SCEPTREPLUS

Final Trial Report

Trial code:	SP 29. 2019 (Yr 2)
Title:	**Salads weed control -** AHDB SceptrePlus Salads residual and contact herbicide screen – Spinach
Crop	Group: Field vegetables - Baby Leaf Spinach (*Spinacea oleracea*) – subfamily *Chenopodiodeae*
Target	General broadleaf weeds and grasses, 3WEEDT EPPO1/089(3) Weeds in leafy and brassica vegetables
Lead researcher:	Angela Huckle
Organisation:	RSK ADAS, Boxworth
Period:	April 2019 - December 2019
Report date:	31st December 2019
Report author:	Liz Johnson, LJ Technical Consultancy Ltd,
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

9th April 2020
Date

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Authors signature

Trial Summary

Introduction

This one year trial was funded to look at new pre- and post-emergence options for broadleaf weed control for drilled baby leaf spinach, assessing both the level of weed control and crop damage. A number of novel residual and contact herbicides with the potential to replace the impending loss of approvals of Pyramin DF (chloridazon) on 30th June 2020 and Intruder (chlorpropham) on 8th October 2020 were compared in baby leaf spinach The trial also evaluated pre-emergence treatment options,to as there has beena change in the timing approval for Venzar (lenacil), which can now only be applied as a post-emergence application.

Methods

A randomised, replicated trial (three replicates) was carried out at a commercial baby leaf grower site nr Petworth, West Sussex, GU28 0JL (The Lettuce Company) on a sandy loam soil type, using spinach cv. SV1846VC.

Pre emergence treatments were applied on the day of drilling on 13 August 2019, post-emergence treatments were applied eight days after drilling on 21 August 2019. There were 12 pre-emergence treatments including an untreated control and a standard of Venzar Flo (lenacil) at 0.8 L/ha (expired approval), with 12 post- emergence treatments including an untreated control and a commercial standard of Venzar 500 SC (lenacil) at 0.4 L/ha.

Results

Table 1. Weed control for pre-emergence treatments at two, three, and four weeks after application. Shown as % weed ground cover: higher score, =more weeds

	% weed cover on dates shown		
Date	**27 Aug**	**3 Sept**	**10 Sept**
Treatment			
1. Untreated	1.91	7.95	9.36
2. Intruder 0.75 L/ha	9.97	14.76	16.6
3. Intruder 1.0 L/ha	9.08	9.88	12.46
4. AHDB 9860 0.75 L/ha	7.63	10.34	13.16
5. AHDB 9860 1.0 L/ha	8.56	11.94	12.92
6. Dual Gold 0.7 L/ha	8.74	8.74	11.94
7. AHDB 9861 1.0 L/ha	2.71	5.42	9.27
8. AHDB 9861 2.0 L/ha	0	2.71	9.73
9. AHDB 9878 0.3 L/ha	10.96	10.96	11.94
10. AHDB 9878 0.5 L/ha	7.33	7.33	8.13
11. AHDB 9987 1.0 L/ha	2.71	5.42	10.86
12.Venzar Flo 0.8 L/ha	1.91	1.91	2.71
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	5.872	5.308	4.443
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Table 2. Weed control for post-emergence treatments at one, two, and three weeks after application. Shown as % weed ground cover: higher score = more weeds.

	% weed cover on dates shown		
Date	**27 Aug**	**3 Sept**	**10 Sept**
Treatment			
1. Untreated	2.71	11.32	15
2. Intruder 0.5 L/ha	0	9.73	11.57
3. Intruder 0.75 L/ha	2.71	9.73	11.32
4. AHDB 9860 0.75 L/ha	5.42	8.13	9.36
5. AHDB 9860 1.0 L/ha	9.73	11.32	12.79
6. AHDB 9860 1.5 L/ha	2.71	2.71	9.54
7. AHDB 9853 0.75 L/ha	2.71	5.42	8.13
8. AHDB 9853 1.0 L/ha	2.71	5.42	8.13
9. AHDB 9853 1.5 L/ha	0	5.42	6.03
10. AHDB 9864 2.0 L/ha	5.42	5.42	8.74
11. AHDB 9864 4.0 L/ha	3.32	0	5.42
12.Venzar 500 0.4 L/ha	3.32	6.03	8.74
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	6.181	5.643	6.609
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Table 3. Mean crop damage for pre-emergence treatments at two, three, and four weeks after application. Shown as % crop damage: higher score = more damage.

Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated	21.9	34.6	23.9
2. Intruder 0.75 L/ha	28.1	36.1	36.1
3. Intruder 1.0 L/ha	26.1	33	28.8
4. AHDB 9860 0.75 L/ha	32.2	55.1	52.8
5. AHDB 9860 1.0 L/ha	32.2	55	49.1
6. Dual Gold 0.7 L/ha	35	61.9	61.9
7. AHDB 9861 1.0 L/ha	32.3	41.2	36.9
8. AHDB 9861 2.0 L/ha	57.8	59	50.8
9. AHDB 9878 0.3 L/ha	62.7	61.9	61.9
10. AHDB 9878 0.5 L/ha	71.6	71.6	71.6
11. AHDB 9987 1.0 L/ha	48.9	66.1	66.1
12.Venzar Flo 0.8 L/ha	28.8	32.7	26.6
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	12.43	16.17	13.97
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Table 4. Mean crop damage for post-emergence treatments at one, two, and three weeks after application. Shown as % crop damage: higher score =more damage. Angular transformed data presented.

Date	**27 Aug**	**3 Sept**	**10 Sept**
Treatment			
1. Untreated	23.9	23.9	21.1

2. Intruder 0.5 L/ha	28.8	39.1	39.1
3. Intruder 0.75 L/ha	35	51.1	51.1
4. AHDB 9860 0.75 L/ha	53.9	68.9	68.9
5. AHDB 9860 1.0 L/ha	58.1	71.6	71.6
6. AHDB 9860 1.5 L/ha	60	71.6	71.6
7. AHDB 9853 0.75 L/ha	34.9	39.1	31
8. AHDB 9853 1.0 L/ha	30.8	28.8	28.8
9. AHDB 9853 1.5 L/ha	71.6	52.8	48.9
10. AHDB 9864 2.0 L/ha	33	35	30.8
11. AHDB 9864 4.0 L/ha	36.6	50.9	50.9
12.Venzar 500 0.4 L/ha	47.2	45	32.7
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	20.18	11.86	12.54
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Conclusions

The commercial standard – Venzar 500 SC applied post-emergence, AHDB 9864 at 2.0 L/ha post-emergence and Intruder applied pre-emergence at 0.75 L/ha and 1.0 L/ha appeared to be safest to the crop. AHDB 9853 at 0.75 L/ha and 1.0 L/ha applied post-emergence appeared to be safe for the crop, but care needs to be taken as there can be variability in crop safety dependent on growth stage and weather at application. As with many residual herbicides, adverse weather such as temperatures above 21°C on the day of spraying, soil or cultural conditions may lead to unsatisfactory results or a check to growth from which recovery may not be complete.

Weed levels were low at the site but there were significant differences to indicate trends. In terms of weed control, in the pre-emergence trial Venzar Flo (no longer approved at this timing) had significantly reduced weeds compared to the untreated plots but Intruder at 0.75 L/ha had significantly greater weed numbers, with a number of weed species present i.e groundsel, runch, mayweed, orache showing, even though it can be safe to the crop. It has a a limited weed control spectrum.

