Grower Summary

SF 161

Rhubarb: Evaluation of herbicides for problem weeds - 2015

Final report 2015

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Project leader:	Chris Creed, ADAS UK Ltd.
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Location of project:	Commercial grower sites in Yorkshire, Nottinghamshire and Hampshire
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The results and conclusions in this report are based on an investigation 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

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 number of new residual and contact acting herbicides offer improved weed control in rhubarb.

Background and expected deliverables

Efficient and cost effective weed control is important in rhubarb as with other crops to prevent yield loss as a result of competition for water, space and nutrients and to enable efficient harvesting without impedance by weed growth.

In recent years, rhubarb crown size and yield has been decreasing in both forced and green pull crops, where weeds have developed resistance to currently used herbicides. Growers believe that this decrease has been caused by increased competition from weeds as well as other influencing factors. Therefore, effective weed management in rhubarb is important to maximise the yield potential of the crop by reducing competition.

The harvesting regime for green pull crops has also changed in recent years, with two to three harvests being taken from a crop through the season to provide extended supply to meet retail demands. Opportunities to apply effective post-harvest herbicides have been reduced or delayed, allowing weeds to increase in size, making control more difficult. Retailers' strict quality protocols for clean produce free of dirt and contamination mean that cultivations carried out for weed control can occasionally lead to unintentional mud splash. The cost of labour is increasing and cultural controls such as hand pulling weeds and spot treatment with knapsack sprayers is becoming prohibitively expensive when margins are tight.

Therefore new effective herbicides that can be applied safely over the crop are required, to reduce the frequency of these operations and to protect the crop from weed competition.

A high priority for investigation in this project was to provide control of 'problem weeds' such as Himalayan balsam and perennials such as docks *(Rumex spp.)* and thistles *(Cirsium arvense)*. Although there is an EAMU for glyphosate in rhubarb, the short dormant season of the crop offers few windows for treatment and since the loss of dichlobenil, perennial weed infestations have been increasing.

The aim of this project was to evaluate a selection of newer herbicides for crop safety and efficacy against a range of problem weeds in rhubarb plantations, compared with industry standards. Three principal areas were addressed, with the objective of providing information for growers on candidate herbicides which:

- Offer control of commonly-occurring annual weeds using residual herbicides;

- Control perennial weeds, often a long-term problem in rhubarb with spot and overall treatments of contact acting herbicides;
- Provide information on any adverse effects on the crop.

Summary of the project and main conclusions

Five experiments were carried out at commercial grower holdings in Yorkshire, Nottinghamshire and Hampshire. Two experiments tested a range of residual herbicides applied pre-harvest for crop safety and efficacy against annual weeds at sites in Yorkshire and Nottinghamshire. Three further experiments tested crop safety and efficacy of a range of contact herbicides applied post-harvest in Yorkshire and Hampshire.

Residual herbicide trials

These residual herbicide trials were set up in a fully randomised block design with 21 treatments including a double replicated untreated control and two grower practice controls (**Table 1**). The grower practice controls were tank mixes of Stomp Aqua (pendimethalin) and Gamit 36 CS (clomazone), and Stomp Aqua and Goltix Flo (metamitron). Apart from herbicide applications, the crop was managed as per commercial practice with other inputs such as fungicides, insecticides, fertilisers and irrigation applied as necessary.

The major weed in the Yorkshire trial was Himalayan balsam *(Impatiens glandulifera)*, and the major weeds at the Nottingham trial site were (in order of incidence); annual meadow grass (*Poa annua)*, small nettle *(Urtica urens)*, scentless mayweed *(Tripleurospermum inodorum)*, groundsel *(Senecio vulgaris)* and fat-hen *(Chenopodium album)*. Black bindweed *(Fallopia convolvulus),* black nightshade *(Solanum nigrum),* cleavers *(Galium aparine),* common chickweed *(Stellaria media),* common field-speedwell *(Veronica persica),* creeping yellow-cress *(Rorippa sylvestris),* field pansy *(Viola arvensis),* knot-grass *(Polygonum aviculare),* redshank *(Persicaria maculosa),* shepherd's-purse *(Capsella bursa-pastoris)* and annual sowthistle *(Sonachus* spp.) appeared in many plots but not as frequently.

Table 1. Treatments applied to plots in 400 L water per hectare. Yorkshire and Nottinghamshire, 2015.

