SCEPTREPLUS

Final Trial Report

Trial code:	SP53. 2020
Title:	AHDB SCEPTREplus: Investigating the impact of different growing media blends on the performance, persistence and leachability of herbicides in container grown crops
Crop	Hardy Nursery Stock
Target	General broadleaf weeds and grasses, 3WEEDT
Lead researcher:	Chloe Whiteside
Organisation:	RSK ADAS Ltd, ADAS Boxworth, Cambridgeshire, CB23 4NN
Period:	May 2019 to October 2020
Report date:	11 February 2021
Report author:	Chloe Whiteside
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

11.02.2021…… ……
Date Authors signature

Trial Summary

Introduction

Containerised hardy nursery stock (HNS) production is one of the largest users of growing media by volume for the Horticulture sector. This sector has relied heavily on peat, but there is increasing Government, environmental and consumer pressure to cease the use of peat and seek out high performing alternative raw materials. Over 20 years of R&D on growing media amendments and ”peat alternatives” has led to a reduction in peat-use (10-50%) for the HNS sector, with a small number of businesses that have fully transitioned to “peat-free” growing media.

Whilst the knowledge for the management of alternative materials such as coir, woodfibre and bark is increasing in terms of irrigation and nutrition management, there has been little work carried out on the impact of different growing media blends on the performance of residual herbicides in container grown crops. It is unknown whether a change in growing media structure can impact on leachability, possibly leading to an increase in active ingredient in the runoff due to a more open structure, resulting in reduced efficacy. In sectors such as HNS, where herbicide applications are vital to maintain clean, marketable crops, it is essential to understand whether these herbicides may work differently in the future, as growing media blends change and the quantity of peat reduces.

There are few herbicides with on-label authorisation for use in HNS. Most products used in the HNS sector are through off-label approval via an Extension of Authorisation for Minor Use (EAMU), but any such application by growers is at their own risk. Pot screens are carried out to expand knowledge of residual herbicide efficacy against key weed species. Extensive screening trials are required, to ensure the herbicide is both effective and safe, particularly for new products or products authorised for use under an EAMU and will not cause unacceptable phytotoxicity to the crop. However, these trials will have been carried out on plants grown in a peat-based medium, and it is not known whether a change in the growing medium could result in crop phytotoxicity. The rates approved for use on a peat-based medium may need revising for peat-reduced or peat-free media.

Although there are several different types of substrates commonly used in the HNS sector, most are comprised of peat, with either woodfibre or bark in varying quantities. Each substrate will have its own water retention and drainage characteristics. Although various physical properties will define the water and air holding capacity of the substrate, they may also impact absorption of pre-emergence herbicides and its influence on weed germination and growth. Such information is not available in the UK, and as the horticulture industry moves towards an increased use of peat-reduced and peat-free media, there is a pressing need to understand the impact on herbicides for HNS containerised growing systems.

This work began in 2019, but because of the germination issues with the weed species used, the trial finished early and was repeated in 2020. Data on leachate was collected in 2019 and data on herbicide efficacy and persistence was collected in 2020.

Methods

Growing media

The four growing media blends used for this work were supplied by Bulrush Horticulture. These blends consisted of; 1 x 70% peat, 1 x 50% peat and 2 x 100% peat-free. To ensure commercial confidentiality, the peat-free components of these blends have been kept anonymised. However, all of the blends supplied have proven ability to grow good quality, marketable plants.

Herbicides

The herbicides selected for inclusion within the trial were; Flexidor (isoxaben 500 g/L), Dual Gold (s-metolachlor 960 g/L) and Sunfire (flufenacet 500 g/L), which have label or EAMU authorisation for use in ornamentals. They are also widely used in the HNS sector, as they have good efficacy against some of the most problematic weeds in containerised HNS production; Hairy bittercress (*Cardamine hirsuta*), Willowherb (*Epilobium spp.)* and Annual meadow grass (*Poa annua*).

2019 – Leachate

During the 2019 trial, 2 L pots were used as these are representative of the containers used in HNS production. The trial was located on an outdoor bed at ADAS Boxworth, so that natural rainfall and additional irrigation via overhead sprinkler would allow for collection of leachate from the pots. For each herbicide tested, there were four growing media treatments, treated and untreated, resulting in 8 treatments per herbicide. There were 18 pots per plot and for the herbicide treated plots, 9 pots per plot were fixed into leachate capture devices. A 5 L black tub was used for each of these 9 pots. A hole was cut into the lid of the tub so that the 2 L pot could be fixed into the lid, using strong waterproof adhesive. Once the lid was attached to the 5 L tub, a seal was created, meaning any water that was collected in the tub would have to pass through the growing media contained within the 2 L pot, thus collecting the leachate. An image of the trial layout is found in the **Appendix**.

Leachate was collected on two occasions; 1 week after herbicide application and 17 weeks after herbicide application. To do this, leachate from each pot per treatment was collected into one large sample. This was then sub-sampled and sent to Concept Life Sciences, Cambridge, who completed the analysis. For the 17 week sample, the tubs were emptied one week prior to collection. This meant that when the sample was collected, any traces of herbicide in the sample would have only been leached through in the last week, rather than many weeks before and left to sit in the tub.

2020 – Herbicide efficacy and persistence

In 2020, cress was used as a representative crop for the fully replicated trial, rather than weeds, just in case there were issues with germination. However, weed seeds were used for two demonstration trials, which were run alongside the cress trial, so that further information could be gathered on the correlation between growing media and herbicides. The weed seeds used for the demonstration were Annual Meadow Grass and Hairy Bittercress.

A germination test was completed on the seeds prior to set-up, with 95% germination in the cress, and between 50-60% germination in the annual meadow grass and hairy bittercress.