In the post-emergence trial, the treatments which had significantly less weeds than the untreated were AHDB 9853 at 1.5 L/ha and AHDB 9864 at 4.0 L/ha but these treatment rates were not crop safe. However the lower rates of these treatments were crop safe, so these actives do show some potential for spinach, and warrant further investigation for integration into programmes.

Take Home Message

No pre-emergence products gave the same combination of crop safety and weed control as Venzar Flo applied pre-emergence. However, there are promising options which could improve weed control at a post-emergence timing. These are AHDB 9853 and AHDB 9864 although these are on the margins of crop safety. Further work is required on rates and timings, and to understand how to intergrate them safely into programmes to avoid crop damage.

Objectives

To compare a number of novel residual and contact herbicides for weed control in baby leaf spinach with the potential to replace the impending loss of approval of Pyramin DF (chloridazon) at the end of June 2020 and Intruder (chlorpropham) on 8th October 2020 and following the change in timing approval for Venzar (lenacil) which is now a post emergence application. This one year trial was to look at new pre and post emergence options for broadleaf weed control for drilled baby leaf spinach, assessing both the level of weed control and crop damage.

Trial conduct

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

Relevant EPPO guideline(s)		**Variation from EPPO**
PP 1/152(3)	Design and analysis of efficacy evaluation trials	None
PP 1/135(3)	Phytotoxicity assessment	None
PP 1/181(3)	Conduct and reporting of efficacy evaluation trials including GEP	None
PP 1/089 (3)	Weeds in leafy and brassica vegetables	One

There was one deviation from EPPO guidance:

PP1/89(3) Section 1.4, Design and lay-out of trial:

"Replicates: at least 4"

Study only had 3 replicates – the large number of treatments provides an acceptable number of residual degrees of freedom.

Test site

Item	**Details**
Location address	Hallgate Farm, Haslingbourne Lane, Byworth, Petworth, Chichester, West Sussex, GU28 0JL,
Crop	Baby leaf spinach
Cultivar	SV 1846VC
Soil or substrate type	Sandy loam, 2 – 3% OM
Agronomic practice	Commercial baby leaf spinach crop drilled on 13th August 2019, 8 million seeds/ha, heavy rain pre drilling & on 14th August, irrigated 6mm on 24th August, 8mm on 27th August, 10mm on 30th August + 8mm on 2nd September. No pre or post emergence herbicides applied to the trial area.
Prior history of site	Previous crop was wholehead lettuce planted spring 2019, wheat in 2018, rotation of wheat, wheat, sweetcorn, wheat, lettuce

Trial design

Item	**Details**
Trial design:	Full randomized block design
Number of replicates:	3
Row spacing:	11 rows per 2m bed
Plot size: (w x l)	2m x 6m
Plot size: (m^2)	12
Number of plants per plot:	9600
Leaf Wall Area calculations	n/a

Treatment details

AHDB Code	Active substance	Product name/ manufacturers code	Formulation batch number	Content of active substance in product	Formulation type
Intruder	chlorpropham	Intruder	543H	400g/l	EC
AHDB 9860	N/D	N/D	N/D	N/D	N/D
Dual Gold	S-metalochlor	Dual Gold	SM05D0172	960g/l	EC
AHDB 9861	N/D	N/D	N/D	N/D	N/D
AHDB 9878	N/D	N/D	N/D	N/D	N/D
AHDB 9987	N/D	N/D	N/D	N/D	N/D
Venzar Flo	lenacil	Venzar Flo	FEB17HE006	440g/l	SC
Venzar 500 SC	lenacil	Venzar 500 SC	FEB17HE006	500g/l	SC
AHDB 9853	N/D	N/D	N/D	N/D	N/D
AHDB 9864	N/D	N/D	N/D	N/D	N/D

Application schedule – Pre emergence

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	Untreated			A
2	Intruder	300	0.75	A
3	Intruder	400	1.0	A
4	AHDB 9860	375	0.75	A
5	AHDB 9860	500	1.0	A
6	Dual Gold	672	0.7	A
7	AHDB 9861	700	1.0	A
8	AHDB 9861	1400	2.0	A
9	AHDB 9878	150	0.3	A
10	AHDB 9878	250	0.5	A
11	AHDB 9987	600	1.0	A
12	Venzar Flo	352	0.8	A

Application schedule – Post emergence

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	Untreated			B
2	Intruder	200	0.5	B
3	Intruder	300	0.75	B
4	AHDB 9860	375	0.75	B
5	AHDB 9860	500	1.0	B
6	AHDB 9860	750	1.5	B
7	AHDB 9853	117.75	0.75	B
8	AHDB 9853	157	1.0	B
9	AHDB 9853	235.5	1.5	B
10	AHDB 9864	800	2.0	B
11	AHDB 9864	1600	4.0	B
12	Venzar 500 SC	200	0.4	B

Application details

	Application A	Application B
Application date	13/08/2019	21/08/2019
Time of day	17:30-18:05	11:20-11:55
Crop growth stage (Max, min average BBCH)	BBCH00 (Pre-Em)	Cotyledon BBCH 10 (Post-Em)
Crop height (cm)	N/A	2-3
Crop coverage (%)	N/A	5-10
Application Method	Spray	Spray
Application Placement	Soil	Soil
Application equipment	Knapsack	Knapsack
Nozzle pressure	2-3Bar	2-3Bar
Nozzle type	Flat Fan	Flat Fan
Nozzle size	02F110	02F110
Application water volume/ha	400	400
Temperature of air - shade (°C)	16.2-16.0	19.8-24.9
Relative humidity (%)	61.8-60.9	68.9-55.7
Wind speed range (m/s)	0.9-0.4	1.3-0.9
Dew presence (Y/N)	N	N
Temperature of soil - 2-5 cm (°C)	N/K	N/K
Wetness of soil - 2-5 cm	Dry	Dry
Cloud cover (%)	25	70

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

Common name	Scientific Name	EPPO Code	Infestation level pre-application	Infestation level at start of assessment period	Infestation level at end of assessment period
Broadleaf weeds & grasses	*N/A*	3WEEDT	0% ground cover	4% ground cover	7% ground cover

Assessment details

	Evaluation Timing (DA)*				
Evaluation date	**After conventional herbicides**	**After Bio-herbicides**	**Crop Growth Stage (BBCH)**	**Evaluation type (efficacy, phytotox)**	**Assessment**
27/08/2019	A – 14 B - 6	n/a	12	Efficacy Phytotox	Phytotox scale 10=dead 0=nil Weeds % ground covered
03/09/2019	A – 21 B - 14	n/a	14	Efficacy Phytotox	Phytotox scale 10=dead 0=nil Weeds % ground covered
10/09/2019	A – 28 B - 21	n/a	14-16	Efficacy Phytotox	Phytotox scale 10=dead 0=nil Weeds % ground covered

* DA – days after application

At each assessment a score was made to record phytotoxicity and % weed ground cover, notes were made on weed species present and photographs taken of crop damage symptoms. Note: Spinach is classified as Leafy vegetable (not forming heads) in the BBCH scale.

Statistical analysis

The pre emergence trial was designed as a randomised block design with three replicates including a replicated untreated control within the 12 treatments. The post emergence trial was aligned beyond the pre emergence trial as a randomised block design with three replicates including a replicated untreated control within the 12 treatments.

All data were analysed by ANOVA using Genstat 18.2 by Chris Dyer at RSK ADAS.
The Phytotoxicity scores were changed to percentages to complete the angular transformation on the data, a Duncan's multiple range test was then completed to identify any differences in the treatments. The back transformed data were presented and then Abbots formula was used to calculate the % increase in crop damage compared to the control.

