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Project number:	N/A – KE project
Project leader:	Angela Huckle, RSK ADAS Ltd.
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Previous report:	N/A
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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.

CONTENTS

GROWER SUMMARY

Headlines

- All treatments and treatment programmes were safe to use in rhubarb crops.
- Authorisation of AHDB 9975 and AHDB 9774 would improve weed control and give alternative modes of action for pre – bud break applications.
- Authorisations of contact herbicides AHDB 9981, AHDB 9994 and AHDB 9731 for use at a post – bud break timing would enable growers to control later germinating seedlings and improve longevity of weed control.

Background

This study compares crop safety and efficacy of several herbicides both new and commercially available at pre- and post- bud break timings for their efficacy against weed species in a crop of rhubarb. Weeds are one of the most common problems in all field crops and can lead to crop loss, yield reduction and reduced plant health. Specific target herbicides authorised for use in rhubarb that control broad leaved weeds and grasses are very few and the diversity of weed species makes it particularly difficult to find effective treatments for broadleaf weeds that don't also damage the crop. Rhubarb is a long-lived perennial crop that breaks dormancy in spring and plantations can be maintained for at least 10 years, and these can be grown on a range of soil types with good drainage. The longevity of the crop means that weed issues can build up over the life of the plantation. Rhubarb has a large root system and requires nutrient inputs and stable soil pH for higher yields and as a result, the successful growth and production of this crop relies on good access to space and little competition for resources with weeds.

There is a limited range of herbicides authorised for use on rhubarb crops, therefore finding alternative chemical modes of action can help in the development of more sustainable integrated weed management (IWM) strategies for the future and guard against resistance development to existing active ingredients. Utilising effective treatment programmes and tank-mixes can make a significant long-term difference for future cultivation and success of the rhubarb crop.

Materials and methods

The trial was sited in a rhubarb crop (variety Stockbridge Harbinger) in Pudsey, Yorkshire. Soil type was a clay loam. Treatments were applied as per **Table 1 and 2** on 17th March 2021 upon bud break and 31st March 2021 post emergence of the crop with at least 2 leaves present. All treatments were applied with a 1.5 m boom, using an Oxford precision knapsack and sprayed at 200 L/ha water volume. A randomized block design was used for the trial layout, with three replicates of 12 treatments, including two untreated controls. There were 36 plots in total, each measuring 1.5 m x 5 m.

The plots were assessed on four occasions, focusing on percentage weed cover and species present, and crop phytotoxicity (i.e. treatment safety). Assessments were carried out at the second application timing and approximately three, seven, and fifteen weeks after treatments were applied.

All crop base inputs were applied by the grower as standard such as fertiliser, irrigation if necessary and pesticides with the exception of any herbicides.

Table 1. The treatment numbers, with their associated applications showing the rates that were used for each application and the timings at which they were used.

	Timing 1 – Within 7 days of bud-break 17th March 2021		**Timing 2 – Post-bud break – at 2 true leaves (TL) and while weeds are before 4 TL 31st March 2021**	
Treatment No	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**
1 and 2	UTC	-		
3*	Stomp Aqua + Gamit 36 CS	3.3 0.25	-	-
4	AHDB 9975 + Gamit 36 CS	4.0 0.25	-	-
5	-	-	AHDB 9975	4.0
6	-	-	AHDB 9994	0.65
7	Stomp Aqua + Gamit 36 CS	3.3 0.25	AHDB 9994	0.65
8	-	-	AHDB 9981	2.0
9	Stomp Aqua + Gamit 36 CS	3.3 0.25	AHDB 9981	2.0
10	-	-	AHDB 9731	1.1
11	Stomp Aqua + Gamit 36 CS	3.3 0.25	AHDB 9731	1.1
12	AHDB 9774 + Gamit 36 CS	1.0 0.25	-	-

Table 2. Commercially available herbicides used in the trial with the active ingredients in each product and the concentration of the product active. Coded products and mode of action.

