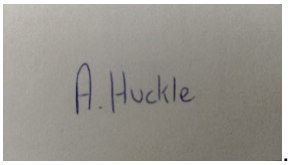
SCEPTREPLUS

Final Trial Report

Trial code:	SP 13 Yr 2. 2018
Title:	Improving weed control in cucurbits (courgettes)
Crop	Group: field vegetables – Cucurbita (courgette)
Target	General broadleaf weeds and grasses, 3WEEDT EPPO1/118(3) Weeds in outdoor fruit vegetables
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS
Period:	21st May 2018 – 31st March 2019
Report date:	15th October 2021
Report author:	Angela Huckle Emily Lawrence
ORETO Number: (certificate should be attached)	409

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

15th October 2021
Date



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Trial Summary

Introduction

While UK courgette growers have benefitted from recent herbicide approvals, there are still very few crop protection products authorised for this crop. Courgettes are a very minor crop in the UK (924 ha in 2018) and sensitive to many herbicides, including those currently approved.

The majority of growers use plastic mulch to control weeds within the crop, but still struggle with inter-row weed competition. It is common practice to apply authorised herbicides via hooded tractor-mounted spray applicators, shielding the crop foliage while treating the weeds between the rows. Wing-P was authorised under EAMU 0619/18 in 2018 and has improved weed control but later applications are needed to give longevity of control through the crops' life. While diquat was approved for inter-row application to control emerged weeds later after planting, it has now been revoked with a final use up of February 2020, therefore alternatives are required.

The limited range of herbicides leaves gaps in the weed spectrum, and growers experience problems with a wide range of weeds. In particular, polygonum weeds, black nightshade, black bindweed, sow thistle, and a number of grass weeds including annual meadow grass, volunteer cereals (especially barley), wild oat, black-grass and brome are problematic for growers. As well as competing with the crop for nutrients and water, these weeds also hinder pickers reducing harvest efficiency.

The trials covered in this report aimed to screen herbicides for crop safety and efficacy, to increase the weed control options available to courgette growers. The trials tested products that showed promise in earlier work, as well as some completely new treatments. Trials were carried out on both planted and drilled crops, under typical commercial growing conditions to ensure relevant results.

Method

Site 1 (transplanted):

Trials were sited at a commercial courgette grower in West Sussex. The trial field was planted on 18th June 2018, with courgette variety 'Kronos'.

Trial 1 (over-row): Treatments were applied at four timings – 24 hours post-planting (25/06/2018), five days post-planting (29/06/2018), two weeks post-planting (09/07/2018), and four weeks after planting (24/07/2018). All were applied with a 1.5 m boom, using an Oxford Precision Sprayer knapsack at 200 L/ha water volume. A randomised block design was used with three replicates of twelve treatments, including two untreated controls and a grower standard treatment (isoxaben + clomazone). There were thirty-six plots in total, each 1.65 m x 7 m.

Trial 2 (inter-row): Treatments were applied at three timings – soon after planting (25/06/2018), two weeks post-planting (09/07/2018), and four weeks post-planting (24/07/2018). All were applied with a lance (0.5 m fan width), using an Oxford Precision Sprayer knapsack at 200 L/ha water volume. A randomised block design was used with three replicates of twelve treatments, including an untreated control and a grower standard treatment (diquat). There were thirty-six plots in total, each 3.3 m x 4 m.

Trial 3 (benfluralin): treatments were applied at two timings – pre-power harrowing and plastic laying (08/06/2018) for benfluralin, and post-planting (25/06/2018) for all other herbicides. Treatments were applied either with a 1.5 m boom, or a lance (0.5 m fan width), as appropriate. An Oxford Precision Sprayer knapsack was used, at 200 L/ha water volume. A randomised block design was used with three replicates of six treatments. There were eighteen plots in total, each 3.3 m x 4 m.

Site 2 (drilled):

Trials were sited at a commercial courgette grower in Gloucestershire. The trial field was drilled on 29th May 2018, with courgette variety 'Tosca'.

Trial 4 (over-row): Treatments were applied at three timings – pre-emergence, post-drilling (01/06/2018); post-emergence, at approx. three true leaves (29/06/2018); and post-emergence, four weeks post-drilling (11/07/2018). All were applied with a 1.5 m boom, using an Oxford Precision Sprayer knapsack at 200 L/ha water volume. A randomised block design was used with three replicates of twenty-two treatments, including two untreated controls and two grower standard treatments (isoxaben + clomazone OR propyzamide). There were sixty-six plots in total, each 1.85 m x 6 m.

Trial 5 (inter-row): Treatments were applied at three timings – pre-emergence, post-drilling (01/06/2018); post-emergence, at approx. three true leaves (29/06/2018); and post-emergence, four weeks post-drilling (11/07/2018). All were applied with a 1.5 m boom, using an Oxford Precision Sprayer knapsack at 200 L/ha water volume. A randomised block design was used with three replicates of twelve treatments. There were thirty-six plots in total, each 1.85 m x 6 m.

All trials were assessed on three occasions, focussing on weed ground cover or percentage of weed killed (efficacy) and crop phytotoxicity (crop safety).

Results

Phytotoxicity (crop safety)

Trial 1 (over-row)

With the exception of Flexidor + Gamit 36 CS applied the day after planting, all treatments applied within a week of planting had a significant effect on the crop which persisted for up to a month after planting (Table 1). This was exhibited mainly as a check to growth with the crop remaining smaller than the untreated controls, or as scorch where Flexidor + Gamit 36 CS was applied over the crop at five days after planting. AHDB 9918 caused scorch and stunting when applied five days after planting, but only stunting when applied a day after planting.

At seven weeks after planting, plots where treatments were applied the day after planting, and AHDB 9987 at half rate in a tank mix with Gamit 36 CS applied at the later timing had recovered to a near acceptable level, or an acceptable level of damage.

All treatments had slightly less effect on the crop when the herbicides were applied the day after planting compared to when they were applied at five days after planting. All give a check to growth, which should be considered with scheduling and speed of growth at application.

AHDB 9985 was tested at two later application timings and had very little effect on the courgette plants when applied at four weeks after planting, compared to when it was applied two weeks later at flowering. But, even when AHDB 9985 was applied at flowering the effect on the crop was a stunt which was recorded as only just under the acceptable score. In Trial 5 a bleaching was observed, which was likely due to weather conditions at application – which was dull, and therefore the courgette leaves may not have been 'waxed up'.

Table 1. Mean phytotoxicity scores at three dates throughout the Trial 1 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Mean crop damage scores		
		9th July Timing D – 2 weeks after planting	24th July Timing E – 1 month after planting (flowering)	10th August – 7 weeks after planting
Untreated		10.0	10.0	10.0
Flexidor 500 + Gamit 36 CS	B	8.3*	9.0	9.7

Treatment	Timing	Mean crop damage scores		
		9th July Timing D – 2 weeks after planting	24th July Timing E – 1 month after planting (flowering)	10th August – 7 weeks after planting
Flexidor 500 + Gamit 36 CS	C	**7.0***	8.0*	**7.3***
AHDB 9987	B	**5.7***	**6.3***	**7.0***
AHDB 9987 + Gamit 36 CS	B	**5.6***	**6.0***	**6.7***
AHDB 9918	B	**6.0***	**7.3***	8.0*
AHDB 9987	C	**5.0***	**6.0***	**6.3***
AHDB 9987 + Gamit 36 CS	C	**5.0***	**6.3***	**7.0***
AHDB 9918	C	**5.0***	**5.7***	**6.3***
diquat, then AHDB 9985	B D	-	8.3	8.7
diquat, then AHDB 9985	B E	-	-	**7.7***
p value		<0.001	<0.001	<0.001
d.f.		23	23	23
L.S.D.		1.373	1.689	1.641

* Statistically different to untreated

Trial 2 (inter-row)

A number of the treatments caused a check to speed of growth even when applied inter-row, but in many cases it was only just under an acceptable score with no crop loss (Table 2). At the end of the assessment period (early fruit) those treatments which did not have a score below eight were; the commercial standard diquat, AHDB 9995 in a tank mix with Flexidor and Gamit 36 CS, AHDB 9998, AHDB 9825 (alone and in a tank mix with Wing-P), and AHDB 9897 + Phase II.

Crop effects seen were a check to speed of growth and crop variability, and a little transient scorch or yellowing from the contact desiccants Shark, AHDB 9897 and Finalsan. The check to growth would likely be acceptable if enough weed control is gained as this can be factored into schedules, for example this approach is used where Wing-P is now included in commercial programmes.

Table 2. Mean phytotoxicity scores at three dates throughout the Trial 2 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: B = 1 day after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Mean crop damage scores		
		9th July	24th July	10th August
Untreated	-	10.0	10.0	10.0
diquat	D	9.3	9.0	9.0
AHDB 9995 + Flexidor 500 + Gamit 36 CS	B	**7.7***	8.0*	9.0
Wing-P 2L	B	**7.3***	**6.7***	**7.3***
Wing-P 4L	B	**7.0***	**6.3***	**7.7***
Wing-P 2L +	B	**7.3***	**7.0***	**7.7***

Treatment	Timing	Mean crop damage scores		
		9th July	24th July	10th August
AHDB 9998				
AHDB 9998	B	**7.7***	**7.7***	8.0*
AHDB 9825	B	8.3*	8.7	9.3
AHDB 9825 + Wing-P	B	**7.3***	**7.0***	8.0*
Finalsan + Activator 90	D and E	**7.0***	**6.7***	**7.3***
Shark	D	**7.0***	**7.0***	**7.7***
AHDB 9897 + Phase II	D	8.7	8.3*	9.0
p value		0.006	0.003	0.080
d.f.		22	22	22
L.S.D.		1.557	1.652	1.841

* Statistically different to untreated

Trial 3 (benfluralin)

There were no significant differences between scores, but where any herbicides were applied over the crop post-planting, this caused the crop damage score to drop below an acceptable level by causing a check to crop growth which set the crop back a week. However, by the final assessment at early fruiting all plots treated with all except AHDB 9918 had recovered to a near acceptable standard (Table 3). Bonalan (benfluralin) did not cause any unacceptable damage to the courgettes, or any perceptible reduction in the speed of growth.

Table 3. Mean phytotoxicity scores at three dates throughout the Trial 3 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: A = pre-planting and incorporated, and B = 5 days after planting.

Treatment	Timing	Mean crop damage scores		
		9th July Timing B + 2 weeks	24th July Timing B + 4 weeks	10th August Timing B + 6 weeks
Bonalan	A	8.3	8.7	9.0
Bonalan, then Gamit 36 CS*	A B	8.0	8.7	8.3
Bonalan, then Gamit 36 CS	A B	**7.3**	**7.7**	**7.7**
Bonalan, then AHDB 9918	A B	**5.7**	**6.3**	**6.7**
Bonalan, then AHDB 9987	A B	**5.7**	**7.0**	**7.7**
Bonalan, then AHDB 9987 + Gamit 36 CS	A B	**5.7**	**6.7**	**7.7**
	p value	0.066	0.106	0.170
	d.f.	10	10	10
	L.S.D.	2.293	2.020	1.758

* inter-row application

Trial 4 (over-row)
All of the pre-emergence herbicide treatments were safe to use in drilled courgettes in this trial with only a little yellowing caused where AHDB 9987 + Gamit was applied (Table 4). This occurred at two months after application and would be likely to be caused by the Gamit moving into the rooting zone after a rain event. However, the damage was only just under acceptable. Wing-P 2.0 L/ha was damaging and caused crop death in the drilled pumpkin trial (see separate report SP13. 2018) so care still needs to be taken when using this product in a drilled cucurbit crop. The soil type at this trial site was a clay loam, and demonstrates the influence that soil type can have on crop safety with the product being safe at this site, but causing crop death on the pumpkin trial site with a sandy soil. However, at this site it still caused a slight but acceptable check to the speed of growth of the courgettes.

None of the post-emergence applications caused any unacceptable crop effects with the exception of AHDB 9994, which caused a moderate check to the growth of the crop, scorch and yellow spotting. In the inter-row application of diquat there was drift which caused crop death and confounded assessment of the effects of AHDB 9985, although yellowing was observed after application of AHDB 9985 when applied at flowering. This was not seen at the Trial 1 site, but conditions at application at Trial 4 were duller and therefore there would be more risk of damage if the leaves were not as well waxed up at application.