The distribution of weeds was low at all assessments < 10% including the untreated. For the % efficacy, an angular transformation was carried out then a Duncan's multiple range test was then completed to identify any differences in the treatments. The back transformed data were presented and then Abbots formula was used to calculate the % increase in efficacy compared to the control.

Results

Weed control – pre-emergence

Table 5. Weed control for pre-emergence treatments at two, three, and four weeks after application. Shown as % weed ground cover, higher score, more weeds Angular transformed data presented.

	% weed cover on dates shown		
Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated	1.91	7.95	9.36
2. Intruder 0.75 L/ha	9.97	14.76	16.6
3. Intruder 1.0 L/ha	9.08	9.88	12.46
4. AHDB 9860 0.75 L/ha	7.63	10.34	13.16
5. AHDB 9860 1.0 L/ha	8.56	11.94	12.92
6. Dual Gold 0.7 L/ha	8.74	8.74	11.94
7. AHDB 9861 1.0 L/ha	2.71	5.42	9.27
8. AHDB 9861 2.0 L/ha	0	2.71	9.73
9. AHDB 9878 0.3 L/ha	10.96	10.96	11.94
10. AHDB 9878 0.5 L/ha	7.33	7.33	8.13
11. AHDB 9987 1.0 L/ha	2.71	5.42	10.86
12.Venzar Flo 0.8 L/ha	1.91	1.91	2.71
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	5.872	5.308	4.443
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Weed control – post-emergence

Table 6. Weed control for post-emergence treatments at one, two, and three weeks after application. Shown as % weed ground cover, higher score, more weeds. Angular transformed data presented.

	% weed cover on dates shown		
Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated	2.71	11.32	15
2. Intruder 0.5 L/ha	0	9.73	11.57
3. Intruder 0.75 L/ha	2.71	9.73	11.32
4. AHDB 9860 0.75 L/ha	5.42	8.13	9.36
5. AHDB 9860 1.0 L/ha	9.73	11.32	12.79
6. AHDB 9860 1.5 L/ha	2.71	2.71	9.54
7. AHDB 9853 0.75 L/ha	2.71	5.42	8.13
8. AHDB 9853 1.0 L/ha	2.71	5.42	8.13
9. AHDB 9853 1.5 L/ha	0	5.42	6.03
10. AHDB 9864 2.0 L/ha	5.42	5.42	8.74
11. AHDB 9864 4.0 L/ha	3.32	0	5.42
12.Venzar 500 0.4 L/ha	3.32	6.03	8.74
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	6.181	5.643	6.609
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Weed control as % reduction by Abbotts formula – Pre-emergence

Table 7. Mean % weed reduction for the pre-emergence trial at two, three, and four weeks after application using back transformed means data for % Abbotts reduction**.**

	% weed reduction from compared to untreated as Abbotts formula		
Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated			
2. Intruder 0.75 L/ha	2602.7	293.44	208.47
3. Intruder 1.0 L/ha	2145.05	53.97	75.99
4. AHDB 9860 0.75 L/ha	1489.19	68.57	96.03
5. AHDB 9860 1.0 L/ha	1897.3	123.8	89.04
6. Dual Gold 0.7 L/ha	1981.98	20.87	61.78
7. AHDB 9861 1.0 L/ha	101.8	-53.35	-1.97
8. AHDB 9861 2.0 L/ha	-100	-88.28	7.94
9. AHDB 9878 0.3 L/ha	2154.05	88.91	61.78
10. AHDB 9878 0.5 L/ha	1367.57	-14.8	-24.39
11. AHDB 9987 1.0 L/ha	101.8	53.35	34.29
12.Venzar Flo 0.8 L/ha	0	-94.19	-91.53
P value			
d.f			
Lsd			
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Weed control as % reduction by Abbotts formula – Post-emergence

Table 8. Mean % weed reduction for the post-emergence trial at two, three, and four weeks after application using back transformed means data for % Abbotts reduction**. Negative values show a weed increase**

	% weed reduction from compared to untreated as Abbotts formula		
Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated			
2. Intruder 0.5 L/ha	-100	-25.96	-40.01
3. Intruder 0.75 L/ha	0	-25.96	-42.44
4. AHDB 9860 0.75 L/ha	299.02	-48.13	-60.52
5. AHDB 9860 1.0 L/ha	1176.65	0	-26.8
6. AHDB 9860 1.5 L/ha	0	-94.19	-58.95
7. AHDB 9853 0.75 L/ha	0	-76.87	-70.15
8. AHDB 9853 1.0 L/ha	0	-76.87	-70.14
9. AHDB 9853 1.5 L/ha	-100	-76.87	-83.51
10. AHDB 9864 2.0 L/ha	299.02	-76.87	-65.5
11. AHDB 9864 4.0 L/ha	50.4	-100	-86.68
12.Venzar 500 0.4 L/ha	50.4	-71.34	-65.5
P value			
d.f			
Lsd			
	Not significantly different from untreated control (p>0.05)		
	Significantly lower than untreated control (p<0.05)		

Phytotoxicity – pre emergence

Table 9. Mean crop damage for pre-emergence treatments at two, three, and four weeks after application. Shown as % crop damage, higher score, more damage. Angular transformed data presented.

Date	**27th Aug**	**3rd Sept**	**10th Sept**
Treatment			
1. Untreated	21.9	34.6	23.9
2. Intruder 0.75 L/ha	28.1	36.1	36.1
3. Intruder 1.0 L/ha	26.1	33	28.8
4. AHDB 9860 0.75 L/ha	32.2	55.1	52.8
5. AHDB 9860 1.0 L/ha	32.2	55	49.1
6. Dual Gold 0.7 L/ha	35	61.9	61.9
7. AHDB 9861 1.0 L/ha	32.3	41.2	36.9
8. AHDB 9861 2.0 L/ha	57.8	59	50.8
9. AHDB 9878 0.3 L/ha	62.7	61.9	61.9
10. AHDB 9878 0.5 L/ha	71.6	71.6	71.6
11. AHDB 9987 1.0 L/ha	48.9	66.1	66.1
12.Venzar Flo 0.8 L/ha	28.8	32.7	26.6
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	12.43	16.17	13.97
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Phytotoxicity – post emergence

Table 10. Mean crop damage for post-emergence treatments at one, two, and three weeks after application. Shown as % crop damage, higher score, more damage. Angular transformed data presented.

Date	27th Aug	3rd Sept	10th Sept
Treatment			
1. Untreated	23.9	23.9	21.1
2. Intruder 0.5 L/ha	28.8	39.1	39.1
3. Intruder 0.75 L/ha	35	51.1	51.1
4. AHDB 9860 0.75 L/ha	53.9	68.9	68.9
5. AHDB 9860 1.0 L/ha	58.1	71.6	71.6
6. AHDB 9860 1.5 L/ha	60	71.6	71.6
7. AHDB 9853 0.75 L/ha	34.9	39.1	31
8. AHDB 9853 1.0 L/ha	30.8	28.8	28.8
9. AHDB 9853 1.5 L/ha	71.6	52.8	48.9
10. AHDB 9864 2.0 L/ha	33	35	30.8
11. AHDB 9864 4.0 L/ha	36.6	50.9	50.9
12.Venzar 500 0.4 L/ha	47.2	45	32.7
P value	0.05	0.05	0.05
d.f	22	22	22
Lsd	20.18	11.86	12.54
	Not significantly different from untreated control (p>0.05)		
	Significantly different than untreated control (p<0.05)		

Figure 1: Pre emergence herbicide - % Crop damage using angular back transformed data