Herbicide	**Active ingredient(s) or main mode of action**
Stomp Aqua	pendimethalin 455 g/L
Gamit 36 CS	clomazone 360 g/L
AHDB 9975	Residual
AHDB 9994	Residual with contact activity
AHDB 9981	Contact
AHDB 9731	Contact
AHDB 9774	Residual

Summary

Eight treatments significantly reduced weed levels for up to three weeks after the second herbicide application which was applied post- bud break. Four of these treatments then showed a trend for weed reduction for a further four weeks, with the best treatments reducing weed cover by at least 50% at this assessment timing. These were; AHDB 9975 either applied alone post- bud break, or in a tank mix with Gamit 36 CS pre- bud break, and AHDB 9981 or AHDB 9731 applied post- bud break after a pre- bud break application of Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha. The pre- bud break application of Stomp Aqua + Gamit 36 CS was beneficial in suppressing weeds, so that greater efficacy was attained when the post- bud break herbicides were applied later, compared to just using the products AHDB 9981, AHDB 9731 and AHDB 9994 at a post- bud break timing alone.

The weed spectrum at the site was mainly fumitory and charlock which favoured the herbicides AHDB 9975 and AHDB 9731 for charlock control, and AHDB 9981 for fumitory control (**Table 5**). AHDB 9994 would still be a useful herbicide for post- bud break use as it gives good control of weeds such as fat hen, sowthistle, annual meadow grass, mayweed and cleavers which can also be problematic in rhubarb crops.

Weed species	**AHDB 9975 pre-em**	**AHDB 9774 pre-em**	**AHDB 9994 post-em (pre)**	**AHDB 9981 post-em**	**AHDB 9731 post-em**
Fumitory	*	**R**	**(MS)**	**S**	*
Charlock	**S**	*	-	**MS**	**S**
Annual meadow grass	S	S	(S)	MR	-
Black bindweed	S	MS	(S/MS)	MS	MS
Black nightshade	S	-	-	S	S
Cleavers	-	MS	(S/MS)	S	MS
Common field speedwell	S	MS	(S)	S	-
Fat hen	S	MS	S	S	MR
Groundsel	MS	MS	-	S	-
Mayweed	S	S	(S/MS)	MS	S
Redshank	S	R	(S/MS)	MS	S
Shepherds purse	S	MS	(S)	MS	S
Small nettle (annual)	-	MS	MS	MS	-
Sowthistle	MS	-	S	S	-

AHDB 9774 has also shown some control of Himalayan Balsam in past trials (SF 161), and would also be a useful addition or alternative to include in current herbicide programmes.

All treatments and treatment programmes were safe to use in rhubarb.

Conclusions

- AHDB 9975 applied alone post- bud break, or in a tank mix with Gamit 36 CS pre-bud break performed better than the current commercial standard Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha.
- AHDB 9774 + Gamit 36 CS applied pre- bud break also performed better than the current commercial standard and would add some control of Himalayan Balsam.
- AHDB 9981 and AHDB 9731 applied post- bud break after a pre- bud break application of Stomp Aqua + Gamit 36 CS improved weed control for up to seven weeks after application.
- Although AHDB 9994 did not perform as well as the other experimental products in the trial, this is due to the weed spectrum present, and an authorisation would be useful.
- As rhubarb is a long season crop, the contact herbicides which are safe to apply post-bud break could also be beneficial to use as a post-harvest 'top-up' to aid weed control later in the season.

SCIENCE SECTION

Introduction

This study compares crop safety and efficacy of several herbicides both new and commercially available at pre- and post- bud break timings for their efficacy against weed species in a crop of rhubarb. Weeds are one of the most common problems in all field crops and can lead to crop loss, yield reduction and reduced plant health. Specific target herbicides authorised for use in rhubarb that control broad leaved weeds and grasses are very few and the diversity of weed species makes it particularly difficult to find effective treatments for broadleaf weeds that don't also damage the crop. Rhubarb is a long-lived perennial crop that breaks dormancy in spring and plantations can be maintained for at least 10 years, and these can be grown on a range of soil types with good drainage. The longevity of the crop means that weed issues can build up over the life of the plantation. Rhubarb has a large root system and requires nutrient inputs and stable soil pH for higher yields and as a result, the successful growth and production of this crop relies on good access to space and little competition for resources with weeds.

There is a limited range of herbicides authorised for use on rhubarb crops, therefore finding alternative chemical modes of action can help in the development of more sustainable integrated weed management (IWM) strategies for the future and guard against resistance development to existing active ingredients. Utilising effective treatment programmes and tank-mixes can make a significant long-term difference for future cultivation and success of the rhubarb crop.

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AHDB 9994	Residual with contact activity
AHDB 9981	Contact
AHDB 9731	Contact
AHDB 9774	Residual

Statistical analysis:

Data was analysed by analysis of variance (ANOVA) by the ADAS statistician, Chris Dyer using Genstat. A significance level of $p<0.05$ was used to compare all treatments.

