	0	0.2	0.4	1.6
8	Stomp 400SC + HurricaneSC	3.3 L/ha + 0.1 L/ha	3.8	9.8	3.6	3.3	7.4	13.8
		P (ANOVA)	ns	ns	ns	ns	ns	ns
		df	14	14	14	14	14	14
		S.E.D	4.32	5.29	1.762	1.169	5.02	5.28

Moss was more prevalent at the Darby Nursery Stock site than at Kingfisher Nurseries. However, none of the treatments applied at Darby Nursery Stock significantly reduced moss cover (Table 11).

Table 11. Effect of treatment on mean percentage moss cover at Darby Nursery Stock, assessed 17 September and 4 November 2008

			Mean % moss cover	
Treatment		**Rate**	**17/09/08**	**04/11/08**
1	Untreated control		36.7	71.7
2	New Code A	1.0 kg/ha	9.3	33.0
3	Hurricane SC	0.1 L/ha	13.7	51.7
4	Hurricane SC	0.2 L/ha	28.3	48.3
5	Stomp 400SC	3.3 L/ha	15.0	51.0
6	Sumimax	0.1 L/ha	10.0	30.0
7	Chikara	0.15 kg/ha	0	1.3
8	Stomp 400SC + Hurricane SC	3.3 L/ha + 0.1 L/ha	28.3	53.3
		P (ANOVA)	ns	ns
		df	14	14
		S.E.D	14.92	27.22

Crop height (data not presented)

There were no differences in height between treatments for any of the species.

Phytotoxicity

There was no evidence of visual phytotoxicity to the foliage caused by New Code A, Stomp 400SC, Sumimax and Chikara. Treatments including Hurricane SC caused some leaf bleaching on *Vinca* (Fig. 6).

Figure 6. Effect of Hurricane SC treatment causing white blotching on the foliage of *Vinca,*.

Herbicide leaching assessment

No residues of pendimethalin or flazasulfuron were found in the sand-bed drainage water collected on 18 February or 9 March 2009.

Conclusions

The only treatment with potential to prevent container grown shrubs rooting through on sand-beds appears to be Chikara although the evidence on a range of species is rather limited. Chikara largely prevented rooting through in *Buddleija* which was the strongest rooting species in the experiment, although the los of some plants within the experiment meant that differences were not quite statistically significant at the final recording. Other treatments such as New Code A and Sumimax appeared to have an effect on some species but were less consistent. Where Chikara was used there was some initial reduction in the amount of *Buddleija* root within the container but this was considered acceptable and subsequent root development was normal.

For heathers Chikara and New Code A also prevented rooting through completely. However the reduction in root within the container from both was considered to be detrimental. Stomp

400SC was also effective in preventing rooting through but did not have the adverse effect of reducing rooting within the container. Stomp 400SC may therefore be considered a better option for heather growers. However Stomp 400SC is a formulation that is disliked by some growers. The active pendimethalin is unlikely to have a long term future under the move to hazard based criteria under the EC proposals for future pesticide approval. The alternative for heather growers would be to use Chikara but use a lower rate than that tested in this project. Since this project started, development work on New Code A has ceased and it has been decided not to develop the product for the UK or European market.

Although the primary focus of the project was prevention of rooting through some of the treatments also provided a good level of weed control both for seedling weeds and moss and liverwort. Overall Chikara provided the best weed control.

Chikara has UK approval for use as a total herbicide on land not intended to bear vegetation. The current approval does not allow use on sand-beds so a SOLA would be required to permit this use. If a SOLA is granted, because of the limited number of species tested in this project over one season it would be advisable for growers to be cautious and try a small area first before scaling up to treating larger areas.