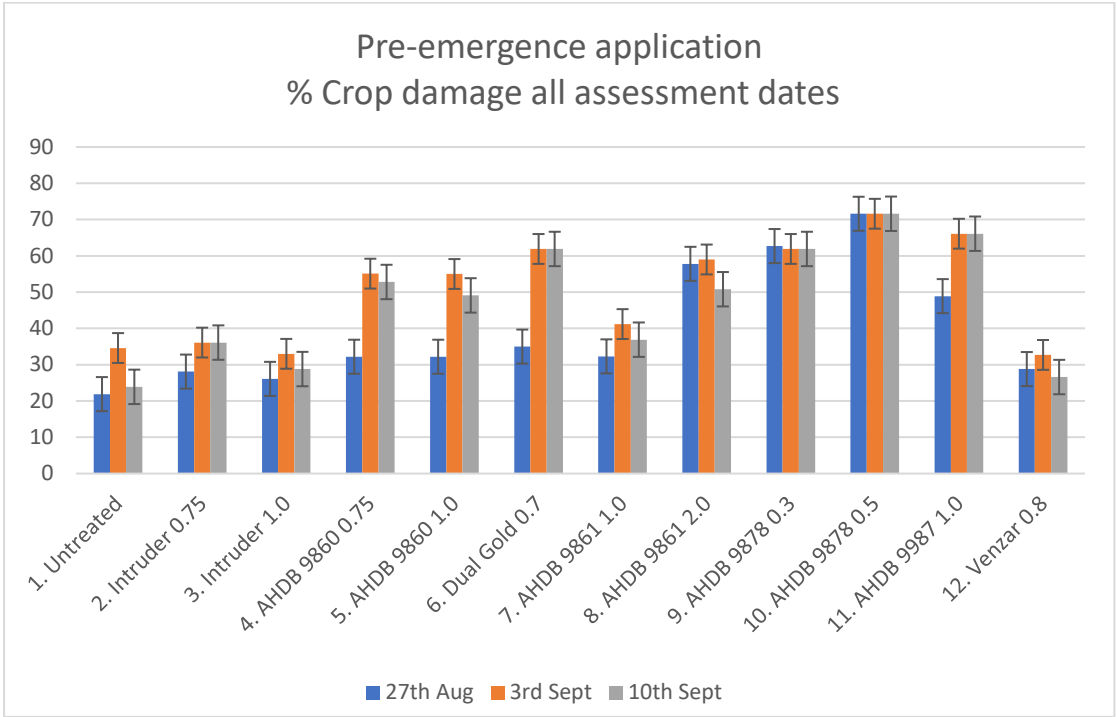
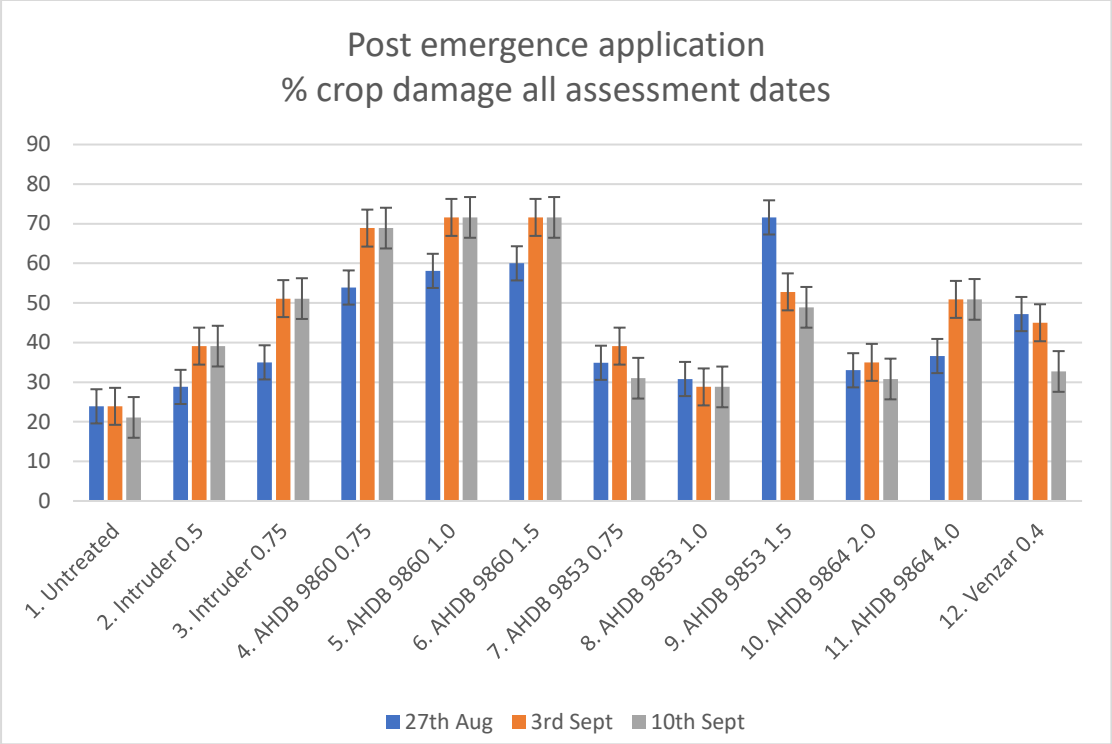


Figure 2: Post emergence herbicide - % Crop damage using angular back transformed data



Discussion

There were signs of yellowing in the trial area and surrounding field crop on 3rd September 2019 but there were very little signs seen at the final assessment on the 10th September 2019.This was due to the extremes of weather at drilling and was taken into account in the assessments.

Weed levels were very low at this site, and there was a limited weed spectrum – groundsel (*Senecio vulgaris*), runch (*Raphanus raphanistrum*), mayweed (*Tripleurospermum inodorum*), orache (*Atriplex patula*), fat hen (*Chenopodium album*) and volunteer cereal.

There were very few significant differences in weed control from any of the pre emergence nor post emergence herbicides applied. In the pre emergence trial, the only treatment which had statistically less weeds than the untreated plots was Venzar Flo, though Intruder at 0.75 L/ha was significantly weedier than the untreated plots, a number of weed species being present – Groundsel, Runch, Mayweed, Orache. In the post emergence trial, the only treatments which had significantly less weeds than the untreated was AHDB 9853 at 1.5 L/ha and AHDB 9864 at 4 L/ha.

There were significant differences between the pre emergence and post emergence herbicides in terms of crop damage (phytotoxicity symptoms), a number of the treatments were unsafe to the crop and a number of treatments were on the margin of crop safety. There is zero tolerance in terms of quality defects and weed contamination allowed for the harvested crop supplied to customers. The whole crop is mechanically harvested and there is very limited opportunity to remove any damaged leaves or weed species, apart from hand weeding prior to harvesting the crop. This emphasises the need to find a herbicide, preferably a pre emergence which will control a wide weed spectrum including groundsel, without having any impact on crop quality. The other challenge for baby leaf crops is the short growing cycle, with time being a constraint on any initial crop damage growing out of the crop before the crop is harvested.

Intruder (chlorpropham) was tested as a pre emergence application and post emergence application at various rates, the EAMU approval for baby leaf permits a maximum application rate of 1.9 L/ha applied within 14 days of crop emergence for drilled crops. Pre emergence applied at 0.75 L/ha and 1 L/ha appeared to be crop safe, with some variability in crop growth but not significantly different from the untreated control. The 0.75 L/ha rate was significantly weedier than the untreated plot. A further herbicide would need to be applied depending on the weed spectrum as Intruder controls a limited weed spectrum or the crop would require hand weeding prior to harvest which tends to be standard practice for baby leaf crops to also check for any foreign objects.