Table 4. Mean phytotoxicity scores at three dates throughout the Trial 4 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in **bold.**

Treatment	Timing	Mean crop damage scores		
		29th June - 4 weeks after drilling (Timing G)	11th July - flowering (Timing H)	25th July - (Timing H + 2 weeks)
Untreated	-	-	10.0	10.0
Flexidor 500 + Gamit 36 CS	G	-	10.0	10.0
Kerb Flo	G	-	10.0	10.0
Flexidor 500 + Gamit 36 CS	F	10.0	10.0	10.0
AHDB 9987	F	10.0	10.0	10.0
AHDB 9987 + Gamit 36 CS	F	10.0	10.0	**7.7***
AHDB 9918	F	10.0	10.0	10.0
AHDB 9995	F	9.7	10.0	10.0
AHDB 9995 + Gamit 36 CS	F	10.0	10.0	10.0
Wing-P 2.0 L/ha	F	9.0	10.0	8.3
AHDB 9898	F	9.3	10.0	10.0
AHDB 9998	F	10.0	10.0	10.0
Wing-P 2.0 L/ha + AHDB 9998	F	9.7	10.0	8.3
AHDB 9994	F	10.0	10.0	10.0
AHDB 9917	F	9.7	10.0	10.0
AHDB 9987	G	-	10.0	10.0
AHDB 9987 + Gamit 36 CS	G	-	10.0	9.3

Treatment	Timing	Mean crop damage scores		
		29th June - 4 weeks after drilling (Timing G)	11th July - flowering (Timing H)	25th July - (Timing H + 2 weeks)
AHDB 9918	G	-	10.0	10.0
AHDB 9994	G	-	**5.7***	8.0
diquat, then AHDB 9985 1.0 L/ha	G H	9.8	**1.0***	**3.7***
diquat, then AHDB 9985 1.5 L/ha	G H	9.9	**1.0***	**5.3***
p value		(NS) 0.164	<0.001	<0.001
d.f.		24	45	45
L.S.D.		0.6435	0.1733	2.206

* Statistically different to untreated

Trial 5 (inter-row)
All of the treatments were crop safe (Table 5).

Table 5. Mean phytotoxicity scores at three dates throughout the Trial 5 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in **bold.**

	Mean crop damage scores		
	29th June 4 weeks after drilling Timing G	11th July Timing H	25th July Timing H + 2 weeks
Untreated	9.83	10.00	10.00
diquat	9.83	9.00	10.00
AHDB 9995 + Flexidor 500+ Gamit 36 CS	10.00	10.00	10.00
Wing-P (2.0 L/ha)	10.00	10.00	10.00
Wing-P (4.0 L/ha)	9.33	10.00	10.00
Wing-P + AHDB 9998	10.00	9.67	10.00
AHDB 9998	9.67	10.00	10.00
AHDB 9997	10.00	10.00	10.00
Finalsan + Activator 90	9.83	10.00	10.00
(Finalsan + Activator 90) x2	9.83	10.00	10.00
Shark	9.83	9.00	10.00
AHDB 9897 + Phase II	9.83	9.67	10.00
p value	0.119	0.437	-
d.f.	10	22	-

	Mean crop damage scores		
	29th June 4 weeks after drilling Timing G	11th July Timing H	25th July Timing H + 2 weeks
L.S.D.	0.5753	1.100	-

* Statistically different to untreated

Weed cover

Trials 1-3

There were no significant differences in weed reduction in these trials as weed levels were low. Results of the percentage reduction in weed levels compared to the untreated are shown in Tables 6, 7 and 8.

Trial 1 (over-row)

Table 6. Percentage reduction in weed cover at Trial 1 (calculated using Abbott's formula) – values highlighted in red show an increase in weed cover. Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Weed cover reduction (%)	
		9th July	24th July
Flexidor 500 + Gamit 36 CS	B	22.08	37.42
Flexidor 500 + Gamit 36 CS	C	25.69	24.53
AHDB 9987	B	31.99	44.11
AHDB 9987 + Gamit 36 CS	B	25.41	20.63
AHDB 9918	B	-0.78	23.41
AHDB 9987	C	16.70	26.97
AHDB 9987 + Gamit 36 CS	C	30.79	24.53
AHDB 9918	C	32.39	44.81
diquat, then AHDB 9985	B D	13.73	17.28
diquat, then AHDB 9985	B E	32.39	31.29

Trial 2 (inter-row)

Table 7. Percentage reduction in weed cover at Trial 2 (calculated using Abbott's formula). Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Weed cover reduction (%)	
		9th July	24th July
diquat	D	26.50	11.09
AHDB 9995 + Flexidor 500+ Gamit 36 CS	B	44.66	23.15
Wing-P 2L	B	61.58	54.45
Wing-P 4L	B	51.60	38.94
Wing-P + AHDB 9998	B	51.60	44.66
AHDB 9998	B	44.66	40.35
AHDB 9825	B	38.94	44.66
AHDB 9825 + Wing-P	B	46.21	44.66
(Finalsan + Activator 90) x2	D and E	38.94	19.74
Shark	D	11.09	0.00
AHDB 9897 + Phase II	D	32.74	0.73

Trial 3 (benfluralin)

Table 8. Percentage reduction in weed cover at Trial 3, relative to 'control' treatment of Bonalan only (calculated using Abbott's formula) – highlighted values in red show an increase in weed cover. Letters denote spray timing: A = pre-planting and incorporated, and B = 5 days after planting.

Treatment	Timing	Weed cover reduction (%)	
		9th July (Timing B)	24th July (Timing B + 2 weeks)
Bonalan, then Gamit 36 CS*	A B	-13.42	21.04
Bonalan, then Gamit 36 CS	A B	22.11	28.73
Bonalan, then AHDB 9918	A B	44.79	69.04
Bonalan, then AHDB 9987	A B	38.26	49.65
Bonalan, then AHDB 9987 + Gamit 36 CS	A B	22.11	36.24

*applied inter-row

Trial 4 (over-row)
Three pre-emergence treatments combined crop safety with a reduction of the percentage overall weed level greater than 25% by visual estimate at the final assessment. These were AHDB 9995 + Gamit 36CS, Wing-P 2.0 L/ha and Wing P 2.0 L/ha + AHDB 9998 (Table 9).

Table 9. Mean percentage weed kill by visual estimation (weed reduction) values for Trial 4. For example, 100%= 100% weeds killed with zero weeds present. Letters denote spray timing: F = pre-emergence, G = at 3 true leaves, H = one month after drilling (flowering)

		Mean % weed reduction – visual estimate	
Treatment	**Timing**	**11th July- flowering (Timing H)**	**25th July- (Timing H + 2 weeks)**
Untreated	-	0.0	5.0
Flexidor 500+ Gamit 36 CS	G	30.0	8.3
Kerb Flo	G	0.0	0.0
Flexidor 500 + Gamit 36 CS	F	16.7	3.3
AHDB 9987	F	8.3	6.7
AHDB 9987 + Gamit 36 CS	F	36.7	0.0
AHDB 9918	F	0.0	0.0
AHDB 9995	F	51.7	13.3
AHDB 9995 + Gamit 36 CS	F	75.0	33.3
Wing-P 2.0 L/ha	F	65.0	35.0
AHDB 9898	F	0.0	0.0
AHDB 9998	F	0.0	3.3
Wing-P 2.0 L/ha + AHDB 9998	F	58.3	26.7
AHDB 9994	F	36.7	10.0
AHDB 9917	F	13.3	0.0
AHDB 9987	G	3.3	0.0
AHDB 9987 + Gamit 36 CS	G	10.0	0.0
AHDB 9918	G	6.7	0.0
AHDB 9994	G	55.0	33.3
diquat, then AHDB 9985 1.0 L/ha	G H	50.0	0.0
diquat, then AHDB 9985 1.5 L/ha	G H	50.0	16.7

*Untreated control; treatments 1 and 2

Trial 5 (inter-row)
Five products gave equivalent or better reduction in the percentage weed cover when compared to the standard inter-row application of diquat (Table 10). The treatments were Wing-P at either 2.0 or 4.0 L/ha, AHDB 9897 + Phase II, Shark and Finalsan + Activator 90 applied twice.

AHDB 9897 + Phase II was the most effective treatment reducing the weed level by the highest percentage. Finalsan + Activator 90 was much more effective as a double application when compared to the single application, increasing weed reduction from 35% to 71.7%.

Table 10. Mean percentage weed kill by visual estimation (weed reduction) values for Trial 5 For example, 100%= 100% weeds killed with zero weeds present. Letters denote spray timing: F = pre-emergence, G = at 3 true leaves, H = one month after drilling (flowering)

Treatment	Timing	Mean % weeds reduction – visual estimate		
		29th June 4 weeks after drilling Timing G	11th July Timing H	25th July Timing H + 2 weeks
Untreated	-	0.0	0.0	23.3
Diquat	F	0.0	93.3	73.3
AHDB 9995 + Flexidor 500+ Gamit 36 CS	F	89.3	80.0	63.33
Wing-P (2.0 L/ha)	F	87.0	65.0	86.7
Wing-P (4.0 L/ha)	F	96.0	93.3	75.0
Wing-P + AHDB 9998	F	83.3	68.3	38.3
AHDB 9998	F	83.3	45.0	16.7
AHDB 9997	G	35.0	13.3	0.0
Finalsan + Activator 90	G, H	0.0	83.3	35.0
(Finalsan + Activator 90) x2	G	0.0	65.0	71.7
Shark	G	0.0	97.0	91.7
AHDB 9897 + Phase II	G	0.0	98.0	95.0

Conclusions

- In the planted courgette trials, coded product AHDB 9987 was crop safe when applied over the courgettes either at full rate alone or at ½ rate in a tank mix with Gamit and would provide additional control of weeds such as fat hen, cranesbill, and wild radish and increase control of groundsel and sow thistle.
- Timing the herbicide application within two days of planting while the thicker cotyledons were present was safer than application a few days later once the true leaves had emerged.
- All of the experimental herbicides applied over the crop caused a slight check to growth which set the crop back by a week – this would need to be considered within harvest schedules.
- Bonalan (benfluralin) was crop safe.
- In the inter-row trials, both planted and drilled, all treatments were crop safe, many caused a check to growth but this was deemed acceptable.

- The contact desiccants; Shark, AHDB 9897 and Finalsan caused scorch where the spray contacted the edge of the leaves falling in the row, but the effect was transient.
- In the drilled crop, where the inter-row herbicides were applied, five products gave equivalent or better reduction in the percentage weed cover when compared to the standard inter-row application of diquat. The treatments were Wing-P at either 2.0 or 4.0 L/ha, AHDB 9897 + Phase II, Shark and Finalsan + Activator 90 applied twice.

Take home message

Authorisation of AHDB 9987, Shark, and AHDB 9897 would improve weed control in courgette crops. AHDB 9897 + Phase II and Shark would be particularly useful as alternatives for inter-row application after the loss of diquat. Finalsan gained an authorization in 2020, (EAMU 1609/20) and should improve weed control when applied twice as an inter-row application.

Objectives

1. Trial 1: to compare a number of post-planting herbicides with the commercial standard (isoxaben + clomazone pre-emergence) for selectivity (crop safety) and efficacy in courgettes.
2. Trial 2: to compare a number of residual and contact herbicides applied as inter-row applications with the commercial standard (diquat) for selectivity (crop safety) and efficacy in courgettes.
3. Trial 3: to compare promising newer pre-emergence and post-emergence herbicide programmes for courgettes; applied as both incorporated, over-the-row and inter-row applications for selectivity (crop safety) and efficacy in courgettes.

Trial conduct

UK regulatory guidelines were followed but EPPO guideline took precedence. The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		**Variation from EPPO**
EPPO PP1/135(4)	Phytotoxicity assessment	None
EPPO PP1/152(4)	Guideline on design and analysis of efficacy evaluation trials	None
EPPO PP1/225 (2)	Minimum effective dose	None
EPPO PP1/181 (4)	Conduct and reporting of efficacy evaluation trials including good experimental practice	None
EPPO PP 1/214(3)	Principles of acceptable efficacy	None
EPPO PP 1/224(2)	Principles of efficacy evaluation for minor uses	None

Test site

Item	**Details**	
Location address	**Site 1:** Field: Stone Barn Barkers /02 Barfoots (Sefter Farm) Pagham Road Bognor Regis, PO20 7FL West Sussex Grid reference: SU 85000 03000	**Site 2:** Field: Barn Field Loveridge W R Haines (Leasow Farms) Ltd. The Cam (B4035) Chipping Campden, GL55 6JT Gloucestershire Grid reference: SP 16482 39226
Crop	Courgette	
Cultivar	Kronos	Tosca
Soil or substrate type	Silt clay loam	Clay loam
Agronomic practice	See Appendix A	
Prior history of site	See Appendix A	

Trial design

Item	**Details**
Trial design:	Fully randomised block
Number of replicates:	3
Row spacing:	**0.83 m** (Trial 1, 2 & 3), **0.93 m** (Trial 4 & 5)
Plot size: (w x l)	**1.65 m x 7 m** (Trial 1), **3.3 m x 4 m** (Trial 2 & 3), **1.85 m x 6 m** (Trial 4 & 5)
Plot size: (m^2)	**11.6 m^2** (Trial 1), **13.2 m^2** (Trial 2 & 3), **11.1 m^2** (Trial 4 & 5)
Number of plants per plot:	Approx. 4 per m^2
Leaf Wall Area calculations	N/A