Treatment no.	Treatment	Active	Rate	Approval status
1 + 2 (Untreated controls)	-	-	-	-
3 (Standard 1)	Stomp Aqua +	pendimethalin 455 g/L +	3.3 L/ha	EAMU
	Gamit 36 CS	clomazone 360 g/L	0.25 L/ha	EAMU
4 (Standard 2)	Stomp Aqua +	pendimethalin 455 g/L +	3.3 L/ha	EAMU
	Goltix Flo	metamitron 700 g/L	5.0 L/ha	EAMU
5	Gamit 36 CS	clomazone 360 g/L	0.25 L/ha	EAMU
6	Callisto	mesotrione 100 g/L	1.5 L/ha	Not approved on rhubarb
7	Defy	prosulfocarb 800 g/L	5.0 L/ha	Not approved on rhubarb
8	Flexidor 500	isoxaben 500 g/L	0.5 L/ha	Not approved on rhubarb
9	Sencorex WG*	metribuzin 70% w/w	1.25 Kg/ha	EAMU
10	H32	-	-	Not approved on rhubarb
11	Dual Gold	s-metalochlor 960 g/L	1.4 L/ha	Not approved on rhubarb
12	H33	-	-	Not approved in UK
13	H33 high rate	-	-	Not approved in UK
14	H34	-	-	Not approved on rhubarb
15	H35	-	-	Not approved on rhubarb
16	H33 + H34	-	-	See above
17	H33 +	-	-	See above
	Gamit 36 CS	clomazone 360 g/L	0.25 L/ha	
18	H35 +	-	-	See above
	Gamit 36 CS	clomazone 360 g/L	0.25 L/ha	
19	H36	-	-	Not approved in UK
20	H37	-	-	Not approved on rhubarb
21	H38	-	-	Not approved on rhubarb

* Note: Although Sencorex WG was used in the trials, Sencorex Flow is the form approved for use on rhubarb. Check the EAMU for the rate approved for use.

Just prior to or at bud break, the site was marked out and the residual herbicides were applied on 10 March at Yorkshire and 16 March at Nottinghamshire. The treatments were applied over the sets to the beds using an Oxford precision (OPS) knapsack sprayer and a 2m boom with 04F110 flat fan nozzles, to achieve a medium spray quality of 400 L/ha.

Phytotoxicity to the rhubarb was assessed on each plot, using a scale of 0 – 9, whereby 9 showed no effect, 7 was a commercially acceptable effect or damage, 1 was a very severe effect and 0 was plant death. Plots were also assessed for percentage weed cover and the weed species present were also recorded. At the Nottinghamshire site, the number of weed seedlings of each species were counted at the first three assessment dates instead of percentage weed cover.

Contact herbicide trials – main trials

These trials were set up in a fully randomised block design with 18 treatments including a double replicated untreated control (**Table 2**). There were no grower practice controls, as there are currently no techniques or herbicides commonly used by all rhubarb growers, due to the difficulty of crop safety and effective application of approved contact herbicides in all situations. Apart from herbicide applications, the crop was managed as per commercial practice with other inputs such as fungicides, insecticides, fertilisers and irrigation applied as necessary.

In Yorkshire the major weeds were Himalayan balsam (*Impatiens glandulifera*). Creeping thistle (*Cirsium arvense*), common nettle (*Urtica dioica*), common wormwood or mugwort (*Artemisia vulgaris*), hedge bindweed (*Calystegia sepium*), field bindweed (*Convolvulus arvensis*), common couch (*Elytrigia repens*), curled dock (*Rumex crispus*), cleavers (*Galium aparine*) and soft brome (*Bromus hordeaceus*) appeared in many plots but not as frequently.

In Hampshire the major weeds were dandelion *(Taraxacum officinale),* fat-hen *(Chenopodium album),* field bindweed *(Convolvulus arvensis),* Canadian fleabane *(Conyza canadensis),* perennial sowthistle *(Sonchus arvensis),* scentless mayweed *(Tripleurospermum inodorum)* and common wormwood or mugwort *(Artemisia vulgaris).* Creeping thistle *(Cirsium arvense),* common nettle *(Urtica dioica),* shepherd's-purse *(Capsella bursa-pastoris),* cleavers *(Galium aparine),* black nightshade *(Solanum nigrum),* groundsel *(Senecio vulgaris)* and redshank *(Persicaria maculosa)* appeared in many plots, but not as frequently.