Results

Phytotoxicity:

The results of the phytotoxicity assessments showed no statistical differences when treatments were compared with the untreated control for any of the assessment dates. This indicates that the experimental treatments should be safe to use in rhubarb crops. There was scorch from frost at the assessments three and seven weeks after treatment application (**Figure 1**), but this appeared to affect all plots broadly equally including the untreated control and did not lift damage much above an acceptable level (**Table 3**).

Table 3. Mean percentage phytotoxic damage values at application at Timing 2, and three, seven, and fifteen weeks after treatment application. Figures at 20% or below are deemed commercially acceptable.

Treatment (Applied pre bud break unless otherwise stated)	Mean percentage phytotoxic damage (%)			
	At Timing 2	+3 weeks	+7 weeks	+15 weeks
	31.03.21	21.04.21	25.05.21	11.07.21
Untreated Control	0.0	1.6	10.0	6.6
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha	0.0	0.0	20.0	6.7
AHDB 9975 + Gamit 36 CS 0.25 L/ha	0.0	6.7	26.7	10.0
AHDB 9975 post bud-break	0/0	3.3	20.0	10.0
AHDB 9994	0.0	3.3	20.0	13.3
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9994 post bud-break	0.0	16.7	23.3	0.0
AHDB 9981	0.0	16.7	16.7	20.0
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9981 post bud-break	0.0	10.0	20.0	13.3
AHDB 9731	0.0	0.0	26.7	3.3
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9731 post bud-break	0.0	13.3	13.3	13.3
AHDB 9774 + Gamit 36 CS 0.25 L/ha	0.0	6.7	30.0	3.3
F pr. (p-value)	0.0	0.300	0.574	0.435
d.f.	22	22	22	22
L.S.D.	0.0	16.08	20.62	16.39
Significantly different from the untreated control				
Not significantly different from the untreated control				

 

Figure 1) left: Frost scorch on older leaves of rhubarb in the untreated control in trial area, **right:** frost scorch on commercial crop (no post bud break herbicide applied)

Efficacy

Statistically significant changes in percentage weed cover were only observed on the second assessment date which was carried out three weeks after the final application (**Table 4 and Figures 2 and 3**). However, the third assessment also showed a continued trend of weed reduction in those treatments which were effective at the second assessment. The treatments which significantly reduced mean percentage weed cover compared to the untreated control were the standard Stomp Aqua 3.3 L/ha + Gamit 0.25 L/ha, and those which contained the coded product AHDB9975 applied either pre- or post- bud break, or those where coded products AHDB 9981 or AHDB 9731 were applied post- bud break. AHDB 9774 + Gamit 36CS applied pre bud break also significantly reduced weed levels at the second assessment three weeks after the final application. This was also over one month after the initial pre- bud break application.

Although weed reductions are no longer significantly reduced at the third assessment, the plots where AHDB 9975 was applied pre- or post bud break continue to exhibit a substantial reduction in weed cover at seven weeks after spray application. This trend is also observed where AHDB 9981 or AHDB 9731 were applied at 2 rhubarb leaves, after an initial pre- bud break application of Stomp Aqua 3.3 L/ha + Gamit 0.25 L/ha.

At 15 weeks after treatment application there was little difference in weed levels between the untreated control and any of the treatments as any residual herbicide activity had deteriorated.

Table 4. Mean percentage weed cover values at Timing 2, and three, seven and fifteen weeks after the final treatment application.

Treatment (Applied pre bud break unless otherwise stated)	**Mean percentage weed cover (%)**			
	At Timing 2	**+3 weeks**	**+7 weeks**	**+15 weeks**
	31.03.21	**21.04.21**	**25.05.21**	**13.07.21**
Untreated Control	4.2	17.6	56.2	98.4
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha	3.3	12.3	45.0	92.7
AHDB 9975 + Gamit 36 CS 0.25 L/ha	3.0	3.7	25.7	96.7
AHDB 9975 post bud-break	4.0	7.7	19.3	87.7
AHDB 9994	6.7	21.0	46.0	100.0
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9994 post bud-break	4.0	14.0	41.7	90.0
AHDB 9981	5.3	6.3	39.3	93.0
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9981 post bud-break	3.7	7.7	22.3	83.0
AHDB 9731	3.8	10.2	55.0	100.0
Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha then AHDB 9731 post bud-break	2.7	5.0	24.0	81.7
AHDB 9774 + Gamit 36 CS 0.25 L/ha	1.3	5.7	34.3	97.3
p-value	0.404 (NS)	0.002	0.615 (NS)	0.170 (NS)
d.f.	22	22	22	22
L.S.D.	1.797	3.909	21.10	7.20
Significantly different from the untreated control				
Not significantly different from the untreated control				