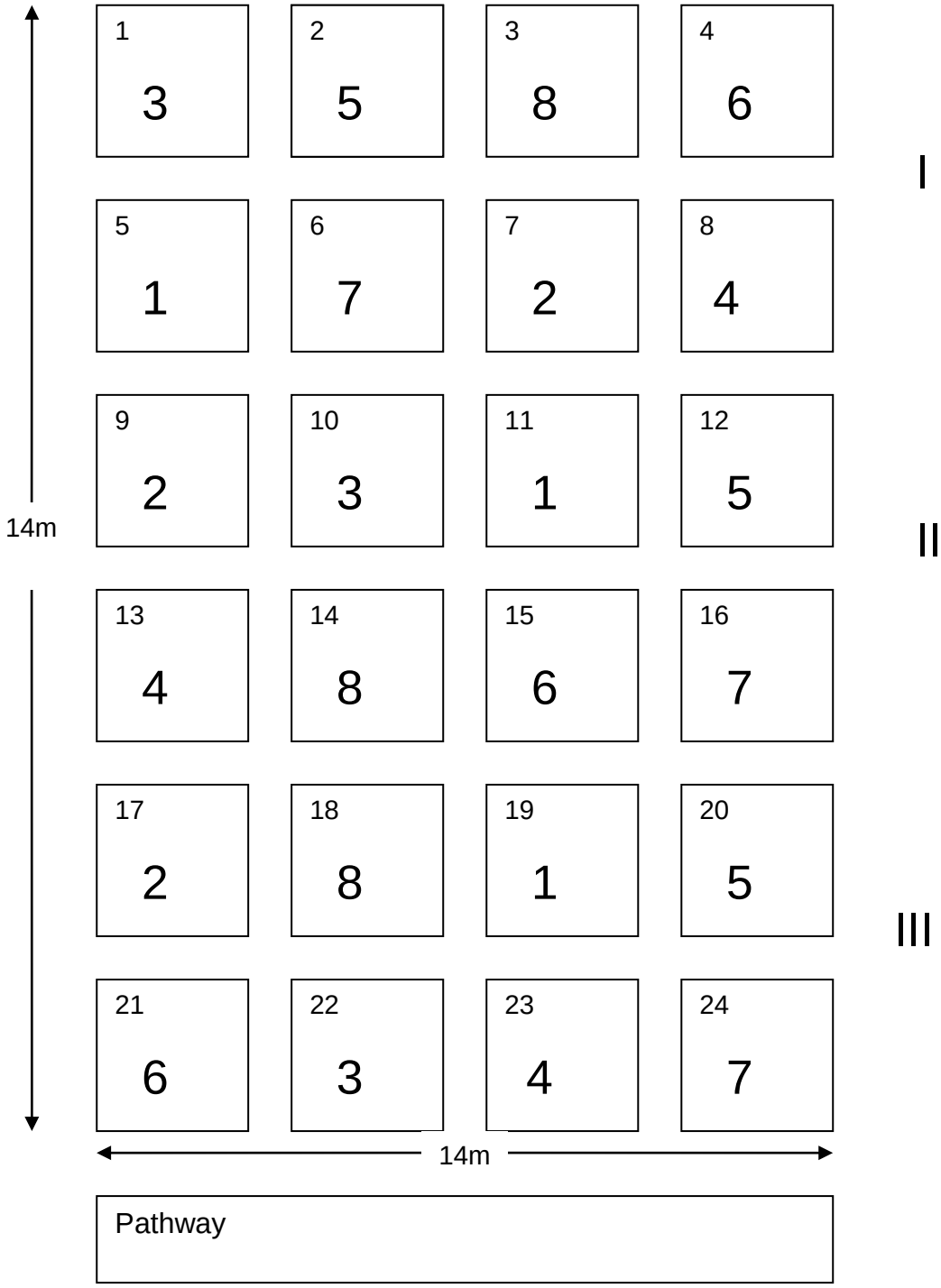
Reference

Rowell, D., (1996) HDC report HNS35d 'Chemical weed control in sand-beds for hardy nursery stock'

Technology transfer

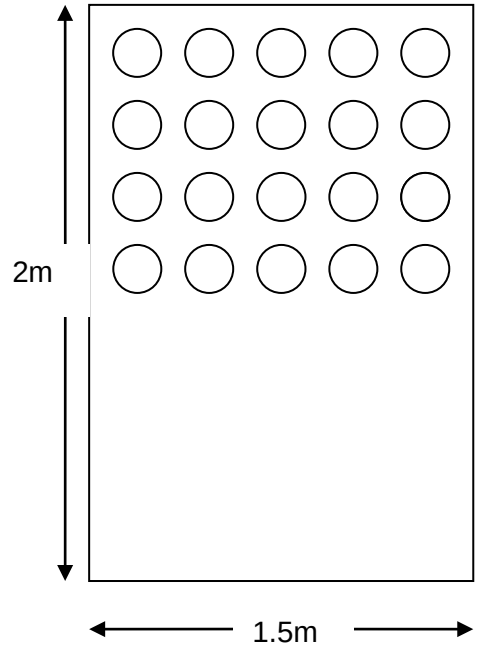
An article for HDC news has been published and a talk based on these results was presented to growers at the HDC herbaceous perennial technical discussion group on 10 February 2009.