Table 2. Treatments applied to plots in 200 L water per hectare. Yorkshire and Hampshire, 2015.

		Treatment timing		
Treatment no.	**Treatment name**	**Timing 1 Post-harvest (1 - 2 weeks after topping)**	**Timing 2 (3-4 weeks after Timing 1)**	**Approval status**
Untreated and inter-row glyphosate treatments				

		Treatment timing		
Treatment no.	**Treatment name**	**Timing 1 Post-harvest (1 - 2 weeks after topping)**	**Timing 2 (3-4 weeks after Timing 1)**	**Approval status**
1 + 2	Untreated	-	-	-
3	Master Gly 36T inter-row	Master Gly 36T inter-row 5.0 L/ha*	-	Not approved for use in rhubarb
4	Master Gly 36T inter-row fb Stomp Aqua + Gamit 36 CS	Master Gly 36T inter-row 5.0 L/ha*	Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha	See above and table 1.
Over the row treatments				
5	Master Gly 36T	Master Gly 36T 5.0 L/ha*		Not approved for use in rhubarb
6	Shark	Shark 0.8 L/ha		Not approved for use in rhubarb at this timing
7	H39	H39		Not approved for use in rhubarb
8	Reglone	Reglone 4.0 L/ha		Approved only for inter-row use
9	Dow Shield once	Dow Shield 0.5 L/ha		Not approved for use in rhubarb
10	Dow Shield twice	Dow Shield 0.25 L/ha	Dow Shield 0.5 L/ha	See above
11	H38	H38		Not approved for use in rhubarb
12	H40	H40		Not approved for use in rhubarb
Over the row Shark followed by residual/contact herbicides				
13	Shark fb Sencorex Flow	Shark 0.8 L/ha	Sencorex Flow 1.45 L/ha	See above and table 1.
14	Shark fb H33	Shark 0.8 L/ha	H33	See above and table 1.
15	Shark fb H33 + Defy	Shark 0.8 L/ha	H33 + Defy 5.0 L/ha	See above and table 1.
16	Shark fb H33 + Sencorex Flow	Shark 0.8 L/ha	H33 + Sencorex Flow 1.45 L/ha	See above and table 1.
17	Shark fb H36	Shark 0.8 L/ha	H36	See above and table 1.
18	Shark fb H37	Shark 0.8 L/ha	H37	See above and table 1.

fb = followed by.

* Note: max individual dose under the EAMU is 4.0 L/ha, as an on-label application to stubbles or before planting or production it is 5.0 L/ha.

After the crop was harvested and then topped, the site was marked out and the contact herbicides were applied two weeks after topping on 13 May in Yorkshire, and three weeks after topping on 4 June in Hampshire. The Timing 2 treatments were applied between three to four weeks after the Timing 1 treatments, on 5 June in Yorkshire, and 29 June in Hampshire. The treatments were applied using an OPS knapsack sprayer and a 2m boom with 02F110 flat fan nozzles, to achieve a medium spray quality at 200 L/ha.

Phytotoxicity to the rhubarb was assessed on each plot. Plots were also assessed for percentage weed cover, phytotoxic effects on weeds and weed species present were also recorded.

Contact herbicides - extra trial

This trial was set up in a fully randomised block design with 5 treatments including an untreated control (**Table 3**). There was no grower practice control, as there are currently no techniques or herbicides commonly used by all rhubarb growers, due to the difficulty of crop safety and effective application of approved contact herbicides. Apart from herbicide applications, the crop was managed as per commercial practice with other inputs such as fungicides, insecticides, fertilisers and irrigation applied as necessary.

Table 3. Treatments applied to plots in 200 L water per hectare (see tables 2 and 4 for approval status of products used). Hampshire, 2015.

Treatment no.	Treatment	Active	Rate
1 (Untreated control)	-	-	-
2	Shark	carfentrazone-ethyl 60g/L	0.3 L/ha
3	Shark	carfentrazone-ethyl 60g/L	0.8 L/ha

4	Shark +	carfentrazone-ethyl 60g/L +	0.3 L/ha
	Dow Shield 400	clopyralid 400 g/L	0.5 L/ha
5	Shark +	carfentrazone-ethyl 60g/L +	0.3 L/ha
	Dow Shield 400 +	clopyralid 400 g/L + metribuzin	0.5 L/ha
	Sencorex Flow	600 g/L	1.45 L/ha

After the crop was harvested and then topped, the site was marked out and the contact herbicides were applied two weeks after topping on 13 May in Yorkshire, and three weeks after topping on 4 June in Hampshire. The Timing 2 treatments were applied between three to four weeks after the Timing 1 treatments, on 5 June in Yorkshire, and 29 June in Hampshire. The treatments were applied using an OPS sprayer and a 2m boom with 02F110 nozzles, to achieve a medium spray quality at 200 L/ha.