Both the main trial and the demonstration trial were carried out in a glasshouse at ADAS Boxworth, from 1st September 2020 until 21 October 2020. For the main trial, for each herbicide tested, there were four growing media blends, herbicide treated and untreated, resulting in eight treatments. The growing media blends consisted of; 1 x 70% peat nursery standard, 1 x 50% peat and 2 x peat-free blends. Each plot contained eight 9 cm pots, four of which were used for the first seed sowing, and four of which were used for the second seed sowing. Each treatment was replicated three times, resulting in a total of 192 pots per herbicide treatment. Two sowings would allow for the gathering of data on persistence of the

herbicide. If the herbicide was washed through the growing media within a week of application, this would show up in the second sowing data.

For the demonstration trials on annual meadow grass and hairy bittercress, there were four growing media blends, herbicide treated and untreated, resulting in eight treatments. There were eight 9 cm pots, four of which were used for the first seed sowing, and four of which were used for the second seed sowing, and no replication.

Pots were filled with the relevant growing media blend on 1st September 2020, the pots were irrigated lightly overhead to ensure the growing media was damp, and then the herbicides were applied using an Oxford precision sprayer with a single nozzle lance and an 02-F110 nozzle to achieve a medium spray quality at 300 L/ha water volume. The pots were set out in plastic crates on the floor within the glasshouse in a randomised design. The demonstration plots were kept separate. Using plastic crates ensured that any herbicide leaching out of the bottom of the pots during irrigation couldn't be taken up by any other pots.

Cress and weed seeds were sown the following day into the first four pots per plot (sowing 1) using a calibrated pinch method to ensure 60-70 seeds per pot. All pots were irrigated lightly overhead as and when required. Cress and weed seeds were then sown again on 15 September 2020 into the remaining four pots per plot, using the same method as before (sowing 2). The pots were monitored and assessments were completed on the cress two weeks after sowing, measuring the number of emerged seedlings per pot and the height of the cress. The weeds in the demonstration plots were assessed at 2 and 4 weeks after sowing, for the number of emerged seedlings per pot.

Results

Dual Gold – s-metolachlor

In the Dual Gold trial, growing media blend components did not appear to impact on the performance or persistence of the herbicide. For both sowing dates, there were only significant differences between herbicide treated and untreated, rather than between growing media blends. In terms of leachability, high levels of s-metolachlor were found in the leachate of all four growing media blends after 1 week. The components used within the blend did not appear to make any difference to the leachability of the herbicide, and after 17 weeks, there were no traces of the herbicide found in the leachate from any of the growing media blends used.

Flexidor – isoxaben

With the Flexidor trial, there were significant differences between the herbicide treated and untreated plots, as well as between the four growing media blends, for both sowing dates. The highest amount of cress germination was seen in the 70% peat standard blend, and the lowest amount of germination was seen in the peat-free blends. In terms of leachability, levels of isoxaben found in the leachate one week after application were relatively low, compared to s-metolachlor and flufenacet. There were also traces of isoxaben found in the leachate after 17 weeks, for all four growing media blends, showing Flexidor was persistent in all of them. The results from this trial show that the performance and persistence of Flexidor should not be adversely affected by different growing media blends, and that actually, weed control appeared to be better in the peat-free products, compared to the 70% peat standard.

Sunfire – flufenacet

With the Sunfire trial, there were no significant differences found between the four growing media blends, or between the herbicide treated and untreated, for either sowing date. However, it must be remembered that Sunfire is predominantly used for grass control, and has limited control of broad-leaved weeds, which is why control in the cress trial may not have been as good as expected. In the annual meadow grass demonstration, differences were seen with more germination in the untreated plots. Importantly, control was similar across the

four growing media blends, suggesting that component parts of the mix do not impact on the performance of the herbicide. In terms of leachability, high levels of flufenacet were found in the leachate from all four growing media blends after one week, although peat-free 1 did appear to be reducing the loss of flufenacet compared to the other mixes. After 17 weeks, there were no traces of flufenacet left from any of the growing media blends. Generally, the results from the Sunfire trial were inconclusive, as it was not completely clear if the growing media blends made an impact on herbicide performance and persistence.

Conclusions

- Different growing media blends do not appear to impact on the performance or persistence of Dual Gold or Sunfire.
- There does appear to be an interaction between growing media blend and Flexidor, with reduced emergence in the peat-free blends.
- When leachate is collected, the relative amounts of each herbicide coming through appear to be related to the solubility of each active ingredient. The association between growing media blend and active ingredient is less clear, although there are some potential trends.
- These results are from one trial, using cress as an indicator plant, therefore the results should be treated with caution. Further work is required to better understand the interactions between growing media components and herbicides.

Objectives

1. To investigate the impact of different growing media blends on the performance of herbicides in container grown crops.
2. To investigate the impact of different growing media blends on the persistence of herbicides in container grown crops.
3. To investigate the impact of different growing media blends on the leachability of herbicides in container grown crops.

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(4)	Design and analysis of efficacy evaluation trials	None
PP 1/135(4)	Phytotoxicity assessment	None
PP 1/181(4)	Conduct and reporting of efficacy evaluation trials including good experimental practice	None

There was one deviation from EPPO guidance:

PP 1/152(4) Section 1.4, Number of treatments and replicates in relation to degrees of freedom:

"Replicates: at least 4"

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

Test site

Item	**Details**
Location address	RSK ADAS Ltd, Battlegate Road, Boxworth, Cambridgeshire, CB23 4NN
Crop	Cress
Soil or substrate type	Peat-reduced and peat-free growing media
Agronomic practice	N/A
Prior history of site	N/A

Trial design

Item	**Details**
Trial design:	Fully randomised block
Number of replicates:	3
Row spacing:	N/A
Plot size: (w x l)	8 x 9 cm pots per plot
Plot size: (m^2)	N/A
Number of plants per plot:	N/A
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	Approval
Untreated	N/A	N/A	N/A	N/A	N/A	N/A
N/A	s-metolachlor	Dual Gold*	SMO5D0172	960	Emulsifiable Concentrate	EAMU 0501/12
N/A	isoxaben	Flexidor	nk	500	Suspension Concentrate	On-label
N/A	flufenacet	Sunfire	343825	500	Suspension Concentrate	EAMU 1065/17