Appendix 1: Darby Nursery Stock site layout



Treatment	*Chemical*	*Rate*
1	Untreated control	
2	Barricade 65WG	1.0 kg/ha
3	Hurricane SC	0.1 L/ha
4	Hurricane SC	0.2 L/ha
5	Stomp 400SC	3.3 L/ha
6	Sumimax	0.1 L/ha
7	Flazasulfuron	0.15 kg/ha
8	Stomp 400SC + Hurricane SC	3.3 + 0.1 L/ha

Individual Plot: Darby Nursery Stock



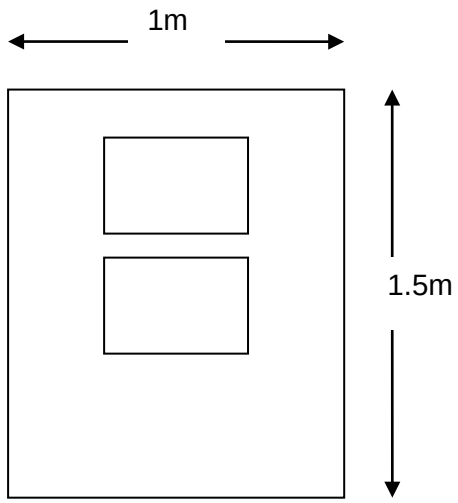
Appendix 2: Kingfisher Nurseries site layout

I	1	2	5	4	
	2	5	6	3	
	3	1	7	6	
	4	8	8	7	
II	9	7	13	6	
	10	2	14	3	
	11	8	15	5	
	12	4	16	1	
III	19	1	17	6	
	20	2	18	4	
	21	3	23	8	
Pathway	22	5	24	7	Pathway

Treatment	*Chemical*	*Rate*
1	Untreated control	
2	Barricade 65WG	1.0 kg/ha
3	Hurricane SC	0.1 L/ha
4	Hurricane SC	0.2 L/ha
5	Stomp 400SC	3.3 L/ha
6	Sumimax	0.1 L/ha
7	Flazasulfuron	0.15 kg/ha
8	Stomp 400SC + Hurricane SC	3.3 + 0.1 L/ha

Individual Plot: Kingfisher Nurseries

Showing 2 x 20 pot empot carriers per plot



Appendix 3. Rainfall data for leaching study

Day	December 2008	January 2009	February 2009	March 2009
1		0.8	0.3	0.0
2		0.0	4.0	0.0
3		0.0	0.0	9.0
4		2.4	10.4	0.0
5		0.0	2.5	0.0
6		0.0	6.1	0.0
7		0.0	0.5	1.1
8		0.0	1.9	3.3
9	0.0	0.0	18.5	
10	0.0	0.0	0.1	
11	0.0	0.0	1.3	
12	1.1	3.6	7.8	
13	8.8	0.0	0.5	
14	0.0	0.0	0.0	
15	0.0	0.2	1.0	
16	0.0	0.3	0.1	
17	0.0	1.5	0.4	
18	0.0	5.4	0.6	
19	2.1	0.0	0.6	
20	0.0	0.0	0.0	
21	0.0	6.5	0.0	
22	0.0	2.6	0.4	
23	0.0	0.0	0.9	
24	0.0	5.4	0.0	
25	0.0	1.3	0.0	
26	0.0	0.0	0.5	
27	0.0	0.0	0.0	
28	0.0	9.5	0.0	
29	0.0	0.0		
30	0.0	0.0		
31	0.0	0.0		

Rainfall data was recorded at Sutton St Edmund (3.8km from site) and Denver, Lincs. (28 km from site). From Feb 2-13 precipitation fell as snow