Phytotoxicity to the rhubarb was assessed on each plot. Plots were also assessed for percentage weed cover, phytotoxic effects on weeds and weed species present were also recorded.

Results

Crop safety of residual herbicides in outdoor rhubarb

No adverse effects were seen on the 2 year old established crop of Stockbridge Arrow planted on a sandy clay loam soil in Yorkshire. However, phytotoxic symptoms were seen in three treatments on the newly planted crop of Stockbridge Arrow in Nottinghamshire. The latter crop was planted into a sandy loam soil and a higher sensitivity to herbicides is often expected to occur on light soil types such as these. This indicates that extra care needs to be taken when selecting residual herbicides and rates of use on rhubarb in this situation.

Phytotoxic effects were seen in the plots at Nottingham treated with Sencorex WG, Callisto and H33 with the greatest effects caused by Sencorex WG applied at 1.25 kg/ha (**Figure 1**). The effect of Sencorex WG was exhibited as chlorosis along the veins of the leaves and symptoms first occurred on 6 May, seven weeks after the sprays were applied. This was two weeks after 30mm of irrigation was applied on 23 April, and the interval between occurrence and the treatment application shows the persistence of the product and its ability to re-activate in the presence of moisture. Between the herbicide application on 10 March and 23 April, conditions were dry with the only significant rainfall occurring at the site on 3 April.

Figure 1. Effects of the application of Callisto and Sencorex on the rhubarb at 7 and 12 weeks after treatment (WAT) L-R a) Callisto – 7 WAT, b) Sencorex WG – 7 WAT, c) Sencorex WG – 12 WAT. Nottinghamshire, 2015

The effects of Sencorex WG were transient and the stronger sets had recovered 12 weeks after application, and by this point new leaves were no longer showing any chlorotic effects. However it should be noted that weaker plants were lost. Sencorex Flow was approved for use on newly established crops during the project and this risk of phytotoxicity should be taken into account when using the product. The use of lower rates may be safer in higher risk situations, especially when planting new crops on light soil types.

Callisto and H33 also showed a less severe phytotoxicity effect with an occasional early leaf showing scorch at seven weeks after treatment, but the sets recovered quickly and had grown through well by 12 weeks after treatment, with no symptoms seen at this point.

Control of commonly-occurring annual weeds using residual herbicides

Herbicides currently approved for use in rhubarb have varying weaknesses in the spectrum of annual weeds controlled. Those weeds resistant or moderately resistant to current actives include Himalayan balsam, black bindweed, mayweed, cleavers, field pansy, groundsel and charlock (Science section Appendix B). In both trials, residual herbicides were found which can control these weeds and offer better or equivalent control than the current grower standards of Stomp Aqua + Gamit 36 CS and Stomp Aqua + Goltix Flow, and significantly better control than the untreated (**Figure 2**). These five herbicides were Sencorex WG, Callisto, H32, H34 and H34 in a tank with H33.