As a post emergence application at 0.5 L/ha and 0.75 L/ha, there was variability in growth of the crop with some signs of distorted/damaged leaves (see photo 1) and signs of leathery/thick leaves 1st/2nd leaves but the 3rd/4th leaves appeared unaffected (see photo 2).

Venzar Flo (lenacil) (old EAMU approval – expired 28th February 2019 as a pre emergence application) showed no significant crop damage in the pre emergence trial and there were significantly less weeds than the untreated plots. Lenacil does control a wide spectrum of weeds including Groundsel. Venzar 500 SC (new EAMU issued March 2019 as a post emergence application at growth stage - BBCH 10) in the post emergence trial, showed some significant initial signs of crop damage, in terms of crop colour and crop variability, but this grew out and the plots were acceptable at harvest.

AHDB 9878 applied as a pre emergence application at both rates 0.3 L/ha and 0.5 L/ha showed significant crop damage at all of the trial assessments; the crop was slower to emerge, had variable emergence, growth was checked, the crop was distorted/scorched and there were signs of spotting on the leaves (see photo 3). Only weed species recorded on the plots was Runch, but too much crop damage was seen at both application rates to be acceptable.

AHDB 9861 applied as a pre emergence application at 1 L/ha- there was some crop damage in terms of, growth of the crop was slower and the crop stand was variable within the plots, this was not significantly different from the untreated control but verged on the margin of crop safety. At 2 L/ha, there was significant crop damage, growth of the crop was checked at an early stage of growth, some leaf distortion was seen and generally the plots were thinner in terms of crop density (see photo 4). Only runch was visible in the plots, no signs of any other weed species present.

AHDB 9860 as a pre emergence application at 0.75 L/ha and 1.0 L/ha, initially there were some slight signs of crop damage in terms that crop growth was checked, variable crop stands and there was significant damage seen at the 2nd assessment on the 3rd September with signs of spotting and damage on leaves evident (see photo 5), particularly at the 1.0 L/ha application rate. As a post emergence application, significant crop damage was seen at all rates 0.75 L/ha, 1 L/ha and 1.5 L/ha and at each assessment date – crop growth was checked, signs of scorching/distortion particularly at the highest rate + some spotting seen on leaves (see photo 6)

AHDB 9853 as a post emergence application, the most significant crop damage was seen at 1.5 L/ha – crop stands were poor, growth was checked but there was significantly less weeds. The crop quality appeared to be acceptable at the final harvest for the 0.75 L/ha and 1.0 L/ha (see photo 7), but from experience of the active, crop damage can be variable and care needs to be taken with growth stage and weather conditions at application.

Some of the crop damage seen with AHDB 9860 and AHDB 9853 post emergence, could have been contributed by the higher temperatures on the day of application and following day - the post emergence applications were made on 21st August at 11.30am, the temperature recorded at the time of application was 19.8 – 24.9 ^{o}C and there were high temperatures again on the bank holiday weekend - 26th August and 27th August reaching ~ 29^{o}C.

The product labels for both these products state:

As with many residual herbicides, adverse weather, soil or cultural conditions may lead to unsatisfactory results or a check to growth from which recovery may not be complete.
Do not apply if temperature is likely to rise above 21°C on the day of spraying and avoid spraying in full sunlight. In these cases, delay the application until the evening.

Dual Gold (s metalochlor) is approved for baby leaf - EAMU approval but it has restricted application dates (1st March to 31st May). When applied as a pre emergence application, the plots were variable and showed significant crop damage compared to the untreated, growth was checked at emergence and there were signs of spotting on the leaves seen at the 2nd assessment on 3rd September – (photo 8).

AHDB 9987 applied as a pre emergence application at 1 L/ha, resulted in significant crop damage, crop growth was checked at emergence – slow growth, variable plot stands, spotting on leaves and distortion seen at the 2nd assessment on the 3rd September (see photo 9).

AHDB 9864 applied as a post emergence application at 2 L/ha did give some slight variability in growth in the plot stands but at the final assessment, there was no significant difference compared to the untreated plots. At the higher application rate of 4 L/ha, crop growth was slower and there were signs of the leaves cupping (see photo 10 &11) and there was significantly more weeds present.

The commercial standard of Venzar 500 SC applied post emergence did not show any significant crop damage at the last assessment, but there can be some initial signs of crop damage.

Intruder applied pre emergence appears to be ok and safer than a post emergence application but controls a limited weed spectrum which does not include Groundsel.

AHDB 9864 applied post emergence at 2 L/ha appears to be crop safe and an approval is currently being pursued.

AH9853 applied at 0.75 L/ha and 1.0 L/ha appear to be safest for the crop, but care needs to be taken, as from the results and previous experience of this active, there can be some variability in terms of crop safety relating to environmental conditions..

Conclusions

The commercial standard – Venzar 500 SC applied post emergence, AHDB 9864 at 2.0 L/ha post emergence and Intruder applied pre emergence at 0.75 L/ha and 1.0 L/ha appeared to be safest to the crop. AHDB 9853 at 0.75 L/ha and 1.0 L/ha applied post emergence appeared to be safe for the crop, but care needs to be taken as there can be variability in crop safety dependent on growth stage and weather at application.

Weed levels were low at the site but there were significant differences to indicate trends. In terms of weed control, in the pre emergence trial Venzar Flo (no longer approved at this timing) significantly reduced weeds compared to the untreated plots but Intruder at 0.75 L/ha had significantly greater weed numbers, with a number of weed species present i.e groundsel, runch, mayweed, orache, showing even though it can be safe to the crop, it controls a limited weed spectrum.

In the post emergence trial, the treatments which had significantly less weeds than the untreated were AHDB 9853 at 1.5 L/ha and AHDB 9864 at 4.0 L/ha but these treatment rates were not crop safe. However the lower rates of these treatments were crop safe, so these actives do show some potential for spinach, and warrant further investigation for integration into programmes.

Acknowledgements

Thanks are given to the hosts, The Lettuce Company for providing the site. To AHDB for providing funding and to technical input from Bolette Palle Neve, David Norman and Angela Huckle. Thanks also to the crop protection manufacturers for supporting the work and providing experimental samples and Syngenta for providing the climatological data.

Appendix

a. Crop diary – events related to growing crop:

Crop	Cultivar	Drilling Date	Row width
Baby Leaf Spinach	SV 1846VC	13/08/2019	11 rows per 2m bed

Crop Dairy – pesticide/fertiliser applications

Date	Product	Rate/ha	Type/Use
21/08/2019	SL567a (metalaxyl m) Hallmark zeon (lambda-cyhalothrin) Mg	0.125 0.075 3	Pythium Leaf miner Trace element
27/08/2019	Switch (cyprodinil + fludioxonil) Revus (mandipropamid) Decis protech (deltamethrin) Movento (spirotetramat)	0.8 0.6 0.42 0.5	Leaf spots Downy mildew Caterpillar Aphid
02/09/2019	Gazelle (acetamiprid)	0.25	Aphid

b. Trial diary:

Date	Event
13/08/2019	Crop drilled
13/08/2019	Treatments A applied
21/08/2019	Treatments B applied
27/08/2019	Weeds, phytotox assessment
03/09/2019	Weeds, phytotox assessment
10/09/2019	Weeds, phytotox assessment

c. Photos:

Photo 1: Intruder 0.75 L/ha post emergence – assessment 10th September 2019 (20 DAT)