Treatment details

AHDB Code	Product name	Active substance	Formulation batch number	Content of active substance in product (g/L)	Formulation type
AHDB 9898	Confidential				
AHDB 9917	Confidential				
AHDB 9994	Confidential				
N/A	Bonalan (no authorisation for use)	benfluralin	SIPAL7005	150.0	Emulsifiable Concentrate
N/A	Activator 90	alcohol ethoxylates natural fatty acids	106814	(g/kg) 750.0 (g/kg) 150.0	Emulsifiable Concentrate
AHDB 9985	Confidential				
AHDB 9998	Confidential				
N/A	Finalsan	pelargonic acid	38089327	186.7	Emulsifiable Concentrate
N/A	Flexidor 500	isoxaben	F006H15002	500.0	Suspension Concentrate
N/A	Gamit 36 CS	clomazone	N/K	360.0	Capsule suspension
AHDB 9897	Confidential				
AHDB 9997	Confidential				
AHDB 9995	Confidential (Approval of active substance withdrawn 2020)				
N/A	Kerb Flo	propyzamide	N/K	400.0	Suspension Concentrate
N/A	Phase II	esterified rapeseed oil	N/K	842.0	Emulsifiable Concentrate
N/A	Reglone	Diquat (Approval of active substance withdrawn 2020)	711838	200.0	Soluble Concentrate
N/A	Shark (authorised only for use pre-planting)	carfentrazone-ethyl	N/K	60.0	Micro-emulsion
AHDB 9825	Confidential				
AHDB 9987	Confidential				
AHDB 9918	Confidential				
N/A	Wing-P	dimethenamid-p + pendimethalin	14243535	212.5 250.0	Emulsifiable Concentrate

Application schedule

Trial 1 (over-row planted):

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
1	Untreated	-	-	-
2	Untreated	-	-	-

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
3*	Flexidor 500 + Gamit 36 CS	B	250 90	0.50 0.25
4	Flexidor 500 + Gamit 36 CS	C	250 90	0.50 0.25
5	AHDB 9987	B	1200	2.00
6	AHDB 9987 + Gamit 36 CS	B	600 90	1.00 0.25
7	AHDB 9918	B	240	0.48
8	AHDB 9987	C	1200	2.00
9	AHDB 9987 + Gamit 36 CS	C	600 90	1.00 0.25
10	AHDB 9918	C	240	0.48
11	Diquat, then AHDB 9985	B D	400 120	2.00 1.00
12	Diquat, then AHDB 9985	B E	400 120	2.00 1.00

* Grower standard

Trial 2 (inter-row planted):

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
1	Untreated	-	-	-
2*	Diquat	D	400	2.00
3	AHDB 9995 + Flexidor 500+ Gamit 36 CS	B	800 250 90	2.00 0.50 0.25
4	Wing-P	B	452 500	2.00
5	Wing-P	B	850 1000	4.00
6	Wing-P + AHDB 9998	B	452, 500 1344	2.00 1.40
7	AHDB 9998	B	1344	1.40
8	AHDB 9825	B	1046.5	2.30
9	AHDB 9825 + Wing-P	B	1046.5 425	2.30 2.00
10	Finalsan + Activator 90	D, E	186.7 750, 150	34.00 0.20
11	Shark	D	60	0.30
12	AHDB 9897 + Phase II	D	26.5 842	0.40 1.00

* Grower standard

Trial 3 (benfluralin planted):

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
1	Bonalan	A	1200	8.00
2	Bonalan, then Gamit 36 CS*	A B	1200 90	8.00 0.25
3	Bonalan, then Gamit 36 CS	A B	1200 90	8.00 0.25
4	Bonalan, then AHDB 9918	A B	1200 240	8.00 0.48
5	Bonalan, then AHDB 9987	A B	1200 1200	8.00 2.00
6	Bonalan, then AHDB 9987 + Gamit 36 CS	A B	1200 600 90	8.00 1.00 0.25

* Inter-row

Trial 4 (over-row drilled):

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
1	Untreated	-	-	-
2	Untreated	-	-	-
3*	Flexidor 500 + Gamit 36 CS	G	250 90	0.50 0.25
4*	Kerb Flo	G	400	1.00
5	Flexidor 500 + Gamit 36 CS	F	250 90	0.50 0.25
6	AHDB 9987	F	1200	2.00
7	AHDB 9987 + Gamit 36 CS	F	600 90	1.00 0.25
8	AHDB 9918	F	240	0.48
9	AHDB 9995	F	800	2.00
10	AHDB 9995+ Gamit 36 CS	F	800 90	2.00 0.25
11	Wing-P	F	425, 500	2.00
12	AHDB 9898	F	504	0.70
13	AHDB 9998	F	1344	1.40
14	Wing-P + AHDB 9998	F	425, 500 960	2.00 1.00
15	AHDB 9994	F	600	1.00
16	AHDB 9917	F	N/K	0.70

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
17	AHDB 9987	G	1200	2.00
18	AHDB 9987 + Gamit 36 CS	G	600 90	1.00 0.25
19	AHDB 9918	G	240	0.48
20	AHDB 9994	G	600	1.00
21	diquat, then AHDB 9985	G H	400 120	2.00 1.00
22	diquat, then AHDB 9985	G H	400 180	2.00 1.50

* Grower standard

Trial 5 (inter-row drilled):

Trt. No.	Treatment: product name or AHDB code	Application timing code	Rate of active substance(s) (g/ha)	Rate of product (L/ha)
1	Untreated	-	-	-
2*	diquat	G	400	2.00
3	AHDB 9995 + Flexidor 500+ Gamit 36 CS	F	800 250 90	2.00 0.50 0.25
4	Wing-P	F	452 500	2.00
5	Wing-P	F	850 1000	4.00
6	Wing-P + AHDB 9998	F	452, 500 1344	2.00 1.40
7	AHDB 9998	F	1344	1.40
8	AHDB 9997	F	100	0.2
9	Finalsan + Activator 90	G	186.7 750, 150	34.00 0.20
10	Finalsan + Activator 90	G, H	186.7 750, 150	34.00 0.20
11	Shark	G	60	0.30
12	AHDB 9897 + Phase II	G	26.5 842	0.40 1.00

* Grower standard

Application details (trial 1, 2, & 3)

	Timing A	Timing B	Timing C	Timing D	Timing E
Application date	08/06/2018	25/06/2018	29/06/2018	09/07/2018	24/07/2018
Time of day	13:25 – 13:30	16:50 – 18:10	11:50 – 12:30	15:50 – 17:00	20:45 – 20:55
Crop growth stage (Max, min average BBCH)	N/A (pre-planting)	BBCH 12	BBCH 13-14	BBCH 17-18	BBCH 61 (flowering)
Crop height (cm)	N/A	15	15	20	30
Crop coverage (%)	N/A	10	10	20	50

	Timing A	Timing B	Timing C	Timing D	Timing E
Application Method	spray	spray	spray	spray	spray
Application Placement	soil	foliar	foliar	foliar	foliar
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2.4 bar	2.4 bar	2.4 bar	2.4 bar	2.4 bar
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan
Nozzle size	02F110	02F110	02F110	02F110	02F110
Application water volume/ha	200	200	200	200	200
Temperature of air - shade (°C)	23.9	22.0 – 24.7	28.0 – 31.0	24.7 – 25.4	22.1 – 22.5
Relative humidity (%)	68.1	51.0 – 57.6	38.4 – 45.2	54.2 – 57.1	80.4 – 80.5
Wind speed range (mph)	4.8	6.9 – 7.5	11.0 – 15.0	4.3 – 11.8	1.5
Dew presence (Y/N)	N	N	N	N/K	N/K
Temperature of soil - 10cm (°C)	22.0	N/K	N/K	N/K	N/K
Wetness of soil - 2-5 cm	dry	dry	dry	wet	N/K
Cloud cover (%)	N/K	0	0	75	50

Application details (trial 4 & 5)

	Timing F	Timing G	Timing H
Application date	01/06/2018	29/06/2018	11/07/2018
Time of day	14:20 – 15:45	11:50 – 13:20	09:30 – 11:15
Crop growth stage (Max, min average BBCH)	BBCH 00	BBCH 12-13	BBCH 61 (flowering)
Crop height (cm)	NA	15	30
Crop coverage (%)	N/A	N/K	50
Application Method	spray	spray	spray
Application Placement	soil	foliar	foliar
Application equipment	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)	Oxford Precision Sprayer (knapsack)
Nozzle pressure	N/K	N/K	N/K
Nozzle type	Flat fan	Flat fan	Flat fan
Nozzle size	03F110	03F110	03F110
Application water volume/ha	200	200	200
Temperature of air - shade (°C)	21.9 – 22.1	25.2 – 26.3	18.2 – 21.1
Relative humidity (%)	78.2 – 80.1	38.2 – 41.1	38.0 – 39.1
Wind speed range (mph)	0.9 – 1.1	1.3 – 1.4	1.2
Dew presence (Y/N)	N	N	N
Temperature of soil - 10cm (°C)	N/K	N/K	N/K
Wetness of soil - 2-5 cm	wet	dry	dry

Cloud cover (%)	N/K	0	80

Untreated levels of pests/pathogens at application and through the assessment period

Common name: Broad leaved weeds and grasses
Scientific name: *N/A*
EPPO code: 3WEEDT

(untreated averages)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Weed level at first assessment	12.0%	13.3%	10.3%	57.3%*	100%*
Weed level at end of assessment period	14.7%	13.3%	16.3%	95%	95%**

* taken from first weed assessment which was a month after emergence
** weed cover reduced slightly as the courgettes increased ground cover

Assessment details

Trial 1, 2 & 3:

Evaluation date	**Evaluation Timing (DA)***	**Crop Growth Stage (BBCH)**	**Evaluation type (efficacy, phytotox)**	**What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)**
09/07/2018	15 (trial 3: 32)		efficacy, phytotox	Percentage of weed cover – whole plot score Phytotox (scale 0-10, 0 = Dead)
24/07/2018	30 (trial 3: 47)		efficacy, phytotox	Percentage of weed cover – whole plot score Phytotox (scale 0-10, 0 = Dead)
10/08/2018	47 (trial 3: 64)		phytotox	Phytotox (scale 0-10, 0 = Dead)

* DA – days after application

Trial 4 & 5:

Evaluation date	**Evaluation Timing (DA)***	**Crop Growth Stage (BBCH)**	**Evaluation type (efficacy, phytotox)**	**What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)**
29/06/2018	29		efficacy, phytotox	Percentage of weeds killed – whole plot score Phytotox (scale 0-10, 0 = Dead)
11/07/2018	41		efficacy, phytotox	Percentage of weeds killed – whole plot score Phytotox (scale 0-10, 0 = Dead)
25/07/2018	55		efficacy, phytotox	Percentage of weeds killed – whole plot score Phytotox (scale 0-10, 0 = Dead)

* DA – days after application

Statistical analysis

All trials had randomised block designs, each with treatments replicated three times.

All data were analysed by ANOVA using Genstat 18.4 by Chris Dyer and Emily Lawrence at RSK ADAS.

As each trial site had an uneven distribution of weeds – which is not unexpected in field situations – there was a need to transform weed cover data prior to analysis. To determine treatment efficacy, an angular transformation was performed then the back transformed means presented, from which the % reduction in weeds was calculated using Abbott's formula. This was only completed for Trials 1-3, as in trials 4-5 weed control was assessed by a visual estimate of percentage weed kill.

Results – Trial 1 (planted crop, over the row applications) and Trial 2 (planted crop, inter-row applications)

Phytotoxicity

The results of phytotoxicity assessments from three dates are presented in Table 1 and **Figure 1** for the over the row trial, and in Table 2 and Figure 2 for the inter-row trial. These were scored on a scale from 0 to 10, with 0 being 'dead', and 10 being 'no effect'. Plots deemed to have a commercially acceptable level of damage were scored 8 or above.

Phytotoxicity was recorded using the following scale:

Crop tolerance score	Equivalent to crop damage (% phytotoxicity)
0	complete crop kill 100%
1	80-95% damage
2	70-80%
3	60-70%
4	50-60%
5	40-50%
6	25-40%
7	15-25%
8*	10-15%
9	5-10%
10	no damage

* 8 = acceptable damage, i.e. damage unlikely to reduce yield, and acceptable to the farmer.

Trial 1 – With the exception of Flexidor + Gamit 36 CS applied the day after planting, all treatments applied within a week of planting had a significant effect on the crop which persisted for up to a month after planting. This was exhibited mainly as a check to growth with the crop remaining smaller than the untreated controls, or as scorch where Flexidor + Gamit 36 CS was applied over the crop at five days after planting. AHDB 9918 caused scorch and stunting when applied five days after planting, but only stunting when applied a day after planting.

At seven weeks after planting, plots where treatments were applied the day after planting, and AHDB 9987 at half rate in a tank mix with Gamit 36 CS applied at the later timing had recovered to a near acceptable level, or an acceptable level of damage.

All treatments had slightly less effect on the crop when the herbicides were applied the day after planting compared to when they were applied at five days after planting. All give a check to growth, which should be considered with scheduling and speed of growth at application.

AHDB 9985 was tested at two later application timings and had very little effect on the courgette plants when applied at four weeks after planting, compared to when it was applied two weeks later at flowering. But, even when AHDB 9985 was applied at flowering the effect on the crop was a stunt which was recorded as only just under the acceptable score.