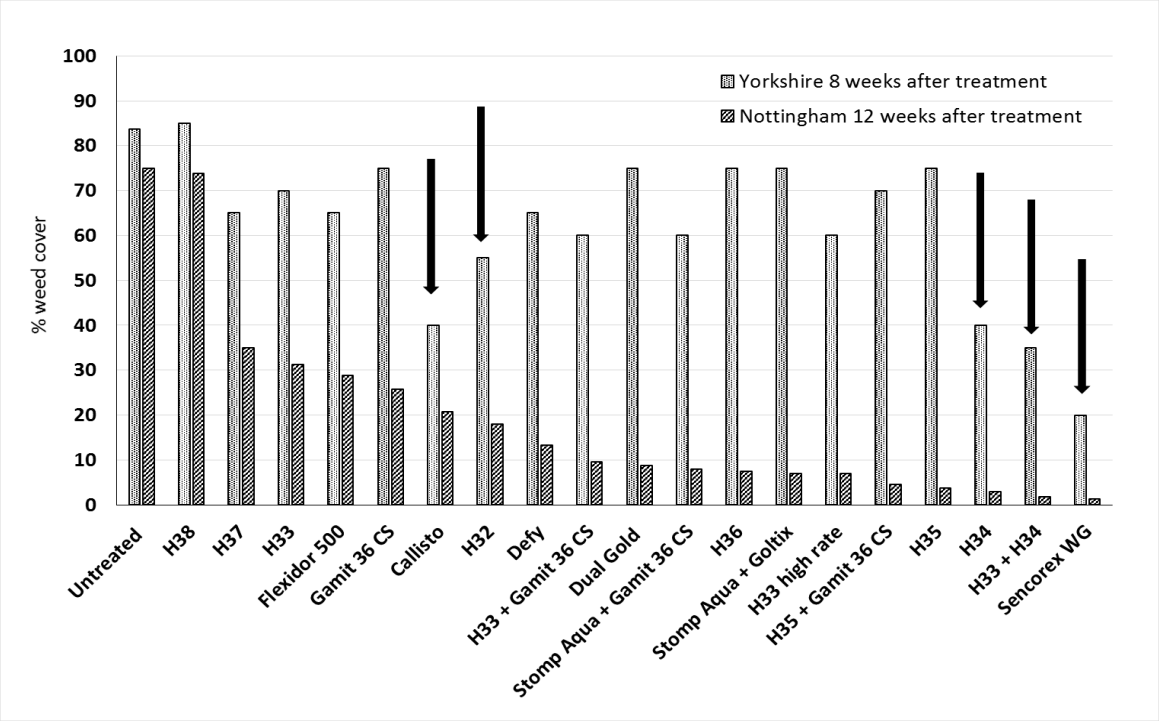

Figure 2. Mean percentage of weed cover at 8 weeks after treatment in Yorkshire and 12 weeks after treatment in Nottinghamshire. Arrows indicate those treatments that gave significantly better control than the untreated plots at both sites. 2015

Sencorex WG was the best product for overall weed control at both sites reducing weed levels by 76% in Yorkshire and by 98% in Nottinghamshire when compared to the untreated. During the project an EAMU was obtained for application of the product as the Sencorex Flow form for use on newly planted rhubarb plantations. However, due to the EAMU restrictions on use, it cannot be applied to established plantations which are going to be harvested within a period of 12 months. Therefore, options are still needed for established crops to maintain weed control during harvest in later years, and thus maintain yields through the plantation life.

Callisto (currently not approved for use on rhubarb) was the second best active for control of Himalayan balsam, reducing levels by 53% when compared to the untreated. It also gave a good reduction in a range of weeds in Nottinghamshire, reducing weed cover by 76%. Despite this, it did not appear as one of the better products for an overall reduction in the percentage of weed cover in Nottinghamshire because it doesn't control annual meadow grass or small nettle well, and these were two of the main weeds at the experimental trial site. But, if partner products are considered it could give control of a wide range of weeds in a tank-mix with Goltix, which would add control of annual meadow grass and small nettle. Callisto also has a broad weed control susceptibility list based on the label and trials data (Appendix B). It should be noted that Callisto has not been tested as a tank-mix on rhubarb, and grower experience in crops such as maize suggest that when mixed

it can increase the phytotoxicity risk. Therefore, if approved, growers should bear this in mind when using a tank-mix.

Dual Gold (currently not approved for use on rhubarb), H36 and H33 at a high rate or in a tank mix with Gamit 36 CS also gave better or equivalent control to the current grower standards in Nottinghamshire, but had no effect on Himalayan balsam. Product H33 in a tank mix with Gamit would give moderate to good control of all the annual weeds, where there are weaknesses in the current approvals except for cleavers.

Product H35 gave better control than the current standards at the Nottinghamshire site only, but was ineffective at controlling the Himalayan balsam in Yorkshire. However, it was applied after the Himalayan balsam had emerged and the mode of action of this herbicide means that it gives best control when applied pre-emergence, as it is absorbed by the subterranean parts of the plant such as the roots and hypocotyl (shoots). The product may have a greater effect if applied pre-emergence, and this approach may be worth testing in future.

Overall, an approval for Callisto or H32 would give greater or equivalent weed control where there are currently weaknesses in both geographical situations.