Photo 2: Intruder 0.5 L/ha post emergence – assessment 3rd September – leathery leaves (13 DAT)

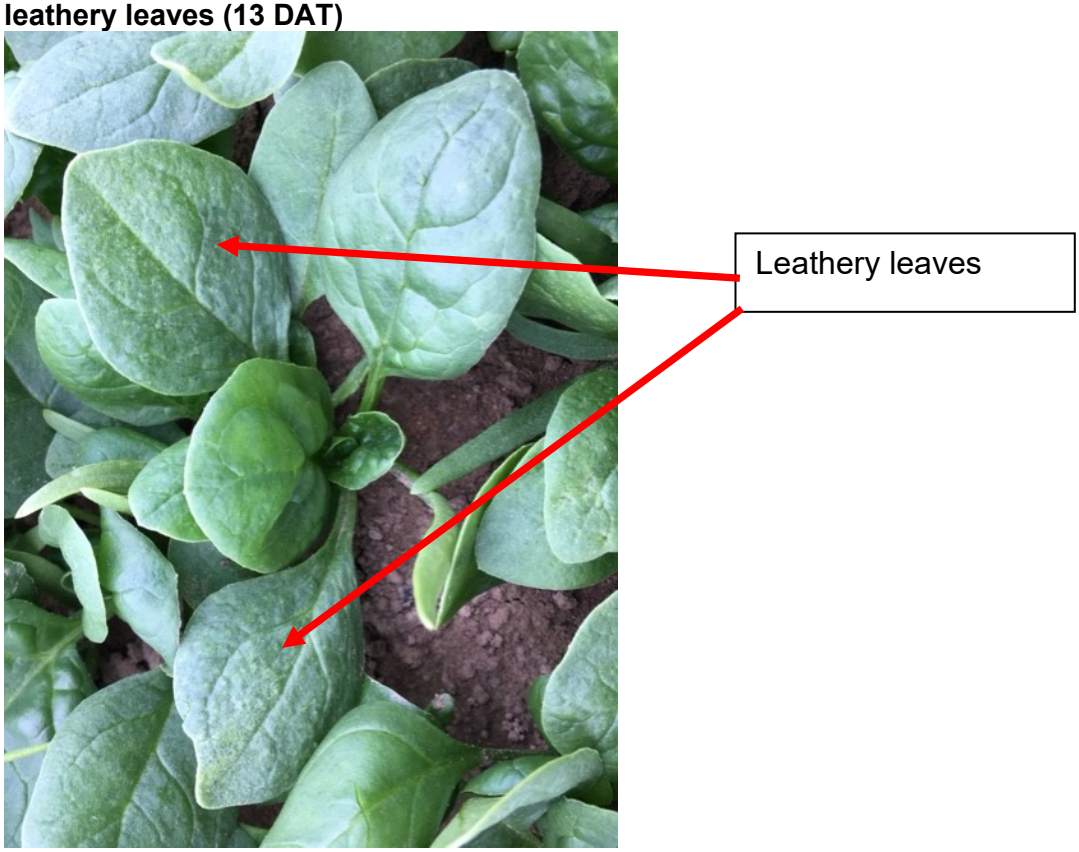


Photo 3: Pre emergence – AHDB 9878 0.3 L/ha – LHS and AHDB 9878 0.5 L/ha – RHS – assessment date – 3rd September 2019 (21 DAT)

Photo 4: AHDB 9861 2 L/ha pre emergence – assessment date 3rd September 2019 (21 DAT)

Photo 5: AHDB 9860 1 litre/ha pre emergence – assessment date 3rd September 2019 - variable stand + spotting on leaves (21 DAT)

Photo 6: AHDB 9860 1.5 L/ha post emergence – assessment date 3rd September 2019 – leaf distortion, variable growth stages (13 DAT)

Photo 7: AHDB 9853 1 litre/ha post emergence – assessment date 10th September 2019 (20 DAT)

Photo 8: Dual Gold 0.7 L/ha pre emergence – assessment date 3rd September 2019 (21 DAT)

Photo 9: AHDB 9987 1 litre/ha pre emergence – assessment date 3rd September 2019 (21 DAT)

Photo 10: AHDB 9864 post emergence - LHS 2 L /ha and RHS 4 L/ha assessment date 3rd September 2019 (13 DAT)

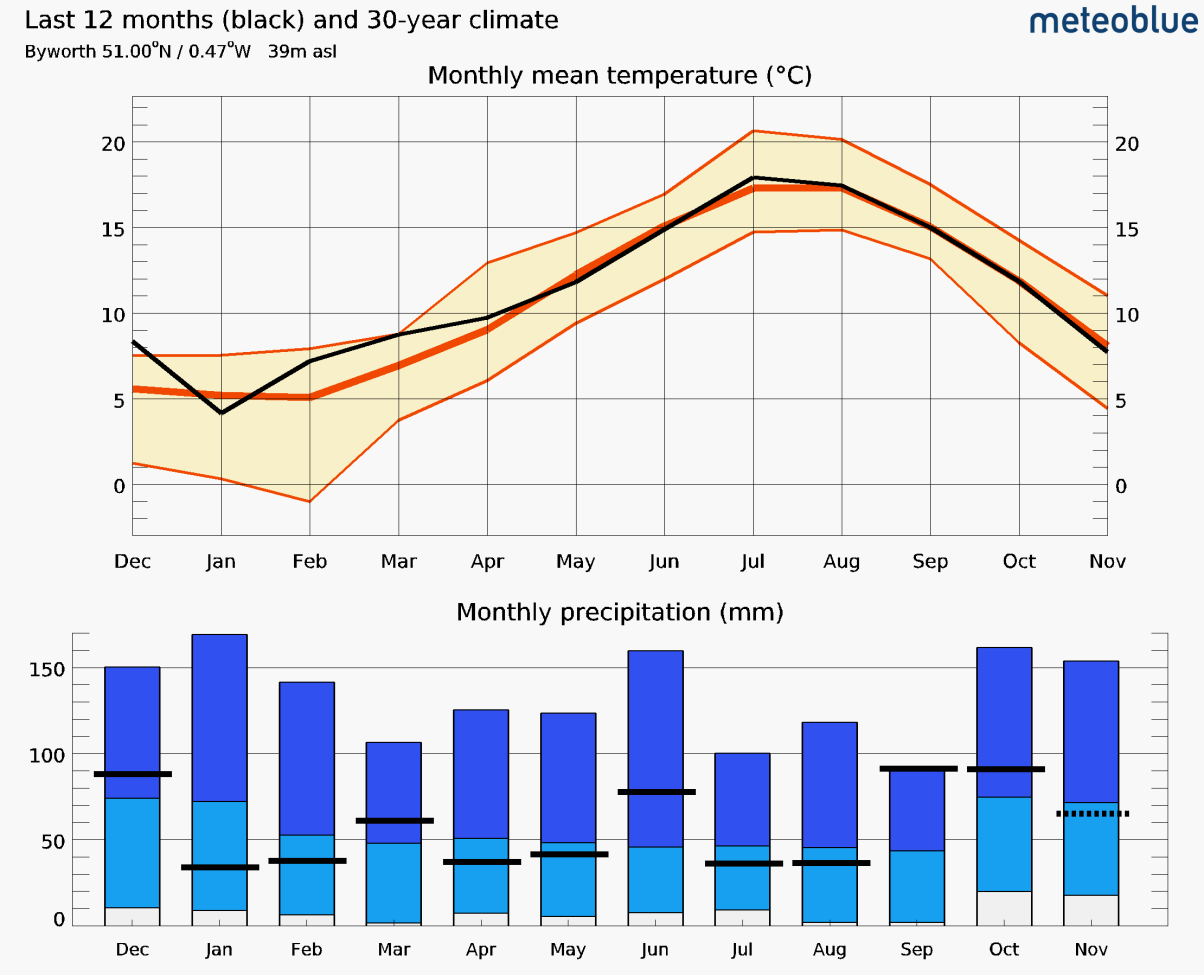
Photo 11: AHDB 9864 post emergence - LHS 2 L /ha and RHS 4 L/ha Assessment date: 10th September 2019 (20 DAT)