Table 1. Mean phytotoxicity scores at three dates throughout the Trial 1 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Mean crop damage scores		
		9th July Timing D – 2 weeks after planting	24th July Timing E – 1 month after planting (flowering)	10th August – 7 weeks after planting
Untreated		10.0	10.0	10.0
Flexidor 500 + Gamit 36 CS	B	8.3*	9.0	9.7
Flexidor 500 + Gamit 36 CS	C	**7.0***	8.0*	**7.3***
AHDB 9987	B	**5.7***	**6.3***	**7.0***
AHDB 9987 + Gamit 36 CS	B	**5.6***	**6.0***	**6.7***
AHDB 9918	B	**6.0***	**7.3***	8.0*
AHDB 9987	C	**5.0***	**6.0***	**6.3***
AHDB 9987 + Gamit 36 CS	C	**5.0***	**6.3***	**7.0***
AHDB 9918	C	**5.0***	**5.7***	**6.3***
diquat, then AHDB 9985	B D	-	8.3	8.7
diquat, then AHDB 9985	B E	-	-	**7.7***
p value		<0.001	<0.001	<0.001
d.f.		23	23	23
L.S.D.		1.373	1.689	1.641

* Statistically different to untreated

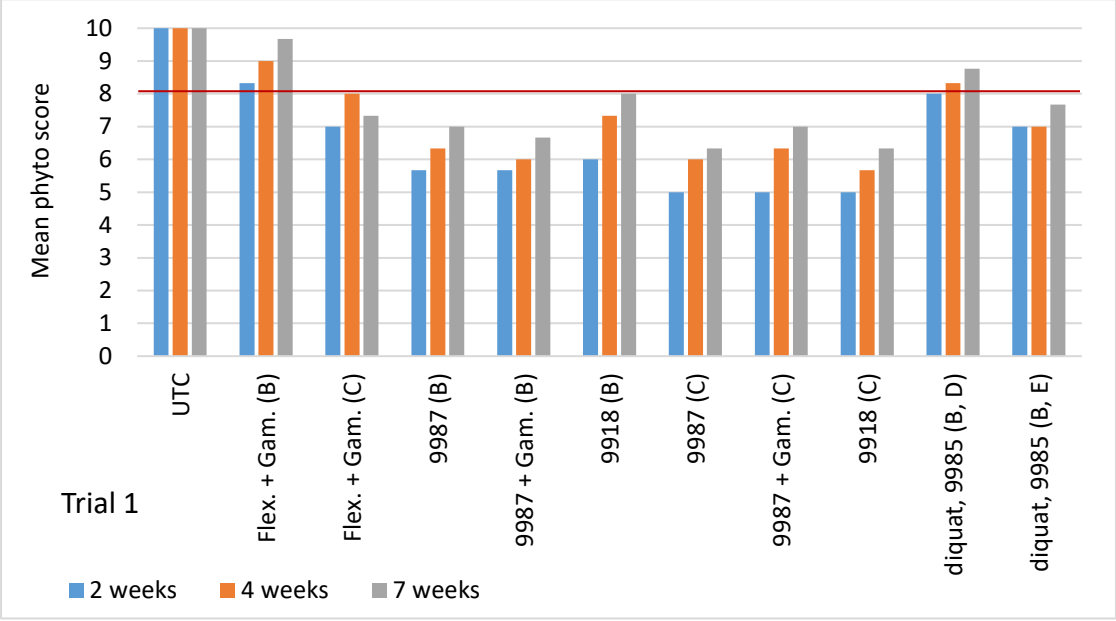


Figure 1. Mean phytotoxicity (0-10) at two, four and seven weeks after Timing B treatment application to Trial 1. Scores of 8 or above deemed acceptable damage (as indicated by red line). *Letters denote spray timing.*

Trial 2 (inter-row) – A number of the treatments caused a check to speed of growth even when applied inter-row, but in many cases, it was only just under an acceptable score. At the end of the assessment period (early fruit) those treatments which did not have a score below eight were; the commercial standard diquat, AHDB 9995 in a tank mix with Flexidor and Gamit 36 CS, AHDB 9998, AHDB 9825 (alone and in a tank mix with Wing-P), and AHDB 9897 + Phase II.

Crop effects seen were a check to speed of growth and crop variability, and a little transient scorch or yellowing from the contact desiccants Shark, AHDB 9897 and Finalsan. The check to growth would likely be acceptable if enough weed control is gained as this can be factored into schedules, for example this approach is used where Wing-P is now included in commercial programmes.

Table 2. Mean phytotoxicity scores at three dates throughout the Trial 2 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: B = 1 day after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Mean crop damage scores		
		9th July	24th July	10th August
Untreated	-	10.0	10.0	10.0
diquat	D	9.3	9.0	9.0
AHDB 9995 + Flexidor 500 + Gamit 36 CS	B	**7.7***	8.0*	9.0
Wing-P 2L	B	**7.3***	**6.7***	**7.3***
Wing-P 4L	B	**7.0***	**6.3***	**7.7***
Wing-P 2L + AHDB 9998	B	**7.3***	**7.0***	**7.7***
AHDB 9998	B	**7.7***	**7.7***	8.0*
AHDB 9825	B	8.3*	8.7	9.3
AHDB 9825 + Wing-P	B	**7.3***	**7.0***	8.0*
Finalsan + Activator 90	D and E	**7.0***	**6.7***	**7.3***
Shark	D	**7.0***	**7.0***	**7.7***
AHDB 9897 + Phase II	D	8.7	8.3*	9.0
p value		0.006	0.003	0.080
d.f.		22	22	22
L.S.D.		1.557	1.652	1.841

* Statistically different to untreated

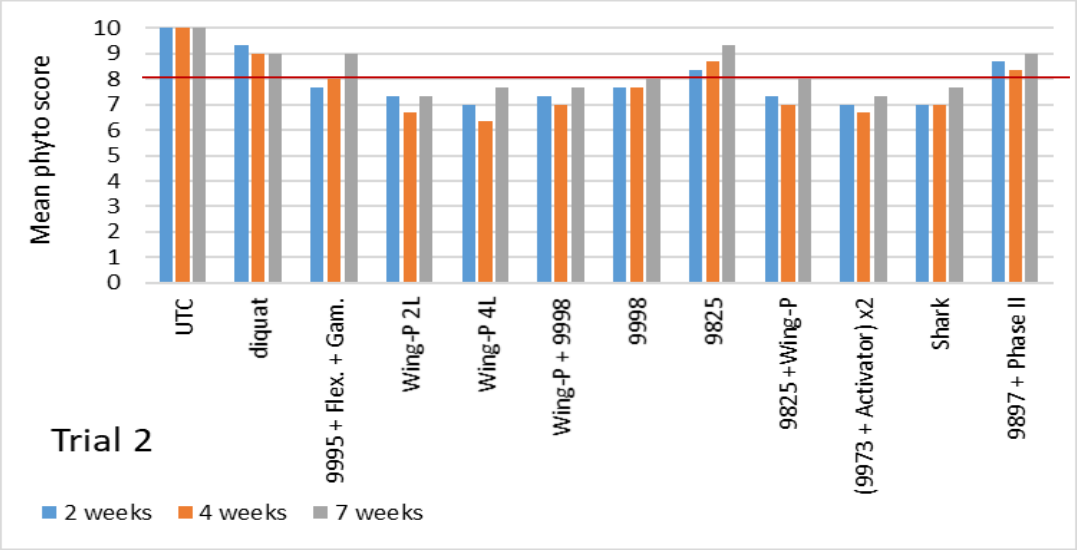


Figure 2. Mean phytotoxicity (0-10) at two, four and seven weeks after Timing B treatment application to Trial 2. Scores of 8 or above deemed acceptable damage (as indicated by red line).

Weed control – mean percentage weed cover

Trial 1

The results for the mean percentage weed cover per treatment are presented in Table 3 and Figure 3. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbott's formula), and results for each treatment are listed in Table 4.

Weed levels were low, and there were no significant differences in weed control.

Table 3. Mean percentage weed cover values for Trial 1 (transformed). Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Trt. No.	Timing	Mean weed cover			
		9th July		24th July	
		Ang	Back-trans	Ang	Back-trans
Untreated	-	19.81	11.48	22.26	14.35
Flexidor 500 + Gamit 36 CS	B	17.40	8.95	17.44	8.98
Flexidor 500 + Gamit 36 CS	C	16.98	8.53	19.22	10.83
AHDB 9987	B	16.23	7.81	16.45	8.02
AHDB 9987 + Gamit 36 CS	B	17.02	8.56	19.73	11.39
AHDB 9918	B	19.89	11.57	19.36	10.99
AHDB 9987	C	18.01	9.56	18.89	10.48
AHDB 9987 + Gamit 36 CS	C	16.37	7.95	19.22	10.83
AHDB 9918	C	16.18	7.76	16.35	7.92
diquat, then AHDB 9985	B D	18.34	9.91	20.15	11.87
diquat, then AHDB 9985	B E	16.18	7.76	18.30	9.86
p value			0.991		0.770
d.f.			23		23
L.S.D.			5.895		6.329

* Untreated control; treatments 1 and 2

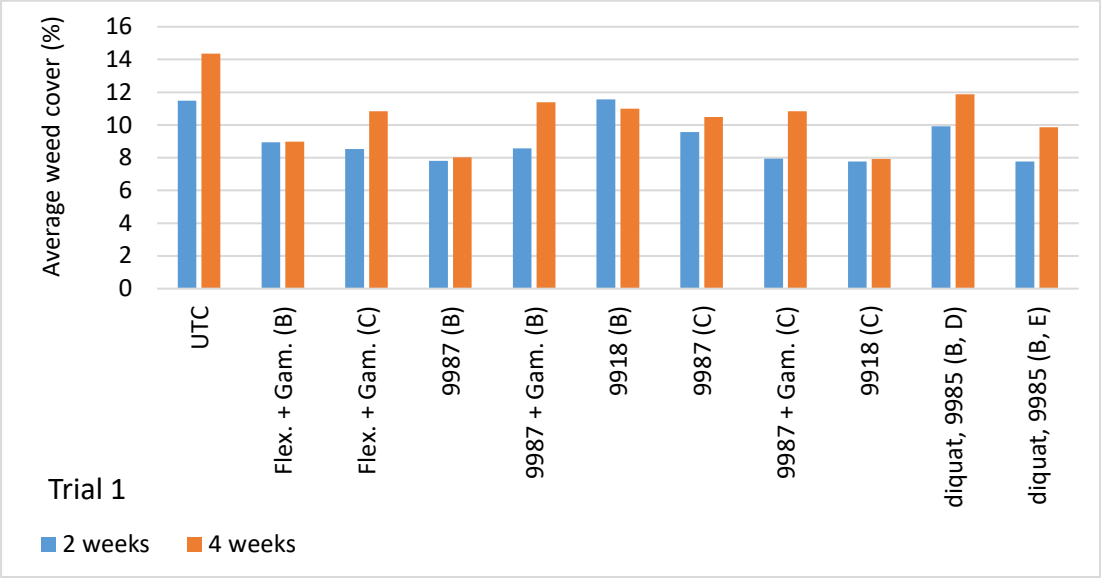


Figure 3. Mean weed cover (%) at two and four weeks after Timing B treatment application to Trial 1 (back-transformed values). ***Note:*** *y-axis max. value of 16%; treatment letters denote spray timing.*

Table 4. Percentage reduction in weed cover at Trial 1 (calculated using Abbott's formula) – values highlighted in red show an increase in weed cover. Letters denote spray timing: B = 1 day after planting, C = 5 days after planting, D = 4 weeks after planting, E = flowering.

Treatment	Timing	Weed cover reduction (%)	
		9th July	24th July
Flexidor 500 + Gamit 36 CS	B	22.08	37.42
Flexidor 500 + Gamit 36 CS	C	25.69	24.53
AHDB 9987	B	31.99	44.11
AHDB 9987 + Gamit 36 CS	B	25.41	20.63
AHDB 9918	B	-0.78	23.41
AHDB 9987	C	16.70	26.97
AHDB 9987 + Gamit 36 CS	C	30.79	24.53
AHDB 9918	C	32.39	44.81
diquat, then AHDB 9985	B D	13.73	17.28
diquat, then AHDB 9985	B E	32.39	31.29

Trial 2

The results for the mean percentage weed cover per treatment are presented in Table 5 and Figure 4. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbott's formula), and results for each treatment are listed in Table 6.

Weed levels were low, and there were no significant differences in weed control.

Table 5. Mean percentage weed cover values for Trial 2 (transformed). Letters denote spray timing: B = 1 day after planting, D = 4 weeks after planting, E = flowering.