*applied under experimental permit 2019/00849 as application was in September

Application schedule – Dual Gold

Treatment number	Growing media blend	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	70% peat standard	Dual Gold	748.8	0.78	A
2	50% peat	Dual Gold	748.8	0.78	A
3	Peat-free 1	Dual Gold	748.8	0.78	A
4	Peat-free 2	Dual Gold	748.8	0.78	A
5	70% peat standard	Untreated	N/A	N/A	N/A
6	50% peat	Untreated	N/A	N/A	N/A
7	Peat-free 1	Untreated	N/A	N/A	N/A
8	Peat-free 2	Untreated	N/A	N/A	N/A

Application schedule – Flexidor

Treatment number	Growing media blend	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	70% peat standard	Flexidor	250	0.5	A
2	50% peat	Flexidor	250	0.5	A
3	Peat-free 1	Flexidor	250	0.5	A
4	Peat-free 2	Flexidor	250	0.5	A
5	70% peat standard	Untreated	N/A	N/A	N/A
6	50% peat	Untreated	N/A	N/A	N/A
7	Peat-free 1	Untreated	N/A	N/A	N/A
8	Peat-free 2	Untreated	N/A	N/A	N/A

Application schedule – Sunfire

Treatment number	Growing media blend	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	70% peat standard	Sunfire	240	0.48	A
2	50% peat	Sunfire	240	0.48	A
3	Peat-free 1	Sunfire	240	0.48	A
4	Peat-free 2	Sunfire	240	0.48	A

5	70% peat standard	Untreated	N/A	N/A	N/A
6	50% peat	Untreated	N/A	N/A	N/A
7	Peat-free 1	Untreated	N/A	N/A	N/A
8	Peat-free 2	Untreated	N/A	N/A	N/A

Application details

	Application A
Application date	01/09/2020
Time of day	15:30
Crop growth stage (Max, min average BBCH)	N/A (pre-emergence)
Crop height (cm)	N/A
Crop coverage (%)	N/A
Application Method	Spray
Application Placement	Onto growing media
Application equipment	Oxford Precision Sprayer (knapsack)
Nozzle pressure	2 bar
Nozzle type	Flat fan
Nozzle size	02f110
Application water volume/ha	300 L/ha
Temperature of air - shade (°C)	25.0
Relative humidity (%)	38.0
Wind speed range (m/s)	1.5 - 2.0
Dew presence (Y/N)	N
Temperature of soil - 2-5 cm (°C)	N/A
Wetness of soil - 2-5 cm	Damp
Cloud cover (%)	60

Assessment details

The fully randomised cress trials were assessed two weeks after each sowing for the number of germinated seedlings per pot and the height of the crop per pot (**Table 1**). The weed demonstration plots were assessed at two, four and six weeks after sowing, as they were slower to germinate.

Table 1. Assessments carried out during the trial period

	Evaluation Timing (DA)*			
Evaluation date	**After conventional herbicides**	**After Bio-herbicides**	**Evaluation type (efficacy, phytotox)**	**Assessment**
15/09/20	14	N/A	Efficacy	No. of emerged cress seedlings per pot and seedling height (all herbicides, sowing 1)
30/09/20	+29	N/A	Efficacy	No. of emerged cress seedlings per pot and seedling height (all herbicides, sowing 2)
15/10/20	+44	N/A	Efficacy	No. of emerged cress seedlings per pot (Flexidor only, sowing 1 and 2)

* DA – days after application

Statistical analysis

The main cress trial design was a randomised block design with three replicates of 8 treatments for each of the three herbicide trials.

All data were analysed by ANOVA as a 4 x 2 factorial using Genstat 18.4 by Chris Dyer at RSK ADAS. *Post hoc* analyses were performed on the data using Duncan's multiple range test.

Results

Cress emergence and height

Dual Gold

Sowing 1

For seedling emergence, there were no significant differences between the four growing media blends that were treated with herbicide (p =0.985). The only significant difference was between herbicide treated and untreated, where there were more seedlings in the untreated plots, as would be expected. There were also no significant differences in cress height between the four growing media blends treated with herbicide (p =0.150). Again, significant differences occurred between herbicide treated and untreated. The plots containing peat-free 1 and peat-free 2 growing media, which were treated with herbicide, were significantly shorter than their untreated counter-parts (**Table 4**). These untreated plots were also taller than the 70% peat nursery standard and 50% peat untreated plots.

Table 2. Number of emerged seedlings and height two weeks after herbicide application and two weeks after sowing 15 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Dual Gold	Untreated	Dual Gold	Untreated
70% peat standard	40.8	45.5	45.2	45.0
50% peat	44.3	49.5	44.7	47.6
Peat-free 1	44.7	51.2	40.7	53.6
Peat-free 2	47.0	51.5	42.7	56.7
P value	0.026		0.009	
d.f.	14		14	
s.e.d.	2.11		2.47	
l.s.d.	4.53		5.29	
Not significantly different from untreated (p>0.05)				
Significantly different from untreated (p<0.05)				

Sowing 2

With the second sowing, where seeds were sown two weeks after herbicide application, there were no significant differences between the four growing media blends that were treated with herbicide (p =0.375). There were some differences between herbicide treated and untreated, however this was not significant either (p =0.199). In terms of cress height, there were no significant differences between the four growing media blends that were treated with herbicide. However, there was a significant difference between herbicide treated and untreated, with the peat-free 2 plots treated with Dual Gold significantly shorter than the peat-free 2 untreated (p =0.004) (**Table 5**).