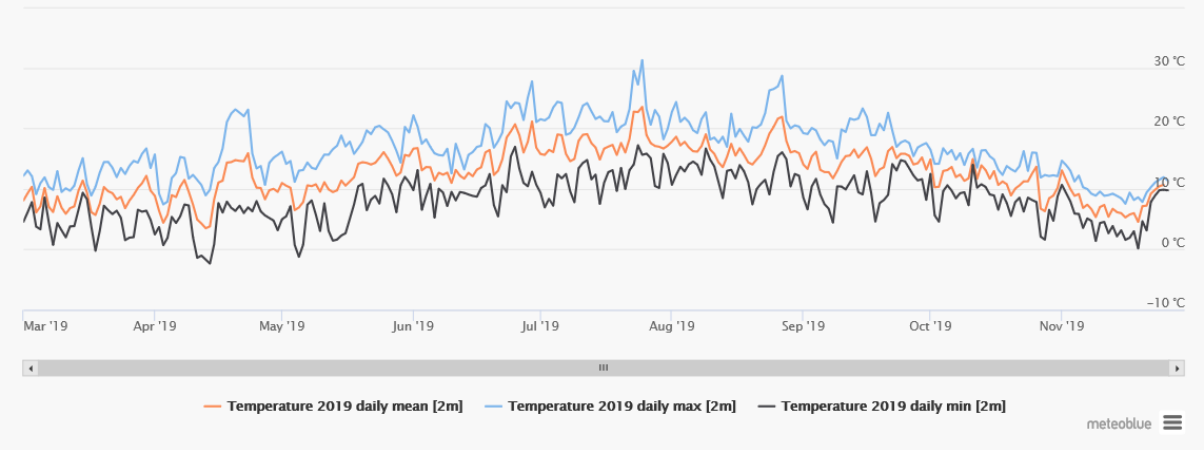
Photo 12: Trial – 3rd September 2019 – 21 days after drilling

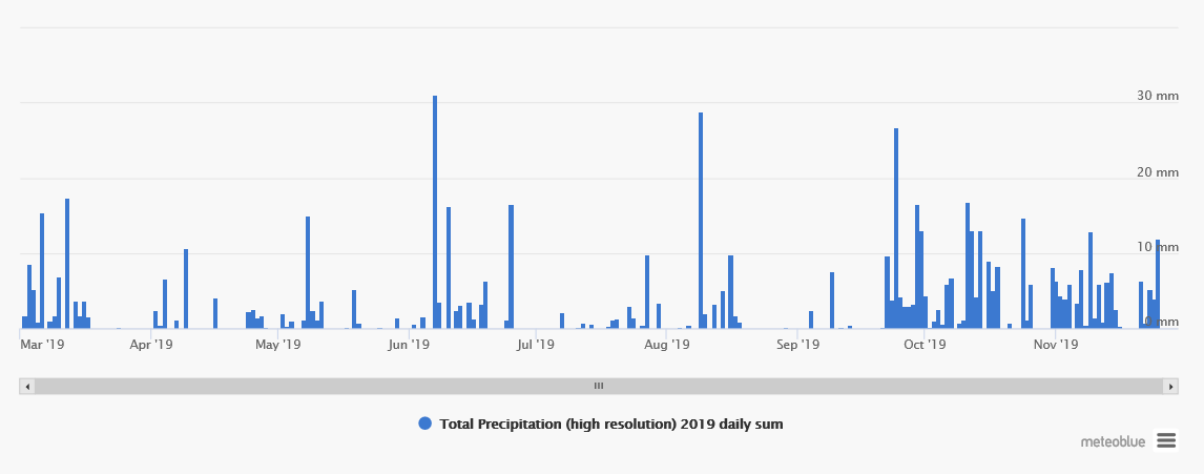
d. Climatological data during study period

August saw some variable weather conditions, there was heavy rainfall just prior to drilling and further heavy rainfall on the 14th August 2019 - the day after drilling and the pre emergence application. We then saw some warmer temperatures prior to the August bank holiday weekend, which was very hot with temperatures reaching ~ 29°C, before the temperatures dropped along with some rainfall in the early part of September.

Climate data, Byworth, Petworth, West Sussex
The actual temperature (black line) compared with the 30 year mean and normal range is given by the coloured area. Actual rainfall, is given by the blackline, with the dark blue area being greater than the 30 year average and the light blue line being less than the 30 year average.


Last 12 months (black) and 30-year climate
Byworth 51.00°N / 0.47°W 39m asl
meteoblue
Monthly mean temperature (°C)
20
15
10
5
0
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly precipitation (mm)
150
100
50
0


30 °C
20 °C
10 °C
0 °C
−10 °C
Mar '19
Apr '19
May '19
Jun '19
Jul '19
Aug '19
Sep '19
Oct '19
Nov '19
Temperature 2019 daily mean [2m]
Temperature 2019 daily max [2m]
Temperature 2019 daily min [2m]
meteoblue



e. Raw data from assessments Pre emergence

Rep	Treatment	phyto 27th Aug	phyto 3rd Sept	phyto 10th Sept	weed 27th Aug	weed 3rd Sept	weed 10th Sept
1	1	0	2	1	1	1	3
1	2	1	1	1	3	5	5
1	3	1	4	2	1	2	5
1	4	1	8	6	5	5	10
1	5	1	6	3	1	5	5
1	6	2	8	8	3	3	5
1	7	1	4	2	0	2	4
1	8	5	7	6	0	0	2
1	9	5	6	6	3	3	5
1	10	9	9	9	1	1	2
1	11	5	8	8	0	2	4
1	12	2	2	2	1	1	2
2	1	4	6	2	0	2	2
2	2	4	8	8	3	10	10
2	3	3	3	3	4	4	5
2	4	5	7	7	0	2	2
2	5	3	8	8	3	3	5
2	6	4	9	9	2	2	3
2	7	4	5	5	2	2	2
2	8	7	8	6	0	0	5
2	9	9	9	9	3	3	3
2	10	9	9	9	2	2	2
2	11	7	8	8	2	2	5
2	12	2	2	2	0	0	0
3	1	2	2	2	0	3	3