Trt. No.	Timing	Mean weed cover			
		9th July		24th July	
		Ang	Back-trans	Ang	Back-trans
Untreated	-	21.14	13.01	21.14	13.01
diquat	D	18.01	9.56	19.89	11.57
AHDB 9995 + Flexidor 500 + Gamit 36 CS	B	15.57	7.20	18.43	10.00
Wing-P 2L	B	12.92	5.00	14.09	5.93
Wing-P 4L	B	14.53	6.30	16.37	7.95
Wing-P 2L + AHDB 9998	B	14.53	6.30	15.57	7.20
AHDB 9998	B	15.57	7.20	16.18	7.76
AHDB 9825	B	16.37	7.95	15.57	7.20
AHDB 9825 + Wing-P	B	15.34	7.00	15.57	7.20
Finalsan + Activator 90	D and E	16.37	7.95	18.85	10.44
Shark	D	19.89	11.57	21.14	13.01
AHDB 9897 + Phase II	D	17.21	8.75	21.06	12.92
p value			0.032		0.088
d.f.			22		22
L.S.D.			4.304		5.385

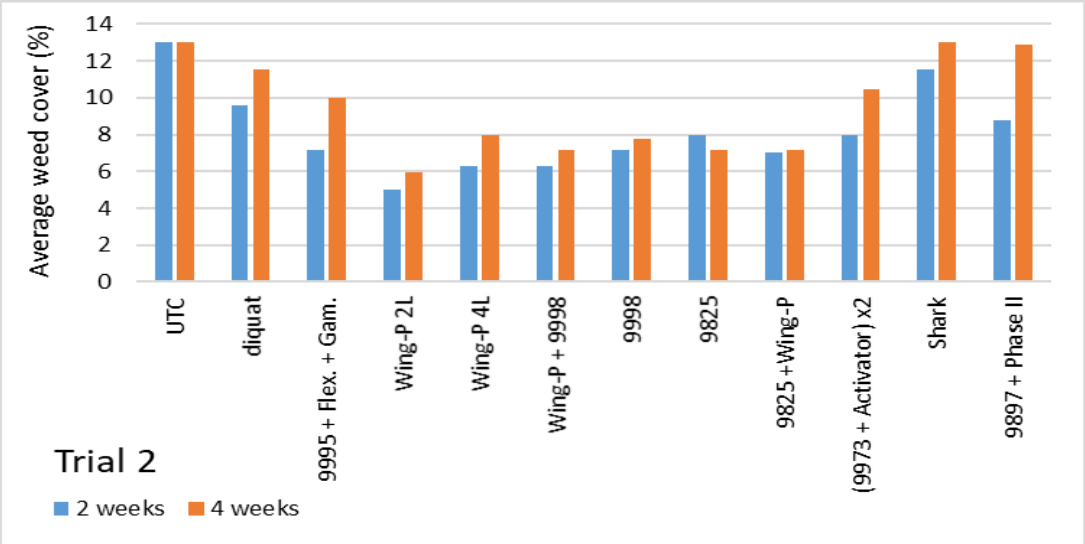


Figure 4. Mean weed cover (%) at two and four weeks after Timing B treatment application to Trial 1 (back-transformed values). Letters denote spray timing: B = 1 day after planting, D = 4 weeks after planting, E = flowering. ***Note:*** *y-axis max. value of 14%; treatment.*

Table 6. Percentage reduction in weed cover at Trial 2 (calculated using Abbott's formula).

Treatment	Timing	Weed cover reduction (%)	
		9th July	24th July
diquat	D	26.50	11.09
AHDB 9995 + Flexidor 500+ Gamit 36 CS	B	44.66	23.15
Wing-P 2L	B	61.58	54.45
Wing-P 4L	B	51.60	38.94
Wing-P + AHDB 9998	B	51.60	44.66
AHDB 9998	B	44.66	40.35
AHDB 9825	B	38.94	44.66
AHDB 9825 + Wing-P	B	46.21	44.66
(Finalsan + Activator 90) x2	D and E	38.94	19.74
Shark	D	11.09	0.00
AHDB 9897 + Phase II	D	32.74	0.73

Results – Trial 3 (benfluralin screen)

Phytotoxicity

The results of phytotoxicity assessments from three dates are presented in Table 7 and Figure 5.

There were no significant differences between scores, but where any herbicides were applied over the crop post-planting, this caused the crop damage score to drop below an acceptable level by causing a check to crop growth which set the crop back a week. However, by the final assessment at early fruiting all plots treated with all except AHDB 9918 had recovered to a near acceptable standard. Bonalan (benfluralin) did not cause any unacceptable damage to the courgettes, or any perceptible reduction in the speed of growth.

Table 7. Mean phytotoxicity scores at three dates throughout the Trial 3 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in bold. Letters denote spray timing: A = pre-planting and incorporated, and B = 5 days after planting.

Treatment	Timing	Mean crop damage scores		
		9th July Timing B + 2 weeks	24th July Timing B + 4 weeks	10th August Timing B + 6 weeks
Bonalan	A	8.3	8.7	9.0
Bonalan, then Gamit 36 CS*	A B	8.0	8.7	8.3
Bonalan, then Gamit 36 CS	A B	**7.3**	**7.7**	**7.7**

Treatment	Timing	Mean crop damage scores		
		9th July Timing B + 2 weeks	24th July Timing B + 4 weeks	10th August Timing B + 6 weeks
Bonalan, then AHDB 9918	A B	**5.7**	**6.3**	**6.7**
Bonalan, then AHDB 9987	A B	**5.7**	**7.0**	**7.7**
Bonalan, then AHDB 9987 + Gamit 36 CS	A B	**5.7**	**6.7**	**7.7**
p value		0.066	0.106	0.170
d.f.		10	10	10
L.S.D.		2.293	2.020	1.758

* inter-row application

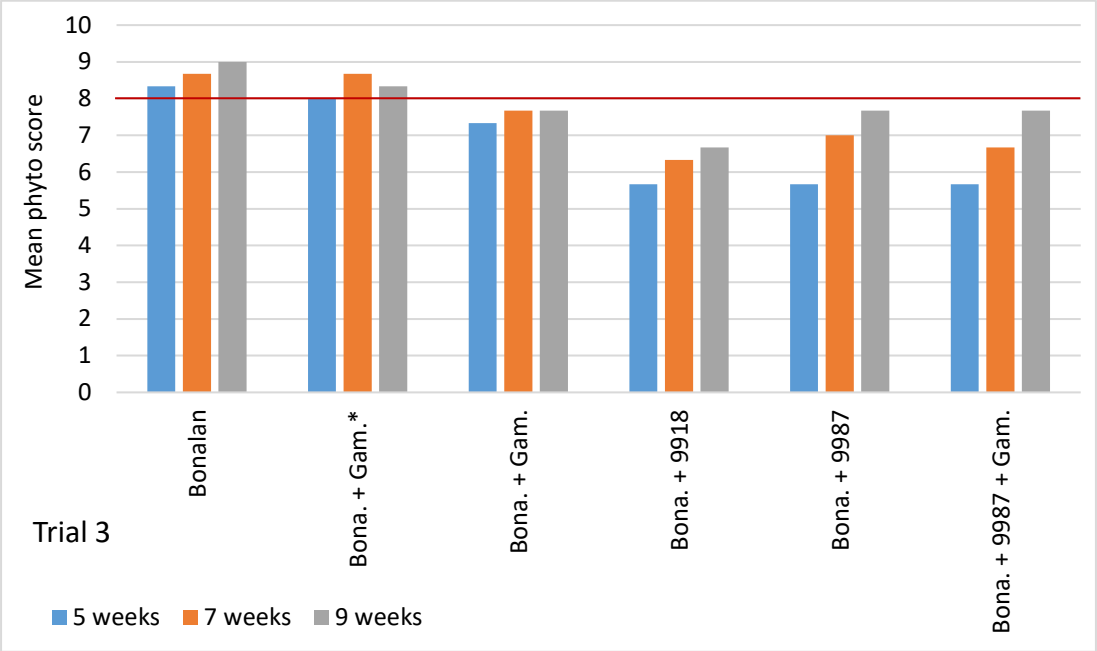


Figure 5. Mean phytotoxicity (0-10) at five, seven and nine weeks after Timing A treatment application to Trial 3. Scores of 8 or above deemed acceptable damage (as indicated by red line).

Weed control – mean percentage weed cover

The results for the mean percentage weed cover per treatment are presented in Table 8 and Figure 6. The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbott's formula), and results for each treatment are listed in Table 9.

There were weakly significant differences between treatments, and the addition of either AHDB 9987 or AHDB 9918 increased the weed control compared to just Bonalan alone for up to four weeks after application.

Table 8. Mean percentage weed cover values for Trial 3 (transformed). Letters denote spray timing: A = pre-planting and incorporated, and B = 5 days after planting.

Trt. No.	Timing	Mean weed cover			
		9th July Timing B + 2 weeks		24th July Timing B + 4 weeks	
		Ang	Back-trans	Ang	Back-trans
Bonalan	A	18.63	10.20	23.37	15.73
Bonalan, then Gamit 36 CS*	A B	19.89	11.57	20.64	12.42
Bonalan, then Gamit 36 CS	A B	16.37	7.95	19.56	11.21
Bonalan, then AHDB 9918	A B	13.73*	5.63	12.75*	4.87
Bonalan, then AHDB 9987	A B	14.53*	6.30	16.35*	7.92
Bonalan, then AHDB 9987 + Gamit 36 CS	A B	16.37	7.95	18.47	10.03
p value			0.040		0.052
d.f.			10		10
L.S.D.			3.899		6.381

* Statistically different to untreated

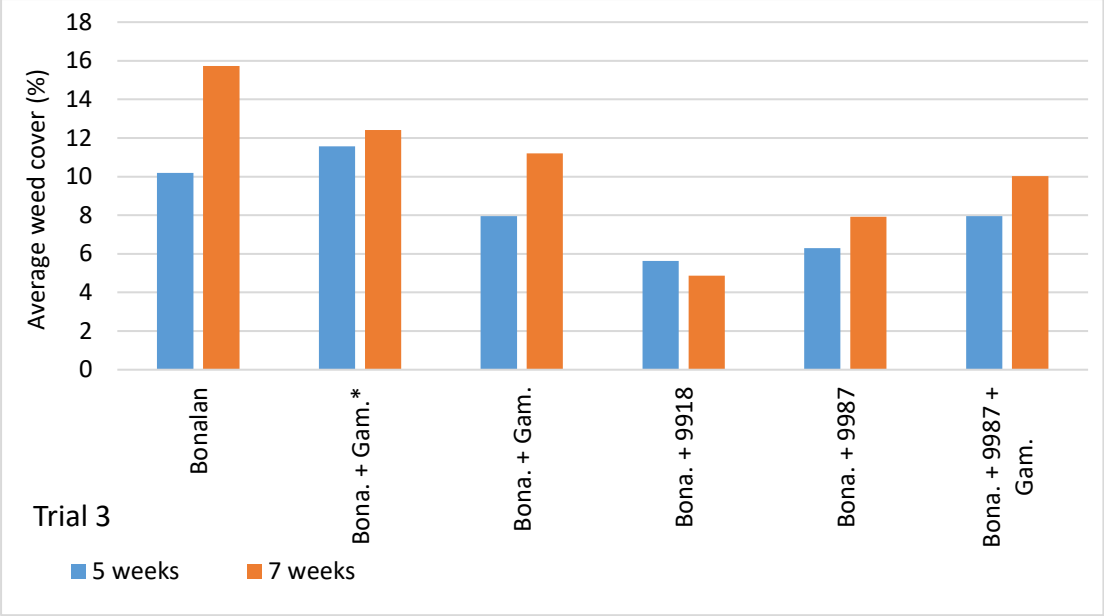


Figure 6. Mean weed cover (%) at five and seven weeks after Timing A treatment application to Trial 3 (back-transformed values). ***Note:*** *y-axis max. value of 18%.*

Table 9. Percentage reduction in weed cover at Trial 3, relative to 'control' treatment of Bonalan only (calculated using Abbott's formula) – highlighted values in red show an increase in weed cover. Letters denote spray timing: A = pre-planting and incorporated, and B = 5 days after planting.

Treatment	Timing	Weed cover reduction (%)	
		9th July (Timing B)	24th July (Timing B + 2 weeks)
Bonalan, then Gamit 36 CS*	A B	-13.42	21.04
Bonalan, then Gamit 36 CS	A B	22.11	28.73
Bonalan, then AHDB 9918	A B	44.79	69.04
Bonalan, then AHDB 9987	A B	38.26	49.65
Bonalan, then AHDB 9987 + Gamit 36 CS	A B	22.11	36.24

Results – Trial 4 (drilled crop, over the row applications)

Phytotoxicity

The results of phytotoxicity assessments from three dates are presented in Table 10 and Figure 7.

All of the pre-emergence herbicide treatments were safe to use in drilled courgettes in this trial with only a little yellowing caused where AHDB 9987 + Gamit was applied. This occurred at two months after application and would be likely to be caused by the Gamit moving into the rooting zone after a rain event. However, the damage was only just under acceptable. Wing-P 2.0 L/ha was damaging and caused crop death in the drilled pumpkin trial (see separate report) so care still needs to be taken when using this product in a drilled cucurbit crop. The soil type at this trial site was a clay loam, and demonstrates the influence that soil type can have on crop safety with the product being safe at this site, but causing crop death on the pumpkin trial site with a sandy soil. However, at this site it still caused a slight but acceptable check to the speed of growth of the courgettes.