Table 3. Number of emerged seedlings and height four weeks after herbicide application and two weeks after sowing 30 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Dual Gold	Untreated	Dual Gold	Untreated
70% peat standard	47.2	56.0	74.8	76.7
50% peat	45.8	46.2	74.4	78.4
Peat-free 1	43.8	47.2	67.8	72.6
Peat-free 2	48.2	50.3	63.2	77.1
P value	0.199		0.004	
d.f.	14		14	
s.e.d.	2.72		1.78	
l.s.d.	5.84		3.82	
Not significantly different from untreated (p>0.05)				
Significantly different from untreated (p<0.05)				

Flexidor

Sowing 1

In the Flexidor trial, there was a significant difference between the four growing media blends that were treated with herbicide (p =0.072), as well as between herbicide treated and untreated (p <.001; **Table 4**), with many more seedlings in the untreated plots, as would be expected. Within the herbicide treated plots, the peat-free 2 growing media had the lowest number of germinated seedlings after two weeks (0.1 per pot) and the 70% peat standard had the highest number of emerged seedlings (4.0). However, in the untreated herbicide plots, the peat-free 2 product had the most emerged seedlings (40.0) and the 70% peat standard had the least emerged seedlings (25.2). There were also significant differences in the height of the cress treated with herbicide (p <.001), with the shortest crop in the peat-free 2 blends (1.3 mm) and the tallest crop in the 70% peat standard (26.0 mm). However, as with emergence, this was the opposite for the untreated plots, with the tallest crop in the peat-free 2 blend (61.4 mm) and the shortest crop in the 70% peat standard (46.8 mm).

Table 4. Number of emerged seedlings and height two weeks after herbicide application and two weeks after sowing 15 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Flexidor	Untreated	Flexidor	Untreated
70% peat standard	4.0	25.2	26.0	46.8
50% peat	3.1	28.8	16.3	48.2
Peat-free 1	0.8	31.3	10.3	51.5
Peat-free 2	0.1	40.0	1.3	61.4
P value	<.001		<.001	
d.f.	14		14	
s.e.d.	2.35		2.49	
l.s.d.	5.05		5.33	
Not significantly different from untreated (p>0.05)				
Significantly different from untreated (p<0.05)				

Sowing 2

The results from the second sowing within the Flexidor trial showed that there was a significant difference between the four growing media blends that were treated with herbicide (p =0.015), as well as between herbicide treated and untreated (p <.001; **Table 5**). Results were similar to the first sowing, with the Flexidor treated plots having the highest number of germinated seedlings in the 70% peat standard (21.8 per pot) and the lowest amount in the peat-free 1 blend (0.3 per pot). However, in the untreated herbicide plots, the peat-free 2 product had the most emerged seedlings (37.8) and the 50% peat blend had the least emerged seedlings (31.9). As with sowing 1 there were also significant differences in the height of the cress treated with herbicide (p <.001), with the shortest crop in the peat-free 2 blends (0.3 mm) and the tallest crop in the 70% peat standard (43.2 mm).

Table 5. Number of emerged seedlings and height four weeks after herbicide application and two weeks after sowing 30 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Flexidor	Untreated	Flexidor	Untreated
70% peat standard	21.8	35.2	43.2	62.1
50% peat	8.7	31.9	20.2	72.0
Peat-free 1	0.3	35.0	2.5	67.8
Peat-free 2	0.4	37.8	0.3	69.1
P value	<.001		<.001	
d.f.	14		14	
s.e.d.	2.48		3.80	
l.s.d.	5.32		8.15	
Not significantly different from untreated (p>0.05)				
Significantly different from untreated (p<0.05)				

Sunfire

Sowing 1

In the first sowing of the Sunfire trial, there were no significant differences between the four growing media blends that were treated with herbicide (p =0.957), or between herbicide treated and untreated (p =0.146; **Table 6**). For each growing media blend, there were more emerged seedlings in the Sunfire treated plots than there were in the untreated plots. However, the cress was shorter in the 70% peat standard and 50% peat blend treated with Sunfire than the untreated. The cress was marginally taller in the peat-free blends treated with Sunfire than the peat-free untreated blends.

Table 6. Number of emerged seedlings and height two weeks after herbicide application and two weeks after sowing 15 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Sunfire	Untreated	Sunfire	Untreated
70% peat standard	52.6	50.2	56.1	61.4
50% peat	66.5	58.4	65.3	67.3
Peat-free 1	59.2	53.3	69.2	67.1
Peat-free 2	68.2	62.0	77.6	74.5
P value	0.146		0.871	
d.f.	14		14	
s.e.d.	3.66		3.24	

l.s.d.	7.86	6.96
Not significantly different from untreated (p>0.05)		
Significantly different from untreated (p<0.05)		

Sowing 2

With the second sowing, again, there were no significant differences between the four growing media blends that were treated with herbicide (p =0.539), or between herbicide treated and untreated (p =0.893; **Table 7**). Only the peat-free 1 blend treated with Sunfire had less germinated seedlings than its untreated counterpart. There was also very little difference in crop height between the Sunfire treated and untreated plots, regardless of growing media blend.

Table 7. Number of emerged seedlings and height four weeks after herbicide application and two weeks after sowing 30 Sept 2020

Growing media blend	No. of emerged seedlings		Cress height (mm)	
	Sunfire	Untreated	Sunfire	Untreated
70% peat standard	39.3	36.4	60.3	66.8
50% peat	39.7	39.2	67.5	66.4
Peat-free 1	31.9	37.5	59.2	61.5
Peat-free 2	36.7	35.6	64.2	61.8
P value	0.893		0.579	
d.f.	14		14	
s.e.d.	2.12		2.35	
l.s.d.	4.56		5.04	
Not significantly different from untreated (p>0.05)				
Significantly different from untreated (p<0.05)				

Leachate

Leachate was collected on two occasions in the 2019 trial. The first collection was 1 week after herbicide application and the second collection was 17 weeks after herbicide application. The results are presented in **Table 8**. In addition, the parameters for each of the three herbicide products is presented in **Table 9**.

The relative amounts of each herbicide coming through appear to be related to the solubility of each active ingredient. The association between growing media blend and active ingredient is less clear, although there are some potential trends.