Crop safety of contact herbicides in outdoor rhubarb

Roundup over the row was too damaging at the rates used at both experimental sites and killed some sets. H39 over the row and Roundup inter-row were also too damaging at Yorkshire. The latter treatment may have reduced the vigour of the rhubarb because it was more difficult to apply the spray low enough to avoid drift onto the plants, as the crop is grown on ridges. Conversely, effects from Roundup applied inter-row to the crop grown on the flat in Hampshire were scored as slight by 11 weeks after treatment, whereas at the same assessment timing in Yorkshire moderate effects were still seen. Therefore Roundup between the row could be safely used depending on the situation that the rhubarb is grown in.

Dow Shield 400 (not approved for use on rhubarb) caused severe effects to the rhubarb at both sites at the rates used in the trial, causing cupping of leaves, distortion and twisting of new growth and deformed or thickened new leaves. These effects were still occurring at 11 weeks after the first applications in Yorkshire and 18 weeks after the first applications in Hampshire. Although the effects are long-lasting and set back growth by a number of weeks in the year of application, no crop death was seen in the plots. If Dow Shield 400 was applied at a lower rate, or as a spot treatment, the phytotoxic effects may be reduced, and this would be worth investigating due to the value of the product for perennial thistle control.

Shark, Reglone and H40 initially scorched the rhubarb, but the plots treated with these contact herbicides recovered reasonably quickly to a level where the crop would be acceptable to harvest again at least 8 weeks after application. It should be noted that although Shark and Reglone are approved for use on rhubarb, they are not approved for use at this timing or application method.

The recovery from the herbicide applications varied by site and product. The plots sprayed with Shark recovered the quickest and plants appeared to be at a commercially acceptable quality at four weeks after application in both Yorkshire and Hampshire. It took slightly longer for the rhubarb to recover from Reglone and H40, with the plants at an acceptable quality by seven weeks after application in Hampshire. In Yorkshire, the crop treated with Reglone had recovered by six weeks after application, and by eight weeks for the crop treated with H40.

The Timing 2 treatments of single herbicides and tank mixes applied to the crop three to four weeks after the Timing 1 treatments also scorched the rhubarb, causing yellowing and necrosis of the leaves present at application. The crop grew through these symptoms and had recovered with no or only slight symptoms seen at seven weeks after the sprays were applied in Yorkshire, and eight weeks after the sprays were applied in Hampshire. It should be noted that if these sprays are applied one month after the first sprays as in the trials, then the crop takes a further three to four weeks to recover than those plots that only received one application of Shark, Reglone or H40.

Control of perennial weeds using overall and spot applications of contact herbicides

Control of perennial weeds is particularly troublesome in perennial crops such as rhubarb as the windows for ‘clean-up’ spray applications are limited and short. Products such as Roundup can only be safely applied when the crop is fully dormant during December and January, and in practice opportunities to spray can be few and far between in these months. Therefore herbicides that could be applied safely to the plantation outside this window would be very useful to growers. Five post-harvest applied treatments gave significant control of weeds at both trial sites, and also proved safe to the crop with no or only slight effects seen at 11 weeks after treatment, or when the crop in the trial would have been ready for harvest again.

These treatments were single applications of Shark or H40, and Shark followed by an additional application of Sencorex Flow, H36 or Sencorex Flow in a tank mix with H33. In addition, in Hampshire, Roundup applied as a shielded application between the rows and then followed up by an application of Stomp Aqua + Gamit 36 CS gave significant weed control and was safe to the crop at this site (**Table 4**).

Shark gave the best control for a single applied product, significantly reducing weed cover to approximately 13% cover for up to 11 weeks in both Yorkshire and Hampshire. This equates to a reduction in weed cover of 84% in Yorkshire, and 48% in Hampshire when compared to the levels in the untreated plots at each site. Although Shark performed well in the contact herbicide trials, its efficacy can be variable depending on how well the weeds are growing and the temperature when it is applied. It performs best when weeds are growing well under warm conditions. In addition, during the project, Shark was applied on 10 March at 0.8 L/ha to the emerged Himalayan balsam in the residual trial area and had very little effect on the weed. Temperature on average on the day of application by the grower (11 March) was 7.5 ^{0}C, with average temperature over the seven days after application of 5.2 ^{0}C. Shark worked better when applied in Yorkshire at 11.5 ^{0}C, and temperature reached 19 ^{0}C on the day of application, with an average temperature over the seven days after application of 9.9 ^{0}C. In Hampshire, the temperature on the day and after application was even higher than these. It is also worth noting that the weeds were also growing strongly at the time of application in the contact herbicide trials.