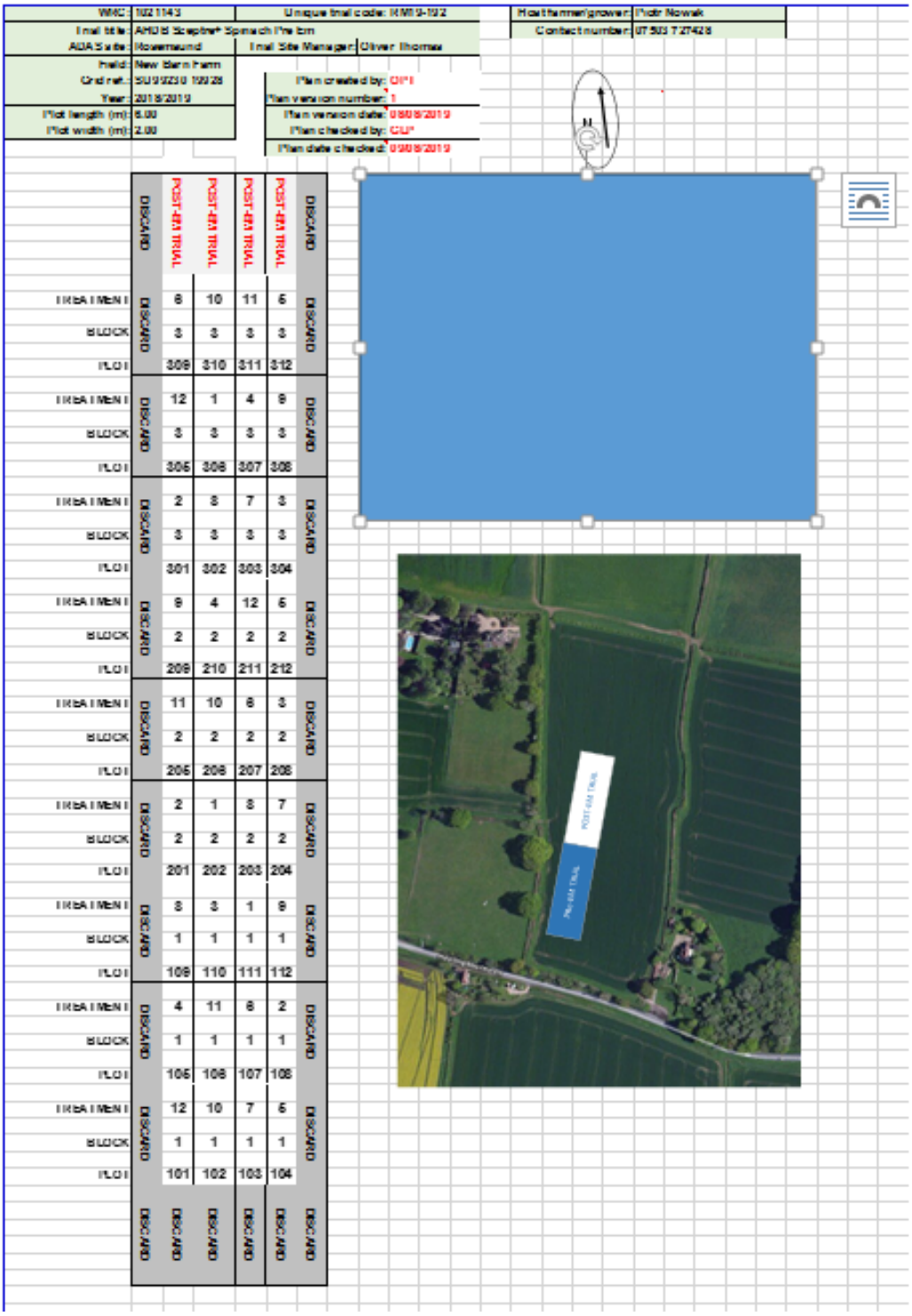
3	2	2	2	2	3	5	10
3	3	2	2	2	3	3	4
3	4	3	5	6	3	3	5
3	5	5	6	6	3	5	5
3	6	4	6	6	2	2	5
3	7	4	4	4	0	0	2
3	8	9	7	6	0	2	2
3	9	9	8	8	5	5	5
3	10	9	9	9	2	2	2
3	11	5	9	9	0	0	2
3	12	3	5	2	0	0	0

Raw data from assessments Post emergence

Rep	Treatment	phyto 27^{th} Aug	phyto 3^{rd} Sept	phyto 10^{th} Sept	weed 27^{th} Aug	weed 3^{rd} Sept	weed 10^{th} Sept
1	1	1	1	1	0	2	2
1	2	2	3	3	0	2	2
1	3	4	8	8	0	5	5
1	4	8	8	8	0	2	2
1	5	8	9	9	5	5	10
1	6	8	9	9	0	0	1
1	7	2	4	3	0	2	2
1	8	4	3	3	0	2	2
1	9	9	6	6	0	2	2
1	10	2	2	2	2	2	2
1	11	2	4	4	0	0	2
1	12	5	5	5	0	2	2
2	1	2	2	1	2	5	10
2	2	3	4	4	0	2	2
2	3	4	6	6	0	2	2
2	4	9	9	9	2	2	3
2	5	9	9	9	2	2	3
2	6	9	9	9	0	0	5
2	7	3	3	2	0	0	2
2	8	2	2	2	0	0	2
2	9	9	7	7	0	2	3
2	10	4	4	2	0	0	2
2	11	2	7	7	0	0	2
2	12	8	7	2	0	0	2
3	1	2	2	2	0	5	10

3	2	2	5	5	0	5	10
3	3	2	4	4	2	2	5
3	4	2	9	9	2	2	3
3	5	4	9	9	2	5	3
3	6	5	9	9	2	2	3
3	7	5	5	3	2	2	2
3	8	2	2	2	2	2	2
3	9	9	6	4	0	0	0
3	10	3	4	4	2	2	3
3	11	7	7	7	3	0	0
3	12	3	3	2	3	3	3

f. Trial design - Pre emergence plan



g. Trial design - Post emergence plan

WRC:	1021143	Unique trial code:	RM19-193	Host farmer/grower:	Piotr Nowak
Trial title:	AHDB Seedrew Spinach Post Em			Contact number:	07503 727428
ADAS site:	Rosemaund	Trial Site Manager:	Oliver Thomas		
Field:	New Barn Farm				
Grid ref:	SU 99230 19928	Plan created by:	GPT		
Year:	2018/2019	Plan version number:	1		
Plot length (m):	0.00	Plan version date:	09/08/2019		
Plot width (m):	0.00	Plan checked by:	GLF		
		Plan date checked:	09/08/2019		

N

	DISCARD	DISCARD	DISCARD	DISCARD	DISCARD
TREATMENT	DISCARD	2	5	4	6
BLOCK	DISCARD	3	3	3	3
PLOT	DISCARD	309	310	311	312
TREATMENT	DISCARD	10	8	9	3
BLOCK	DISCARD	3	3	3	3
PLOT	DISCARD	305	306	307	308
TREATMENT	DISCARD	11	12	1	7
BLOCK	DISCARD	3	3	3	3
PLOT	DISCARD	301	302	303	304
TREATMENT	DISCARD	9	5	4	12
BLOCK	DISCARD	2	2	2	2
PLOT	DISCARD	209	210	211	212
TREATMENT	DISCARD	6	1	2	7
BLOCK	DISCARD	2	2	2	2
PLOT	DISCARD	205	206	207	208
TREATMENT	DISCARD	10	11	3	8
BLOCK	DISCARD	2	2	2	2
PLOT	DISCARD	201	202	203	204
TREATMENT	DISCARD	7	12	2	11
BLOCK	DISCARD	1	1	1	1
PLOT	DISCARD	109	110	111	112
TREATMENT	DISCARD	3	10	6	1
BLOCK	DISCARD	1	1	1	1
PLOT	DISCARD	105	106	107	108
TREATMENT	DISCARD	5	4	9	8
BLOCK	DISCARD	1	1	1	1
PLOT	DISCARD	101	102	103	104
	DISCARD	PRE-EM TRIAL	PRE-EM TRIAL	PRE-EM TRIAL	PRE-EM TRIAL

h. 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 Alison Richardson
Authorised signatory

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development