Peat-free 1 appears to be good at reducing the immediate loss of flufenacet and isoxaben, although this was a one-off test. S-metolachlor is quite readily leached through the growing media soon after application, although less so in the 70% peat standard blend.

After 17 weeks, there were no traces of s-metolachlor or flufenacet in the leachate collected from any of the growing media blends. However, isoxaben was still present in all growing media blends, with levels very similar for each of the four blends. Isoxaben is a persistent product and this test helps to highlight the fact that it does remain in the growing media long after application.

Table 8. Levels of herbicide (ug/L) found in leachate collected 1 week and 17 weeks after herbicide application to four different growing media blends, 2019

Herbicide	Growing media treatment	Level of herbicide found (ug/L) 1 week after application	Level of herbicide found (ug/L) 17 weeks after application
Dual Gold (s-metolachlor 960 g/L)	70% peat standard	130	0
	50% peat	200	0
	Peat-free 1	230	0
	Peat-free 2	200	0
Flexidor 500 (isoxaben 500 g/L)	70% peat standard	60	2.4
	50% peat	48	1.3
	Peat-free 1	42	1.6
	Peat-free 2	54	2.3
Sunfire (flufenacet 500 g/L)	70% peat standard	140	0
	50% peat	100	0
	Peat-free 1	98	0
	Peat-free 2	260	0

Table 9. Product parameters for each of the herbicides used in this trial. ref. Pesticide Properties Database (PPDB) – University of Hertfordshire

Herbicide	Solubility in water (20°C, ug/L)	Run-off potential	Soil degradation days (DT50)	Mobility
Dual Gold (s-metolachlor 960 g/L)	51	Low	Non-persistent	Moderate
Flexidor 500 (isoxaben 500 g/L)	0.93	Medium	Persistent	Slight to moderate
Sunfire (flufenacet 500 g/L)	480	Low	Non-persistent	Moderate

Growing media physical properties

The results of the growing media physical properties are presented in **Table 10**. These measurements help to explain the structure of the growing media, how open it is, and how well it can hold water.

For air-filled porosity (AFP), there were differences between the four blends, but none of them were out of the commercially acceptable range of 10-25%. Interestingly, peat-free 2 was very similar to the 70% peat standard, which shows that some peat-free blends can have a similar AFP to the standard peat mixes. The highest AFP was seen in the 50% peat blend, with an AFP of 24.35.

There was more of a difference between blends for the available water (AW) measurements. The lowest AW was seen in the 50% peat blend (28.01%), whereas the highest AW was seen in the peat-free 2 blend (37.31%).

With dry bulk density (Db), results were as would be expected, with the greatest Db in the 70% peat standard (0.15 g cm-3) and the lowest Db in both the peat-free blends (0.11 g cm-3).

Table 10. Physical properties of the four growing media blends used in the trial. AFP = air-filled porosity, AW = available water, D_b = dry bulk density

Growing media blend	AFP (%)	AW (%)	D_b (g cm-3)
70% peat standard	20.15	33.14	0.15
50% peat	24.35	28.01	0.14
Peat-free 1	22.82	35.28	0.11
Peat-free 2	20.92	37.31	0.11

Demonstration trial

Flexidor

With the Flexidor demonstration trial, seeds of Hairy Bittercress were sown at 1 and 14 days after herbicide application. Plots were not replicated, so statistical analysis could not be carried out, however some useful observations were made for both of the sowing dates (**Table 11**). Germination of hairy bittercress was quite poor, which did impact to some degree on the observations, although some trends could still be seen.

In the first sowing, there were no germinated weeds in any of the plots, when assessed after two weeks. These pots were kept on for several weeks and monitored. After four weeks (30 September) there was still no germination in any of the Flexidor treated pots, and minimal germination in the untreated pots, with a maximum of 21 seedlings across four pots in the peat-free 2 untreated blend. These pots were kept until 21 October and there was no change.

In the second sowing, after two weeks (30 September), there were some small amounts of germination within each herbicide blend for both herbicide treated and untreated. At the end of the trial on 21 October (7 weeks after herbicide application and 5 weeks after sowing), there were still very few germinated seedlings across the treatments. However, pots treated with Flexidor did have less weeds, and there was little difference between the four growing media blends. These weeds were also much smaller than the untreated.

Table 11. Number of emerged seedlings and height for both sowing dates, two weeks after sowing 15 Sept 2020 (sowing 1) and five weeks after sowing 21 October 2020 (sowing 2)

Growing media blend	Herbicide	Sowing 1		Sowing 2	
		No. emerged weeds 15.09.20	Height (mm) 15.09.20	No. emerged weeds 21.10.20	Height (mm) 21.10.20
70% peat standard	Flexidor	0	0	0.3	3.1
50% peat	Flexidor	0	0	0.5	1.5
Peat-free 1	Flexidor	0	0	0	0
Peat-free 2	Flexidor	0	0	0.1	1.3
70% peat standard	Untreated	0	0	0.8	35.3
50% peat	Untreated	0	0	1.0	43.6
Peat-free 1	Untreated	0	0	4.3	16.9
Peat-free 2	Untreated	0	0	4.1	42.5

Sunfire

With the Sunfire demonstration trial, seeds of Annual Meadow Grass were sown at 1 and 14 days after herbicide application. Plots were un-replicated, however germination was very good so useful observations could be made (**Table 12**).

In the first sowing, there were high numbers of seedlings in the untreated plots when assessed after two weeks. There were also rather high numbers in the two peat-free blends which had been treated with Sunfire, compared to the 70% peat standard and the 50% peat blend. The pots from the first sowing were kept for another two weeks, but there was no more germination in the Sunfire treated pots.

In the second sowing, pots were originally assessed after two weeks (30 September), but there was not much difference between any of the treatments, with germination in all pots. A final assessment was carried out on 21 October (7 weeks after herbicide application and 5 weeks after sowing). There was still not much of a difference between herbicide treated and untreated pots. The treatment with the lowest germination was the 50% peat untreated blend

(19.8) and the treatment with the highest germination was both the peat-free 1 Sunfire treated and the peat-free 2 untreated blends (37.5).