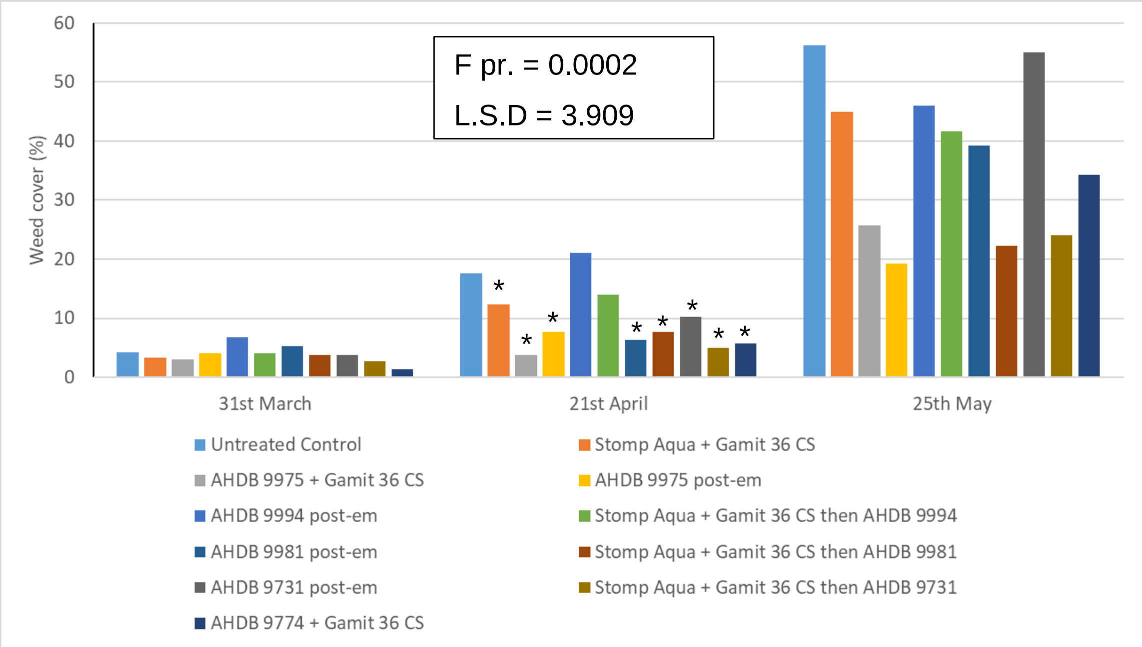

Figure 2. Mean percentage weed cover at three dates, at Timing 2, and three and seven weeks after the final treatment application. Commercial standard is indicated in orange and untreated control is indicated in light blue. Significant treatments indicated by stars.