None of the post-emergence applications caused any unacceptable crop effects with the exception of AHDB 9994, which caused a moderate check to the growth of the crop, scorch and yellow spotting. In the inter-row application of diquat there was drift which caused crop death and confounded assessment of the effects of AHDB 9985, although yellowing was observed after application of AHDB 9985 when applied at flowering. This was not seen at the Trial 1 site, but conditions at application at Trial 4 were duller and therefore there would be more risk of damage if the leaves were not as well waxed up at application.

Table 10. Mean phytotoxicity scores at three dates throughout the Trial 4 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in **bold.**

Treatment	Timing	Mean crop damage scores		
		29th June - 4 weeks after drilling (Timing G)	11th July - flowering (Timing H)	25th July - (Timing H + 2 weeks)
Untreated	-	-	10.0	10.0
Flexidor 500 + Gamit 36 CS	G	-	10.0	10.0
Kerb Flo	G	-	10.0	10.0
Flexidor 500 + Gamit 36 CS	F	10.0	10.0	10.0
AHDB 9987	F	10.0	10.0	10.0
AHDB 9987 + Gamit 36 CS	F	10.0	10.0	**7.7***
AHDB 9918	F	10.0	10.0	10.0
AHDB 9995	F	9.7	10.0	10.0
AHDB 9995 + Gamit 36 CS	F	10.0	10.0	10.0
Wing-P 2.0 L/ha	F	9.0	10.0	8.3
AHDB 9898	F	9.3	10.0	10.0
AHDB 9998	F	10.0	10.0	10.0
Wing-P 2.0 L/ha + AHDB 9998	F	9.7	10.0	8.3
AHDB 9994	F	10.0	10.0	10.0
AHDB 9917	F	9.7	10.0	10.0
AHDB 9987	G	-	10.0	10.0
AHDB 9987 + Gamit 36 CS	G	-	10.0	9.3
AHDB 9918	G	-	10.0	10.0
AHDB 9994	G	-	**5.7***	8.0
diquat, then AHDB 9985 1.0 L/ha	G H	9.8	**1.0***	**3.7***
diquat, then AHDB 9985 1.5 L/ha	G H	9.9	**1.0***	**5.3***
p value		(NS) 0.164	<0.001	<0.001
d.f.		24	45	45
L.S.D.		0.6435	0.1733	2.206

* Statistically different to untreated

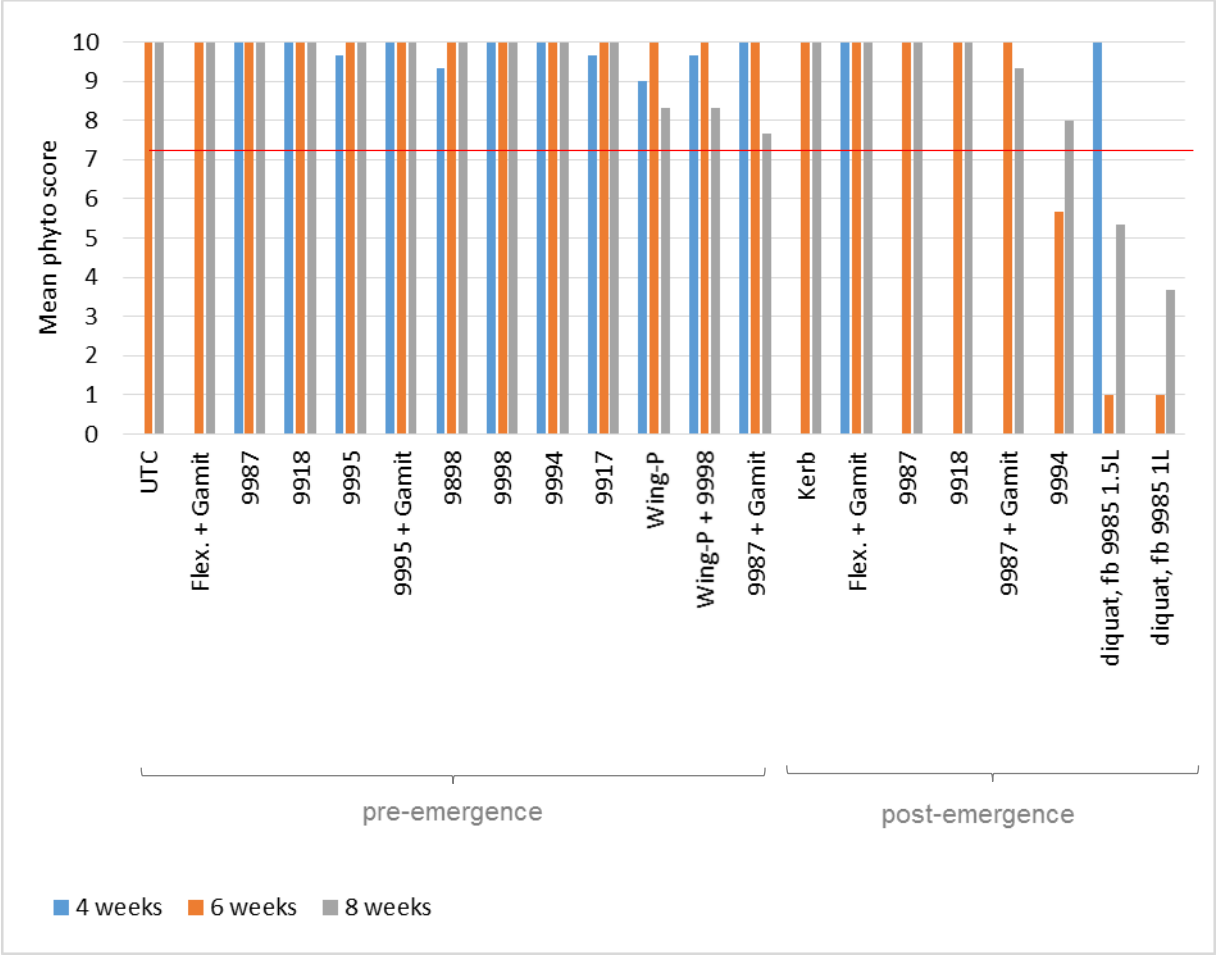


Figure 7. Mean phytotoxicity (0-10) at four, six and eight weeks after drilling and the pre-emergence treatment application to Trial 4. Scores of 8 or above deemed acceptable damage (as indicated by red line). Post-emergence applied at four weeks after drilling

Weed control – mean percentage weed kill

The results for the mean percentage of weed reduction per treatment are presented in Table 11 and Figure 8. The data was collected in this way as the percentage of cover in the untreated was at 100% at the first assessment. Therefore, the data was not transformed under advice from our statistician.

Table 11. Mean percentage weed kill (weed reduction) values for Trial 4 showing the original data and 'percent kill' meaning the percentage of weeds killed by the herbicide programmes. For example, 100%= 100% weeds killed with zero weeds present. Letters denote spray timing: F = pre-emergence, G = at 3 true leaves, H = one month after drilling (flowering)

		Mean % weed reduction – visual estimate	
Treatment	**Application Timing**	**11th July- flowering (Timing H)**	**25th July- (Timing H + 2 weeks)**
Untreated	-	0.0	5.0
Flexidor 500+ Gamit 36 CS	G	30.0	8.3
Kerb Flo	G	0.0	0.0
Flexidor 500 + Gamit 36 CS	F	16.7	3.3

		Mean % weed reduction – visual estimate	
Treatment	**Application Timing**	**11th July- flowering (Timing H)**	**25th July- (Timing H + 2 weeks)**
AHDB 9987	F	8.3	6.7
AHDB 9987 + Gamit 36 CS	F	36.7	0.0
AHDB 9918	F	0.0	0.0
AHDB 9995	F	51.7	13.3
AHDB 9995 + Gamit 36 CS	F	75.0	33.3
Wing-P 2.0 L/ha	F	65.0	35.0
AHDB 9898	F	0.0	0.0
AHDB 9998	F	0.0	3.3
Wing-P 2.0 L/ha + AHDB 9998	F	58.3	26.7
AHDB 9994	F	36.7	10.0
AHDB 9917	F	13.3	0.0
AHDB 9987	G	3.3	0.0
AHDB 9987 + Gamit 36 CS	G	10.0	0.0
AHDB 9918	G	6.7	0.0
AHDB 9994	G	55.0	33.3
diquat, then AHDB 9985 1.0 L/ha	G H	50.0	0.0
diquat, then AHDB 9985 1.5 L/ha	G H	50.0	16.7

*Untreated control; treatments 1 and 2

Four treatments reduced the percentage overall weed level greater than 25% by visual estimate at the final assessment. These were AHDB 9995 + Gamit 36CS, Wing-P 2.0 L/ha and Wing P 2.0 L/ha + AHDB 9998 applied pre-emergence, as well as AHDB 9994 applied post-emergence. (Figure 10 and Table 11). Only the pre-emergence treatments were safe to the courgettes.

Due to the manner the in which data was collected as a visual estimate of percentage weed kill rather than percentage weed cover, we were unable to carry out statistical analyses.

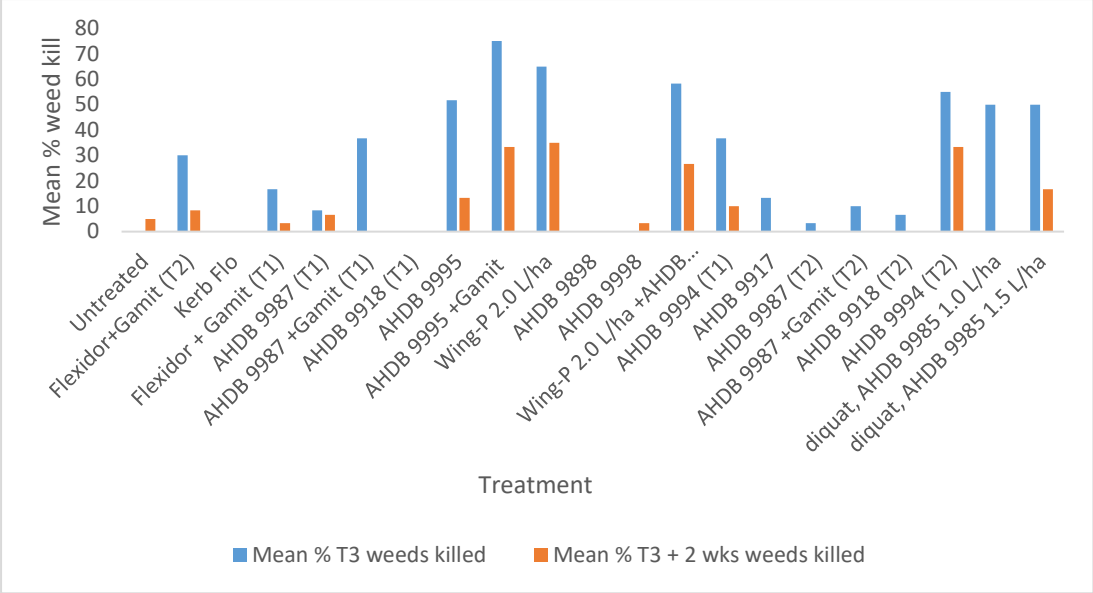


Figure 8. Total mean percentage weeds killed at the Timing H (T3) and two weeks after Timing H treatment application to Trial 4. *Note the maximum value of 80% on the y axis.*

Results - Trial 5 (drilled crop, inter-row applications)

Phytotoxicity

The results of phytotoxicity assessments from three dates are presented in Table 12 and Figure 9. All treatments were crop safe with none causing unacceptable damage to the courgettes (Table 15).