Table 4. Mean percentage of weed cover at Timing 2 application and at the potential harvest date 11 weeks after treatment (WAT) application. Yorkshire and Hampshire, 2015

		Weed cover at dates and sites indicated (%)			
		Yorkshire		Hampshire	
Treatment Timing 1	Treatment Timing 2	5 June	23 July	29 June	26 Aug

		4 WAT Timing 2	11 WAT Harvest	3 WAT Timing 2	11 WAT Harvest
Untreated	Untreated	96.2	88.8	11.7	25.4
Roundup inter-row	-	**15.5**	**38.8**	4.7	17.0
Roundup inter-row	Gamit 36 CS + Stomp Aqua	**16.2**	**22.8**	3.7	**11.5**
Roundup over row	-	**1.8**	**13.5**	4.0	50.0
Shark	-	**6.5**	**13.8**	7.3	**13.2**
H39	-	**10.2**	**35.5**	10.7	32.5
Reglone	-	**28.7**	77.5	10.0	20.0
Dow Shield 0.5 L/ha	-	**69.5**	87.5	9.5	**15.0**
Dow Shield 0.25 L/ha	Dow Shield 0.5 L/ha	97.5	96.8	13.0	18.0
H38	-	96.2	99.2	7.7	18.5
H40	-	**45.0**	**28.0**	11.5	**14.0**
Shark	Sencorex Flow	**19.2**	**12.0**	13.3	**8.2**
Shark	H33	**11.7**	**11.2**	9.7	17.8
Shark	H33 + Defy	**7.2**	**12.5**	10.0	14.0
Shark	H33 + Sencorex Flow	**24.2**	**13.8**	7.7	**7.0**
Shark	H36	**32.0**	**15.2**	4.7	**6.7**
Shark	H37	**14.7**	**44.0**	13.7	27.0
F probability	All treatments	<0.001	<0.001	NS	<0.001
LSD (70 d.f.)		15.88	14.73	-	9.667
F probability	Shark alone vs	0.042	<0.001	NS	0.049
LSD (26 d.f.)	Shark and follow up treatments	16.44	11.42	-	13.17

Note: Figures in **bold** are significantly different from the untreated.

In the additional trial in Hampshire, the rate of Shark at 0.3 L/ha performed as well as the higher rate of 0.8 L/ha, and therefore growers can be assured that the lower rate can be effective as long as the weed spectrum, rate of weed growth and temperature at application are considered.

H40 was the second best treatment for a single applied product at both sites, reducing weed cover significantly to 14% in Hampshire and 28% in Yorkshire at 11 weeks after spray application. This equates to a reduction in weed cover of 68% in Yorkshire and 45% in Hampshire when compared to the levels in the untreated plots at each site. Both Shark and H40 have a good range of control (see Appendix B) and although they are both contact in activity, there is an element of selectivity to their action and Shark is stronger on smooth sowthistle and fat-hen, while H40 gives good control

of groundsel and mayweed. There are also differences between the desiccants Shark and Reglone, with the former being weaker on mayweed, chickweed and groundsel, while diquat is weaker on cleaver, knotgrass and small nettle. Therefore when using these contact herbicides growers need to take into account the weed spectrum, as well as timing of application with regards to speed of weed growth and temperature to select the products to get the best control.

Dow Shield 400 was the only herbicide to fully control perennial thistle with a good kill, but when applied over the crop at the rates used it gave severe crop damage causing cupping of leaves and deformation of new growth, with twisting and deformation of new leaves seen up to 18 weeks after sprays were applied. However, despite this no plant death was seen and an approval for the control of thistle would still be useful as Dow Shield may be safer to use as a spot treatment or at lower rates, and there are currently few other safe options for full control of this weed. H40 as a single spray application and Shark followed by a later application of Sencorex Flow gave good suppression of perennial thistle but did not kill it all.