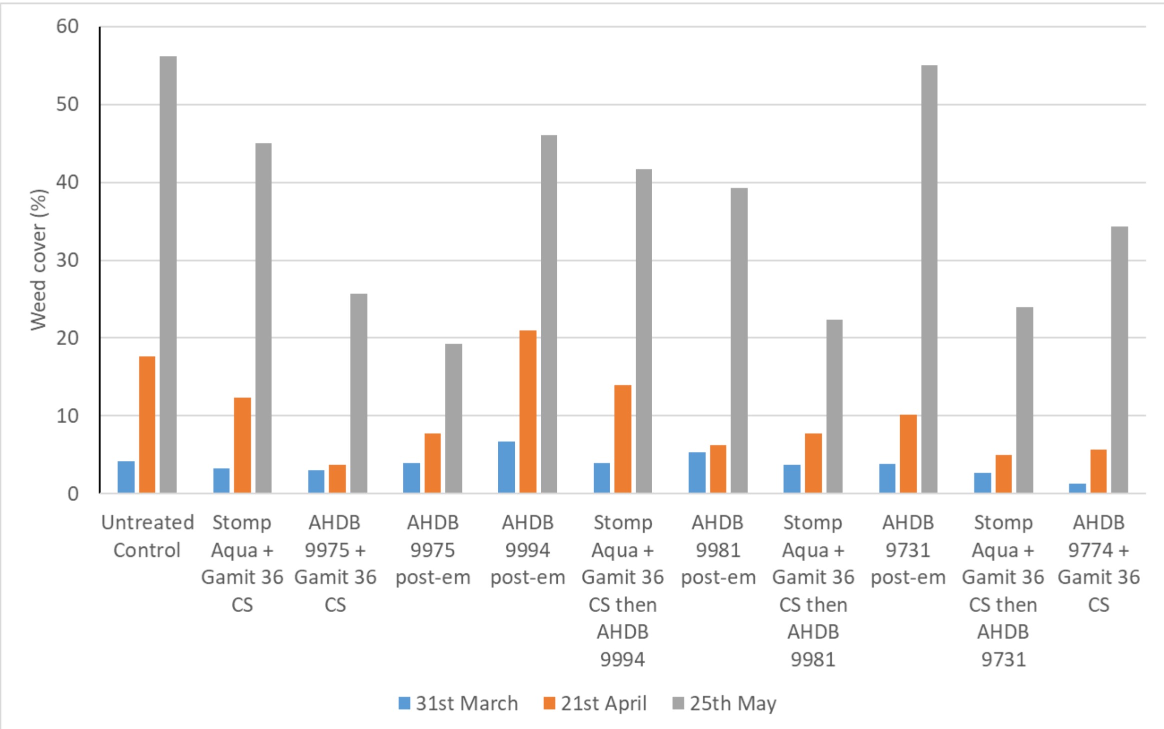

Figure 3. Mean percentage weed cover separated by treatment,

Discussion

Eight treatments significantly reduced weed levels for up to three weeks after the second herbicide application which was applied post- bud break. Four of these treatments then showed a trend for weed reduction for a further four weeks, with the best treatments reducing weed cover by at least 50% at this assessment timing. These were; AHDB 9975 either applied alone post- bud break, or in a tank mix with Gamit 36 CS pre- bud break, and AHDB 9981 or AHDB 9731 applied post- bud break after a pre- bud break application of Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha. The pre- bud break application of Stomp Aqua + Gamit 36 CS was beneficial in suppressing weeds, so that greater efficacy was observed when the post- bud break herbicides were applied later, compared to just using the products AHDB 9981, AHDB 9731 and AHDB 9994 at a post- bud break timing alone.

The weed spectrum at the site was mainly fumitory and charlock which favoured the herbicides AHDB 9975 and AHDB 9731 for charlock control, and AHDB 9981 for fumitory control (**Table 5**). AHDB 9994 would still be a useful herbicide for post- bud break use as it gives good control of weeds such as fat hen, sowthistle, annual meadow grass, mayweed and cleavers which can also be problematic in rhubarb crops.

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Fumitory	*	**R**	**(MS)**	**S**	*
Charlock	**S**	*	**-**	**MS**	**S**
Annual meadow grass	S	S	(S)	MR	-
Black bindweed	S	MS	(S/MS)	MS	MS
Black nightshade	S	-	-	S	S
Cleavers	-	MS	(S/MS)	S	MS
Common field speedwell	S	MS	(S)	S	-
Fat hen	S	MS	S	S	MR
Groundsel	MS	MS	-	S	-
Mayweed	S	S	(S/MS)	MS	S
Redshank	S	R	(S/MS)	MS	S
Shepherds purse	S	MS	(S)	MS	S
Small nettle (annual)	-	MS	MS	MS	-
Sowthistle	MS	-	S	S	-

AHDB 9774 has also shown some control of Himalayan Balsam in past trials (SF 161, Creed. C, 2015), and would also be a useful addition or alternative to include in current herbicide programmes.

Conclusions

- AHDB 9975 applied alone post- bud break, or in a tank mix with Gamit 36 CS pre-bud break performed better than the current commercial standard Stomp Aqua 3.3 L/ha + Gamit 36 CS 0.25 L/ha.
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- Although AHDB 9994 did not perform as well as the other experimental products in the trial, this is due to the weed spectrum present, and an authorisation would be useful.
- As rhubarb is a long season crop, the contact herbicides which are safe to apply post-bud break could also be beneficial to use as a post-harvest ‘top-up’ to aid weed control later in the season.

Knowledge and Technology Transfer

Presentation to Rhubarb Grower Group – 25th January 2022

References

Creed, C. and Huckle, A. (2015) SF 161 - Rhubarb: Evaluation of herbicides for problem weeds. 2015. AHDB Horticulture Final report.