Table 12. Mean phytotoxicity scores at three dates throughout the Trial 5 assessment period (0 to 10; 0 = complete crop death, 10 = no damage). Scores ≥8 deemed commercially acceptable damage, those <8 (unacceptable damage) are highlighted in **bold**. Letters denote spray timing: F = pre-emergence, G = at 3 true leaves, H = one month after drilling (flowering)

		Mean crop damage scores		
	Application Timing	**29th June 4 weeks after drilling Timing G**	**11th July Timing H**	**25th July Timing H + 2 weeks**
Untreated		9.83	10.00	10.00
diquat	G	9.83	9.00	10.00
AHDB 9995 + Flexidor 500+ Gamit 36 CS	F	10.00	10.00	10.00
Wing-P (2.0 L/ha)	F	10.00	10.00	10.00
Wing-P (4.0 L/ha)	F	9.33	10.00	10.00
Wing-P + AHDB 9998	F	10.00	9.67	10.00
AHDB 9998	F	9.67	10.00	10.00
AHDB 9997	F	10.00	10.00	10.00
Finalsan +	G	9.83	10.00	10.00

	Application Timing	Mean crop damage scores		
		29th June 4 weeks after drilling Timing G	11th July Timing H	25th July Timing H + 2 weeks
Activator 90				
(Finalsan + Activator 90) x2	G, H	9.83	10.00	10.00
Shark	G	9.83	9.00	10.00
AHDB 9897 + Phase II	G	9.83	9.67	10.00
p value		0.119	0.437	-
d.f.		10	22	-
L.S.D.		0.5753	1.100	-

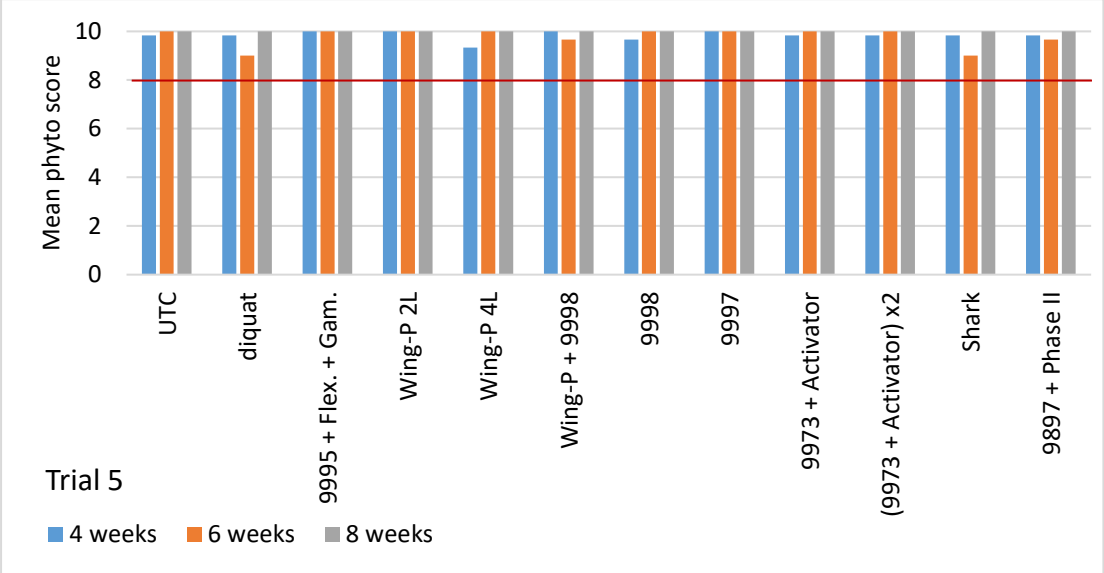


Figure 9. Mean phytotoxicity (0-10) at four, six and eight weeks after Timing F treatment application to Trial 5. Scores of 8 or above deemed acceptable damage (as indicated by red line).

Weed control – mean percentage weed kill

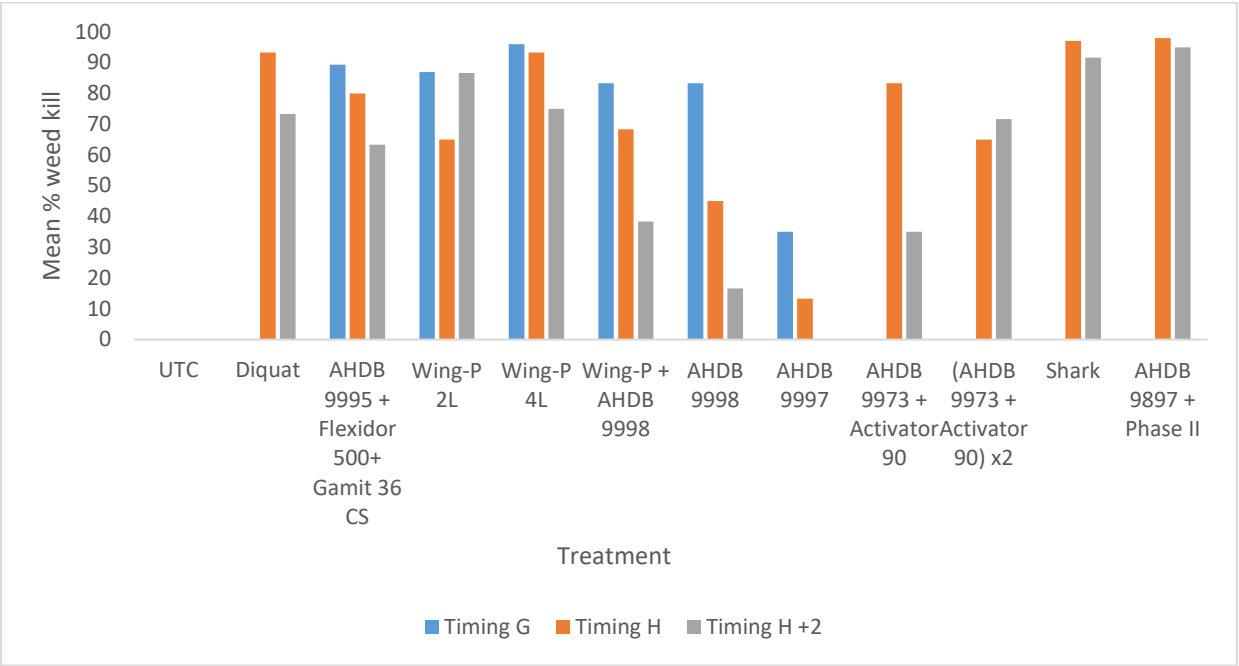
Five products gave equivalent or better reduction in the percentage weed cover when compared to the standard inter-row application of diquat. The treatments were Wing-P at either 2.0 or 4.0 L/ha, AHDB 9897 + Phase II, Shark and Finalsan + Activator 90 applied twice.

AHDB 9897 + Phase II was the most effective treatment reducing the weed level by the highest percentage, (Table 13 and Figure 10). Finalsan + Activator 90 was much more effective as a double application when compared to the single application, increasing weed reduction from 35% to 71.7%.

Table 13. Mean percentage weed kill (weed reduction) values for Trial 5 showing the original data and 'percent kill' meaning the percentage of weeds killed by the herbicide programmes. For example, 100%= 100% weeds killed with zero weeds present.

Treatment		Mean % weed reduction – visual estimate		
	Application Timing	29th June 4 weeks after drilling Timing G	11th July Timing H	25th July Timing H + 2 weeks
Untreated		0.0	0.0	0.0
Diquat	G	0.0	93.3	73.3
AHDB 9995 + Flexidor 500+ Gamit 36 CS	F	89.3	80.0	63.3
Wing-P (2.0 L/ha)	F	87.0	65.0	86.7
Wing-P (4.0 L/ha)	F	96.0	93.3	75.0
Wing-P + AHDB 9998	F	83.3	68.3	38.3
AHDB 9998	F	83.3	45.0	16.7
AHDB 9997	F	35.0	13.3	0.0
Finalsan + Activator 90	G	0.0	83.3	35.0
(Finalsan + Activator 90) x2	G, H	0.0	65.0	71.7
Shark	G	0.0	97.0	91.7
AHDB 9897 + Phase II	G	0.0	98.0	95.0

Figure 10. Mean percentage weed kill (weed reduction) values at zero, two and four weeks after Timing G treatment application to Trial 5.



Discussion

Site 1- transplanted into plastic mulch
There were low weed levels at the trial site, and therefore significant differences in efficacy could not be determined for trials 1 and 2. However, useful differences in crop safety were observed through all trials at the site.

Trial 1 (over-row)

With the exception of Flexidor + Gamit 36 CS applied the day after planting, all treatments applied within a week of planting had a significant effect on the crop which persisted for up to a month after planting. This was exhibited mainly as a check to growth with the crop remaining smaller than the untreated controls, or as scorch where Flexidor + Gamit 36 CS was applied over the crop at five days after planting. AHDB 9918 caused scorch and stunting when applied five days after planting, but only stunting when applied a day after planting.

At seven weeks after planting, plots where treatments were applied the day after planting, and AHDB 9987 at half rate in a tank mix with Gamit 36 CS applied at the later timing had recovered to a near acceptable level, or an acceptable level of damage.

All treatments had slightly less effect on the crop when the herbicides were applied the day after planting compared to when they were applied at five days after planting. All give a check to growth, which should be considered with scheduling and speed of growth at application.

AHDB 9985 was tested at two later application timings and had very little effect on the courgette plants when applied at four weeks after planting, compared to when it was applied two weeks later at flowering. But, even when AHDB 9985 was applied at flowering the effect on the crop was a stunt which was recorded as only just under the acceptable score. In Trial 5 a bleaching was observed, which was likely due to weather conditions at application – which was dull, and therefore the courgette leaves may not have been 'waxed up'.

Trial 2 (inter-row)
There were low weed levels at the trial site, and therefore significant differences in efficacy could not be determined. However, useful differences in crop safety were observed.

A number of the treatments caused a check to speed of growth even when applied inter-row, but in many cases it was only just under an acceptable score with no crop loss. At the end of the assessment period (early fruit) those treatments which did not have a score below eight were; the commercial standard diquat, AHDB 9995 in a tank mix with Flexidor and Gamit 36 CS, AHDB 9998, AHDB 9825 (alone and in a tank mix with Wing-P), and AHDB 9897 + Phase II.

Crop effects seen were a check to speed of growth and crop variability, and a little transient scorch or yellowing from the contact desiccants Shark, AHDB 9897 and Finalsan. The check to growth would likely be acceptable if enough weed control is gained as this can be factored into schedules, for example this approach is used where Wing-P is now included in commercial programmes.

Trial 3 (benfluralin)
Crop safety: There were no significant differences between scores, but where any herbicides were applied over the crop post-planting, this caused the crop damage score to drop below an acceptable level by causing a check to crop growth which set the crop back a week. However, by the final assessment at early fruiting all plots treated with all except AHDB 9918 had recovered to a near acceptable standard. Bonalan (benfluralin) did not cause any unacceptable damage to the courgettes, or any perceptible reduction in the speed of growth.

Weed cover: There were weakly significant differences between treatments. The addition of either AHDB 9987 or AHDB 9918 increased the weed control compared to just Bonalan alone for up to four weeks after application. However, AHDB 9918 caused the greatest phytotoxic effects.

Site 2- drilled crop with no plastic mulch

Trial 4 (over-row)
Three pre-emergence treatments combined crop safety with a reduction of the percentage overall weed level greater than 25% by visual estimate at the final assessment. These were AHDB 9995 + Gamit 36CS, Wing-P 2.0 L/ha and Wing P 2.0 L/ha + AHDB 9998.

All of the pre-emergence herbicide treatments were safe to use in drilled courgettes in this trial with only a little yellowing caused where AHDB 9987 + Gamit was applied. This occurred at two months after application and would be likely to be caused by the Gamit moving into the rooting zone after a rain event. However, the damage was only just under acceptable. Wing-P 2.0 L/ha was damaging and caused crop death in the drilled pumpkin trial (see separate report SP13. 2018) so care still needs to be taken when using this product in a drilled cucurbit crop. The soil type at this trial site was a clay loam, and demonstrates the influence that soil type can have on crop safety with the product being safe at this site, but causing crop death on the pumpkin trial site with a sandy soil. However, at this site it still caused a slight but acceptable check to the speed of growth of the courgettes.

None of the post-emergence applications caused any unacceptable crop effects with the exception of AHDB 9994, which caused a moderate check to the growth of the crop, scorch and yellow spotting. In the inter-row application of diquat there was drift which caused crop death and confounded assessment of the effects of AHDB 9985, although yellowing was observed after application of AHDB 9985 when applied at flowering. This was not seen at the Trial 1 site, but conditions at application at Trial 4 were duller and therefore there would be more risk of damage if the leaves were not as well waxed up at application.

Trial 5 (inter-row)
Five products gave equivalent or better reduction in the percentage weed cover when compared to the standard inter-row application of diquat. The treatments were Wing-P at either 2.0 or 4.0 L/ha, AHDB 9897 + Phase II, Shark and Finalsan + Activator 90 applied twice.

AHDB 9897 + Phase II was the most effective treatment reducing the weed level by the highest percentage. Finalsan + Activator 90 was much more effective as a double application when compared to the single application, increasing weed reduction from 35% to 71.7%. All treatment programmes were crop safe.

Conclusions

- In the planted courgette trials, coded product AHDB 9987 was crop safe when applied over the courgettes either at full rate alone or at ½ rate in a tank mix with Gamit and would provide additional control of weeds such as fat hen, cranesbill, and wild radish and increase control of groundsel and sow thistle.
- Timing the herbicide application within two days of planting while the thicker cotyledons were present was safer than application a few days later once the true leaves had emerged.
- All of the experimental herbicides applied over the crop caused a slight check to growth which set the crop back by a week – this would need to be considered within harvest schedules.
- Bonalan (benfluralin) was crop safe.
- In the inter-row trials, both planted and drilled, all treatments were crop safe, many caused a check to growth but this was deemed acceptable.
- The contact desiccants; Shark, AHDB 9897 and Finalsan caused scorch where the spray contacted the edge of the leaves falling in the row, but the effect was transient.
- In the drilled crop, where the inter-row herbicides were applied, five products gave equivalent or better reduction in the percentage weed cover when compared to the standard inter-row application of diquat. The treatments were Wing-P at either 2.0 or 4.0 L/ha, AHDB 9897 + Phase II, Shark and Finalsan + Activator 90 applied twice.