Table 12. Number of emerged seedlings and height for both sowing dates, two weeks after sowing 15 Sept 2020 (sowing 1) and five weeks after sowing 21 October 2020 (sowing 2)

Growing media blend	Herbicide	Sowing 1		Sowing 2	
		No. emerged weeds 15.09.20	Height (mm) 15.09.20	No. emerged weeds 21.10.20	Height (mm) 21.10.20
70% peat standard	Sunfire	15.3	29.0	28	136.8
50% peat	Sunfire	16.5	34.0	31.8	145.5
Peat-free 1	Sunfire	31.0	31.5	37.5	110.0
Peat-free 2	Sunfire	36.0	34.3	37.3	98.8
70% peat standard	Untreated	9.5	27.5	27.3	116.0
50% peat	Untreated	29.0	25.5	19.8	152.5
Peat-free 1	Untreated	42.8	32.3	33.3	111.0
Peat-free 2	Untreated	48	31.8	37.5	89.0

Discussion

Herbicide performance

Dual Gold – s-metolachlor

In the Dual Gold trial, growing media blend components did not appear to impact on the performance or persistence of the herbicide. For both sowing dates, there were only significant differences between herbicide treated and untreated, rather than between growing media blends. In terms of leachability, high levels of s-metolachlor were found in the leachate of all four growing media blends after 1 week. The components used within the blend did not appear to make any difference to the leachability of the herbicide, and after 17 weeks, there were no traces of the herbicide found in the leachate from any of the growing media blends used.

Dual Gold is mainly used as a short-term early summer product, particularly in programmes or mixed with Flexidor to give improved control, particularly for Willowherb. Results from this trial indicate that product performance should not be adversely affected by growing media blend components.

Flexidor – isoxaben

With the Flexidor trial, there were significant differences between the herbicide treated and untreated plots, as well as between the four growing media blends, for both sowing dates. The highest amount of cress germination was seen in the 70% peat standard blend, and the lowest amount of germination was seen in the peat-free blends. In terms of leachability, levels of isoxaben found in the leachate one week after application were relatively low, compared to s-metolachlor and flufenacet. There were also traces of isoxaben found in the leachate after 17 weeks, for all four growing media blends, showing Flexidor was persistent in all of them. The results from this trial show that the performance and persistence of Flexidor should not be adversely affected by different growing media blends, and that actually, weed control appeared to be better in the peat-free products, compared to the 70% peat standard.

Sunfire – flufenacet

With the Sunfire trial, there were no significant differences found between the four growing media blends, or between the herbicide treated and untreated, for either sowing date.

However, it must be remembered that Sunfire is predominantly used for grass control, and has limited control of broad-leaved weeds, which is why control in the cress trial may not have been as good as expected. In the annual meadow grass demonstration, differences were seen with more germination in the untreated plots. Importantly, control was similar across the four growing media blends, suggesting that component parts of the mix do not impact on the performance of the herbicide. In terms of leachability, high levels of flufenacet were found in the leachate from all four growing media blends after one week, although peat-free 1 did appear to be reducing the loss of flufenacet compared to the other mixes. After 17 weeks, there were no traces of flufenacet left from any of the growing media blends. Generally, the results from the Sunfire trial were inconclusive, as it was not completely clear if the growing media blends made an impact on herbicide performance and persistence.

Growing media characteristics

The results from the three herbicide trials showed that generally, growing media blend did not impact on herbicide performance or persistence, however there may have been some impact on leachability, with the peat-free 1 product appearing to reduce the leachability of isoxaben and flufenacet. However, this is only based on one test, and would need further investigation.

In terms of air-filled porosity (AFP), with the four growing media blends used in the trial, the AFP of all of them was within the target range of 10-25%, with a higher AFP seen in the 50% peat product compared to the two peat-free products. If AFP is too high, the air spaces present are too large and the medium drains quickly. The growing medium will have to be irrigated frequently to prevent drought stress. If herbicides, or other plant protection products, are applied to a growing medium with an AFP that is too high, this could leach through the medium too quickly, and become lost before having the desired effect. The increased irrigation would also exasperate this further. With these growing media blends, the AFP should not impact on growing media leachability.

With available water (AW), all of the blends used within this trial were within the acceptable range of 25-40%, with higher AW in the two peat-free blends. A growing media should have a relatively large amount of available water to overcome potential water loss through evapotranspiration. If AW is low, the plant is unable to extract enough water from the medium for growth, resulting in wilting and whole plant loss. If AW is high, the plant could become waterlogged if it is watered too much and/or too frequently. This can be overcome by careful irrigation management. This suggests that the peat-free materials used within these blends provide a suitable structure for water holding to be maintained, rather than too free-draining, which could result in the loss of herbicides from the material.

For dry bulk density (D_b) – measurements were lower in the two peat-free blends, as would be expected. Whilst this means the blends have a greater potential to store more water, the D_b is less likely to impact on the performance and leachability of herbicides in growing media.

Overall, results from this trial showed that different growing media blends do not appear to impact on the performance and persistence of herbicides. Additionally, leachate does not appear to be increased in the more open structures of peat-free mixes. However, this is one trial carried out using cress as an indicator plant, with un-replicated demonstrations for annual meadow grass and hairy bittercress carried out at the same time. Further work to replicate these results would be required. Similarly, for the leachate, this was only collected on two separate occasions, at 1 and 17 weeks after herbicide application. Ideally, collections would be taken on a weekly basis, to see how long the active ingredients persisted for, and if persistence was longer in some growing media blends than others.

Conclusions

- Different growing media blends do not appear to impact on the performance or persistence of Dual Gold or Sunfire.
- There does appear to be an interaction between growing media blend and Flexidor, with reduced emergence in the peat-free blends.
- When leachate is collected, the relative amounts of each herbicide coming through appear to be related to the solubility of each active ingredient. The association between growing media blend and active ingredient is less clear, although there are some potential trends.
- These results are from one trial, using cress as an indicator plant, therefore the results should be treated with caution. Further work is required to better understand the interactions between growing media components and herbicides.