Residual herbicides with some contact activity were also tested to see if they added more longevity and further control to the purely contact herbicide Shark. Of those tested Sencorex Flow and H36 added a slight reduction in weed control, Sencorex Flow reduced the weed further by 6-7% at both trial sites, while H36 gave an added reduction of 15% in weed levels at the Yorkshire site only. This is only a small extra reduction so the grower would have to decide if this was an approach worth taking. This is especially true if applied one month later than the Shark application as in the trial, as it then takes the crop a further four weeks to recover than those plots where only Shark was applied. Alternatively, applying both products in a tank-mix could be possible in practice.

Effects on the most troublesome perennial weeds were recorded and it was noted that field and hedge bindweed were initially suppressed by Shark and product H40. However, the bindweed started to grow through the initial effects after six to eight weeks and had fully recovered 11 weeks after treatment. No treatments gave long-lasting effects on the mugwort.

Shark provided good control of Himalayan balsam and a range of dicotyledon weeds in both trials but has weaknesses in chickweed, mayweed and groundsel, and growers also need to consider temperature and speed of weed growth to get good efficacy from the product. Pyraflufen-ethyl may be useful to look at in future work as it is a similar desiccant product and is suggested to have stronger activity on mayweed which can be a troublesome weed in rhubarb plantations.

Financial benefits

The production of rhubarb could become economically unviable without effective herbicides, as the increasing cost of labour is making hand-weeding a prohibitively expensive method of weed control. Therefore, growers are searching for methods to reduce their reliance on labour, and increase production efficiency. The availability of effective herbicides would permit growers to achieve this and also help to maintain yields through the life of the plantation as competition for nutrients and water from weeds is reduced. It is difficult to quantify the gain in yield from reducing weed competition but the availability of these herbicides will reduce the need for hand weeding which costs on average £2,200/ha. Where herbicide resistant weeds have developed, a crop may need weeding up to 3 times a year at a cost of up to £6,600/ha. Cultivation is an alternative method, and although lower cost at £42/ha it does not last, and in some planting configurations weeds will still be left in the row. Therefore the approval of the most promising products in the trial could reduce costs of production significantly, by c. £2,200/ha if even just one less weeding session is needed in crops where herbicide resistance to currently approved products has developed. Which over the area of rhubarb grown in the UK (505 ha) this would save the industry £1.11 million overall and maintain the profitability and viability of UK production.

Action points for growers

- Five residual herbicide treatments (Sencorex Flow, Callisto, H32, H34, and H34 in a tank mix with H33) gave better control of most commonly occurring annual broad leaf weeds than the currently approved standards for rhubarb. The weeds controlled include Himalayan balsam, and all these treatments would also increase the range of weeds controlled. H32 and Callisto controlled all broad leaved weeds in the trials except small nettle.

- An EAMU for Sencorex Flow was obtained during the trial for application pre-crop emergence in the year of establishment, and at least 12 months before harvest. This is a useful addition to the current approvals, but caution should be taken with the rate of application to new crops, as when applied at a full rate of 1.45 L/ha in the trials, severe phytotoxicity was seen. This was exhibited as veinal chlorosis. Death of weak sets also occurred. Using lower rates may improve safety to the crop, and is advised especially on lighter soils.

- It is recommended that AHDB Horticulture investigates the possibilities of EAMUs for Callisto, Dual Gold, H33 and H34 to enable improved weed control in established plantations. These herbicides were also relatively safe to the crop.

- Shark (not approved at this application timing) and H40 significantly reduced the percentage of weed cover when applied post-harvest one to two weeks after the crop had been topped, and maintained control up to 18 weeks after application.

- Shark provided good control of Himalayan balsam and a range of dicotyledon weeds in both trials but has weaknesses in chickweed, mayweed and groundsel, and growers also need to consider temperature and speed of weed growth to get good efficacy from the product. Reglone or Retro (diquat) may be a better option in cooler temperatures and when weed growth is slow.

- Dow Shield 400 was the only herbicide to fully control perennial thistle with a good kill, but when applied over the crop at the rates used, it led to severe crop damage causing cupping of leaves and deformation of new growth, with twisting and deformation of new leaves seen up to 18 weeks after sprays were applied. However, despite this no plant death was seen and an approval for the control of thistle would still be useful as Dow Shield may be safer to use as a spot treatment or at lower rates, and there are currently no other safe options for full control of this weed.

- It would be worth investigating the possibility of an EAMU for product H40, as it gives good overall weed control, and is particularly effective on mayweeds as well as giving reasonable control of perennial thistle.