Acknowledgements

AHDB for funding the work, and also the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to the growers who provided sites and crops for the trials as well as technical input, particularly Jim Smith and Neil Cairns of Barfoots, and W.R Haines

Appendix

Crop diaries – events related to growing crops

a. Trial 1, 2 & 3

Crop	Cultivar	Planting date	Row width
Courgette	Kronos	18/06/2018 *(Sowing date in glass house: 25/05/2018)*	0.75 m

Previous cropping

Year	Crop
2017	Potatoes
2016	Sweetcorn
2015	Herbs

Cultivations

Date	Description	Depth (cm)
14/06/2018	Flat-lift	25 cm
14/06/2018	Power-harrow	17 cm
14/06/2018	Bed make	17 cm
14/06/2018	Poly lay	N/A

Active ingredients(s)/fertiliser(s) applied to trial area

Date	Product	Rate
12/06/2018	Digestate	40 cubes/ha
06/07/2018	CAN	300 kg/ha

Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
18/06/2018	Boom irrigation	15
05/07/2018	Boom irrigation	15
15/07/2018	Boom irrigation	25

b. Trial 4 & 5

N/A = not available

Crop	Cultivar	Drilling date	Row width (m)
Courgette	Tosca	29/05/2018	

Previous cropping

Year	Crop
2017	N/A
2016	N/A
2015	N/A

Cultivations

Date	Description	Depth (cm)
N/A	N/A	N/A

Active ingredients(s)/fertiliser(s) applied to trial area

Date	Product	Rate	Unit
N/A	N/A	N/A	N/A

Pesticides applied to trial area

Date	Product	Rate	Unit
N/A	N/A	N/A	N/A

Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
N/A	N/A	N/A

c. Table showing sequence of events by date – this relates to treatments and assessments.

Trial 1, 2 and 3

Date	Event
08/06/2018	Timing A treatments applied.
25/06/2018	Timing B treatments applied.
29/06/2018	Timing C treatments applied.
09/07/2018	Timing D treatments applied. Assessment – phytotoxicity, weed cover.
24/07/2018	Timing E treatments applied. Assessment – phytotoxicity, weed cover.
10/08/2018	Assessment – phytotoxicity.

Trial 4 & 5

Date	Event
01/06/2018	Timing F treatments applied.
29/06/2018	Timing G treatments applied. Assessment – phytotoxicity, weed cover.
11/07/2018	Timing H treatments applied. Assessment – phytotoxicity, weed cover.
25/07/2018	Assessment – phytotoxicity, weed cover.

d. Climatological data during study period from each site.

SITE 1

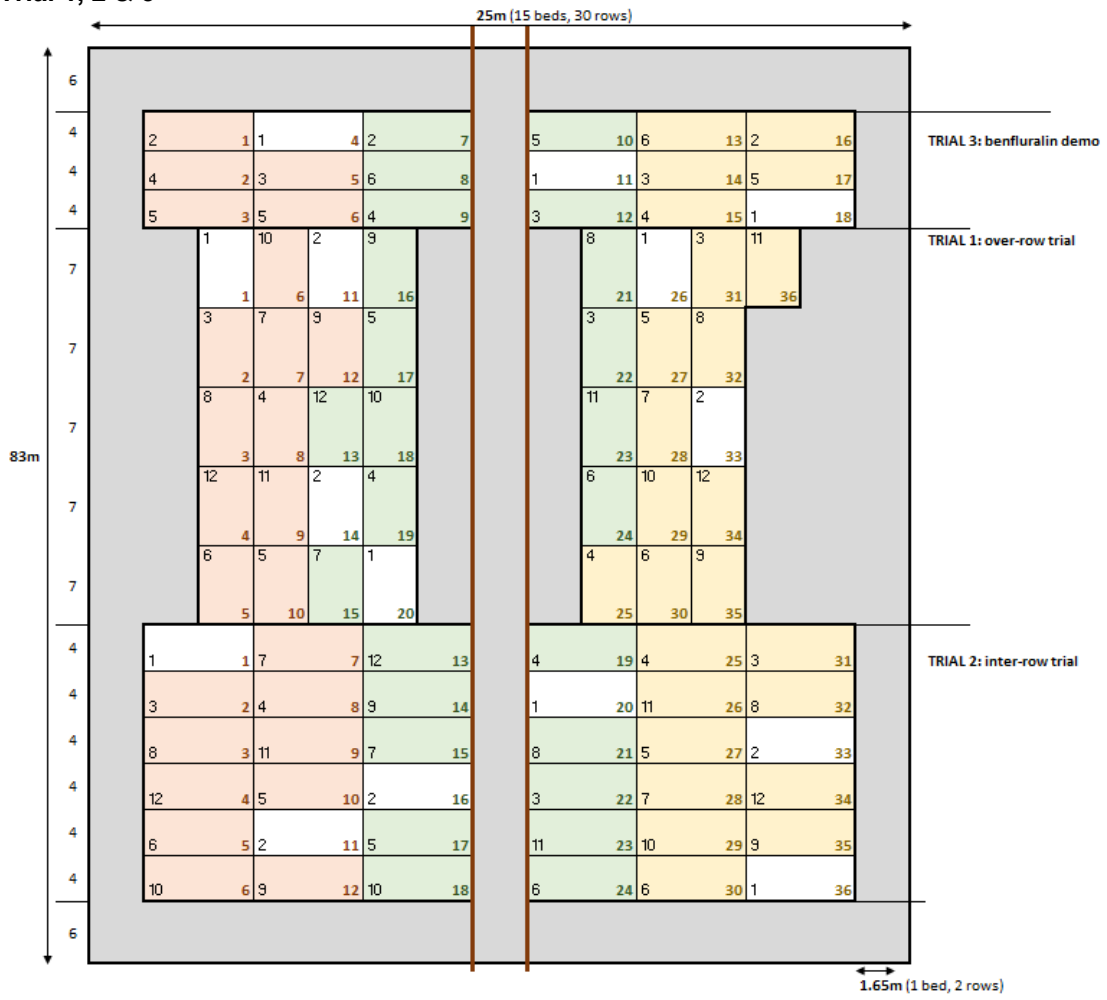
Date	Temperature °C (minimum)	Temperature °C (maximum)	Rainfall* (mm)
08/06/2018	21.5	23.5	0.0
09/06/2018	18.5	21.0	0.0
10/06/2018	17.5	21.5	0.0
11/06/2018	17.5	26.0	0.0
12/06/2018	20.5	24.0	0.0
13/06/2018	18.0	23.5	0.0
14/06/2018	19.5	24.5	0.0
15/06/2018	20.5	24.5	0.0
16/06/2018	21.0	23.5	0.0
17/06/2018	19.5	21.5	1.0
18/06/2018	19.0	26.0	0.0
19/06/2018	22.5	27.0	0.0
20/06/2018	23.5	27.5	1.0
21/06/2018	22.5	25.5	0.0
22/06/2018	20.0	24.5	0.0
23/06/2018	21.0	24.0	0.0
24/06/2018	20.5	25.0	0.0
25/06/2018	16.0	25.0	0.0
26/06/2018	12.0	25.5	0.0
27/06/2018	11.5	29.0	0.0
28/06/2018	14.0	29.5	0.0
29/06/2018	16.0	30.0	0.0
30/06/2018	13.5	31.5	0.0
01/07/2018	18.0	34.0	0.0
02/07/2018	19.5	34.0	0.0
03/07/2018	17.0	30.5	0.0
04/07/2018	15.5	25.5	1.0
05/07/2018	15.0	30.0	0.0
06/07/2018	14.5	32.5	0.0
07/07/2018	16.0	32.5	0.0
08/07/2018	17.5	32.5	0.0
09/07/2018	15.0	29.0	0.0
10/07/2018	16.5	26.5	0.0
11/07/2018	12.0	25.5	0.0
12/07/2018	12.5	25.5	0.0
13/07/2018	16.0	26.5	12.0
14/07/2018	14.0	28.5	0.0
15/07/2018	12.5	29.5	0.0
16/07/2018	13.5	29.0	0.0
17/07/2018	11.0	24.0	0.0
18/07/2018	11.0	26.5	0.0
19/07/2018	11.5	29.0	0.0
20/07/2018	15.0	25.5	1.0
21/07/2018	16.5	28.0	0.0
22/07/2018	13.5	28.5	0.0
23/07/2018	14.0	29.0	0.0
24/07/2018	15.0	29.5	0.0
25/07/2018	15.0	30.5	0.0
26/07/2018	16.5	30.0	0.0
27/07/2018	17.0	31.5	1.0

28/07/2018	16.0	22.5	5.0
29/07/2018	15.5	19.0	26.0
30/07/2018	17.5	23.5	1.0
31/07/2018	15.0	25.5	0.0
01/08/2018	11.0	26.5	0.0
02/08/2018	12.5	29.0	0.0
03/08/2018	14.0	31.5	0.0
04/08/2018	18.5	30.5	0.0
05/08/2018	15.0	28.0	0.0
06/08/2018	12.5	32.5	0.0
07/08/2018	14.5	31.0	0.0
08/08/2018	13.0	24.5	0.0
09/08/2018	15.0	20.0	1.0
10/08/2018	10.0	18.5	5.0

* Rainfall data from AccuWeather.com.

e. Trial design

Trial 1, 2 & 3



Trial 4

TREATMENT	DISCARD	DISCARD	1	9	15	13	21	6	20	16	3	11	5	DISCARD	DISCARD
BLOCK			6	6	6	6	6	6	6	6	6	6	6		
PLOT			56	57	58	59	60	61	62	63	64	65	66		
TREATMENT	DISCARD	DISCARD	10	8	12	22	15	19	4	17	18	7	2	DISCARD	DISCARD
BLOCK			5	5	5	5	5	5	5	5	5	5	5		
PLOT			45	46	47	48	49	50	51	52	53	54	55		
TREATMENT	DISCARD	DISCARD	17	1	8	13	14	20	6	4	7	14	2	DISCARD	DISCARD
BLOCK			4	4	4	4	4	4	4	4	4	4	4		
PLOT			34	35	36	37	38	39	40	41	42	43	44		
TREATMENT	DISCARD	DISCARD	9	10	16	5	21	12	19	3	18	11	22	DISCARD	DISCARD
BLOCK			3	3	3	3	3	3	3	3	3	3	3		
PLOT			23	24	25	26	27	28	29	30	31	32	33		
TREATMENT	DISCARD	DISCARD	2	6	21	19	15	12	10	22	16	14	13	DISCARD	DISCARD
BLOCK			2	2	2	2	2	2	2	2	2	2	2		
PLOT			12	13	14	15	16	17	18	19	20	21	22		
TREATMENT	DISCARD	DISCARD	3	4	7	1	20	5	18	8	11	17	9	DISCARD	DISCARD
BLOCK			1	1	1	1	1	1	1	1	1	1	1		
PLOT			1	2	3	4	5	6	7	8	9	10	11		

Trial 5

TREATMENT	DISCARD	DISCARD	1	11	9	DISCARD	6	5	7	DISCARD
BLOCK			3	3	3		3	3	3	
PLOT			28	29	30		34	35	36	
TREATMENT	DISCARD	DISCARD	3	8	4	DISCARD	12	2	10	DISCARD
BLOCK			3	3	3		3	3	3	
PLOT			25	26	27		31	32	33	
TREATMENT	DISCARD	DISCARD	5	12	10	DISCARD	1	3	7	DISCARD
BLOCK			2	2	2		2	2	2	
PLOT			16	17	18		22	23	24	
TREATMENT	DISCARD	DISCARD	2	4	6	DISCARD	8	9	11	DISCARD
BLOCK			2	2	2		2	2	2	
PLOT			13	14	15		19	20	21	
TREATMENT	DISCARD	DISCARD	1	10	2	DISCARD	7	8	12	DISCARD
BLOCK			1	1	1		1	1	1	
PLOT			4	5	6		10	11	12	
TREATMENT	DISCARD	DISCARD	11	3	9	DISCARD	5	4	6	DISCARD
BLOCK			1	1	1		1	1	1	
PLOT			1	2	3		7	8	9	

f. ORETO certificate

Certificate of

Official Recognition of Efficacy Testing Facilities or Organisations in the United Kingdom

This certifies that

RSK ADAS Ltd

complies with the minimum standards laid down in Regulation (EC) 1107/2009 for efficacy testing.

The above Facility/Organisation has been officially recognised as being competent to carry out efficacy trials/tests in the United Kingdom in the following categories:

Agriculture/Horticulture
Stored Crops
Biologicals and Semiochemicals

Date of issue: 1 June 2018
Effective date: 18 March 2018
Expiry date: 17 March 2023

Signature *Authorised signatory*

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development