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 Neil Bragg, Paul Alexander and Ann McCann, who supplied the growing media blends for the trial.

Appendix

a. Photographs

Trial layout in 2019 showing pots in herbicide treated plots attached to leachate capture devices, ADAS Boxworth

Trial layout in 2020 showing smaller pots placed into plastic bread crates and located within a glasshouse, ADAS Boxworth

Dual Gold Sowing 1 – 2 weeks after herbicide application and sowing

70% peat standard; Dual Gold (left) vs untreated (right)

50% peat; Dual Gold (left) vs untreated (right)

Peat-free 1; Dual Gold (left) vs untreated (right)

Peat-free 2; Dual Gold (left) vs untreated (right)

Dual Gold Sowing 2 – 4 weeks after herbicide application and 2 weeks after sowing

70% peat standard; Dual Gold (left) vs untreated (right)

50% peat; Dual Gold (left) vs untreated (right)

Peat-free 1; Dual Gold (left) vs untreated (right)

Peat-free 2; Dual Gold (left) vs untreated (right)

Flexidor Sowing 1 – 2 weeks after herbicide application and sowing

70% peat standard; Flexidor (left) vs untreated (right)

50% peat; Flexidor (left) vs untreated (right)

Peat-free 1; Flexidor (left) vs untreated (right)

Peat-free 2; Flexidor (left) vs untreated (right)

Flexidor Sowing 2 – 4 weeks after herbicide application and 2 weeks after sowing

70% peat standard; Flexidor (left) vs untreated (right)

50% peat; Flexidor (left) vs untreated (right)

Peat-free 1; Flexidor (left) vs untreated (right)

Peat-free 2; Flexidor (left) vs untreated (right)

Sunfire Sowing 1 – 2 weeks after herbicide application and sowing

70% peat standard Sunfire (left) vs untreated (right)

50% peat Sunfire (left) vs untreated (right)

Peat-free 1 Sunfire (left) vs untreated (right)

Peat-free 2 Sunfire (left) vs untreated (right)

Sunfire Sowing 2 – 4 weeks after herbicide application and 2 weeks after sowing

70% peat standard Sunfire (left) vs untreated (right)

50% peat Sunfire (left) vs untreated (right)

Peat-free 1 Sunfire (left) vs untreated (right)

Peat-free 2 Sunfire (left) vs untreated (right)

b. Climatological data during study period

Date	Temperature °C (maximum)	Temperature °C (minimum)	Temperature °C (average)
02/09/2020	27.6	16.3	19.8
03/09/2020	28.3	16.3	20.7
04/09/2020	27.9	14.3	19.2
05/09/2020	31.4	12.6	20.2
06/09/2020	30.4	13.1	19.8
07/09/2020	22.9	13.3	17.7
08/09/2020	30.8	16.7	22.2
09/09/2020	36.4	15.2	22.0
10/09/2020	34.4	12.2	19.9
11/09/2020	28.5	12.7	18.6
12/09/2020	29.7	14.0	20.0
13/09/2020	33.8	14.7	22.1
14/09/2020	41.9	14.8	24.1
15/09/2020	37.0	15.1	23.4
16/09/2020	32.3	16.9	21.8
17/09/2020	35.4	13.8	20.8
18/09/2020	34.8	12.0	20.1
19/09/2020	35.7	13.2	21.1
20/09/2020	34.8	14.7	21.2
21/09/2020	38.1	14.2	23.0
22/09/2020	36.5	16.1	23.5
23/09/2020	27.1	13.1	18.7
24/09/2020	26.9	11.1	16.1
25/09/2020	21.2	11.4	14.8
26/09/2020	17.8	8.7	12.9
27/09/2020	17.8	11.6	13.4
28/09/2020	30.1	12.0	16.9
29/09/2020	23.7	13.0	16.1
30/09/2020	21.3	12.0	15.8
01/10/2020	29.8	12.7	20.1
02/10/2020	24.5	17.4	21.2
03/10/2020	22.7	17.8	19.2
04/10/2020	21.6	16.9	18.8
05/10/2020	23.4	17.0	19.4
06/10/2020	27.0	17.5	20.3
07/10/2020	28.1	17.2	20.3
08/10/2020	23.5	17.1	19.2
09/10/2020	25.4	17.5	20.0
10/10/2020	27.4	17.6	20.1
11/10/2020	26.2	17.2	19.9
12/10/2020	28.9	17.4	20.4
13/10/2020	21.5	17.2	18.6
14/10/2020	22.7	17.1	19.0
15/10/2020	24.0	17.0	19.2

16/10/2020	22.1	17.1	18.9
17/10/2020	23.1	17.1	19.1
18/10/2020	22.3	17.2	18.8
19/10/2020	30.5	18.2	21.2
20/10/2020	27.9	18.2	21.0
21/10/2020	21.7	14.7	18.0

c. Raw data from assessments

Dual Gold

Plot number	Block	Trt 1	Sowing 1 number 15.09.20	Sowing 1 height (mm) 15.09.20	Sowing 2 number 30.09.20	Sowing 2 height (mm) 30.09.20
101	1	7	50.5	58.0	55.5	77.0
102	1	5	50.5	45.3	60.5	88.5
103	1	8	61.8	70.8	46.5	78.0
104	1	4	60.3	50.8	45.8	69.0
105	1	1	43.3	46.3	49.8	80.0
106	1	2	49.7	47.0	48.5	78.8
107	1	3	51.8	41.0	40.5	76.8
108	1	6	56.0	47.0	43.5	84.0
201	2	8	53.8	62.8	62.5	82.3
202	2	1	43.0	50.3	56.0	74.3
203	2	6	53.5	63.0	49.0	76.0
204	2	2	54.3	50.5	53.3	81.8
205	2	3	52.5	52.0	52.3	67.5
206	2	7	54.5	55.8	44.3	70.8
207	2	5	54.0	57.0	54.0	78.3
208	2	4	48.8	43.8	44.8	62.8
301	3	5	32.0	32.8	53.5	63.3
302	3	4	32.0	33.5	54.0	57.8
303	3	3	29.8	29.0	38.5	59.0
304	3	6	39.0	32.8	46.0	75.3
305	3	7	48.8	47.0	42.0	70.0
306	3	8	39.0	36.5	41.8	71.0
307	3	1	36.0	39.0	36.0	70.0
308	3	2	29.0	36.5	35.8	62.8

Flexidor

Plot number	Block	Trt 1	Sowing 1 number 15.09.20	Sowing 1 height (mm) 15.09.20	Sowing 2 number 30.09.20	Sowing 2 height (mm) 30.09.20
101	1	6	24.5	57.0	33.3	75.5
102	1	8	36.3	68.3	39.5	78.8
103	1	7	35.0	52.0	32.8	65.8
104	1	1	6.3	28.0	34.8	66.5
105	1	3	0.0	0.0	1.0	6.3
106	1	2	2.5	16.8	22.0	37.3
107	1	4	0.0	0.0	1.3	1.0
108	1	5	22.8	46.8	38.0	66.8
201	2	3	1.3	14.5	0.0	0.0
202	2	7	27.0	48.5	40.0	75.0
203	2	4	0.3	3.8	0.0	0.0
204	2	6	19.0	36.5	39.5	83.8
205	2	5	27.8	48.5	36.3	62.0
206	2	8	31.5	58.0	44.5	74.0
207	2	1	2.8	29.5	16.0	28.8
208	2	2	3.5	14.8	2.8	16.0
301	3	1	3.0	20.5	14.8	34.3
302	3	5	25.0	45.0	31.3	57.5
303	3	8	52.3	58.0	29.3	54.5
304	3	4	0.0	0.0	0.0	0.0
305	3	7	32.0	54.0	32.3	62.5
306	3	3	1.0	16.3	0.0	1.3
307	3	2	3.3	17.5	1.5	7.3
308	3	6	43.0	51.0	23.0	56.8

Sunfire

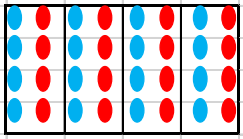
Plot number	Block	Trt 1	Sowing 1 number 15.09.20	Sowing 1 height (mm) 15.09.20	Sowing 2 number 30.09.20	Sowing 2 height (mm) 30.09.20
101	1	5	28.3	62.5	41.8	70.0
102	1	7	37.8	59.3	39.3	66.8
103	1	8	51.0	71.5	35.0	68.5
104	1	3	47.8	68.8	37.0	66.0
105	1	1	57.5	69.8	38.8	65.0
106	1	6	57.8	66.5	38.5	66.5
107	1	4	68.5	79.8	46.5	68.8
108	1	2	69.8	67.0	46.5	78.3
201	2	6	57.3	63.5	38.8	61.8
202	2	2	67.5	70.5	41.3	61.3
203	2	4	70.3	77.0	41.3	71.0
204	2	5	62.0	55.3	37.0	68.0
205	2	3	69.0	69.3	33.0	54.5
206	2	8	75.0	72.8	34.5	60.8
207	2	1	51.3	60.3	38.3	53.3
208	2	7	59.8	65.5	36.3	52.3
301	3	8	60.0	79.3	37.3	56.0
302	3	3	61.0	69.5	25.8	57.0
303	3	1	49.0	38.3	41.0	62.5
304	3	2	62.3	58.5	31.3	63.0
305	3	6	60.3	72.0	40.5	71.0
306	3	7	62.5	76.5	37.0	65.5
307	3	5	60.3	66.5	30.5	62.5
308	3	4	65.8	76.0	22.3	53.0

d. Trial design

Dual Gold

Plot	101	102	103	104	105	106	107	108
Rep	1	1	1	1	1	1	1	1
Trt	7	5	8	4	1	2	3	6
Plot	201	202	203	204	205	206	207	208
Rep	2	2	2	2	2	2	2	2
Trt	8	1	6	2	3	7	5	4
Plot	301	302	303	304	305	306	307	308
Rep	3	3	3	3	3	3	3	3
Trt	5	4	3	6	7	8	1	2

Layout within bread crate (8 pots/plot)



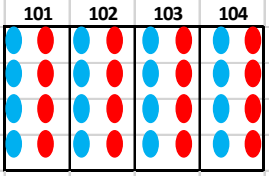
Sowing 1

Sowing 2

Flexidor

Plot	101	102	103	104	105	106	107	108
Rep	1	1	1	1	1	1	1	1
Trt	6	8	7	1	3	2	4	5
Plot	201	202	203	204	205	206	207	208
Rep	2	2	2	2	2	2	2	2
Trt	3	7	4	6	5	8	1	2
Plot	301	302	303	304	305	306	307	308
Rep	3	3	3	3	3	3	3	3
Trt	1	5	8	4	7	3	2	6

Layout within bread crate (8 pots/plot



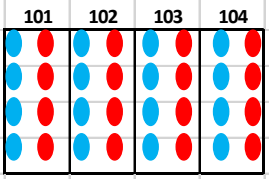
Sowing 1

Sowing 2

Sunfire

Plot	101	102	103	104	105	106	107	108
Rep	1	1	1	1	1	1	1	1
Trt	5	7	8	3	1	6	4	2
Plot	201	202	203	204	205	206	207	208
Rep	2	2	2	2	2	2	2	2
Trt	6	2	4	5	3	8	1	7
Plot	301	302	303	304	305	306	307	308
Rep	3	3	3	3	3	3	3	3
Trt	8	3	1	2	6	7	5	4

Layout within bread crate (8 pots/plot



Sowing 1

Sowing 2

e. 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